Vehicle or destination?

Discordant perspectives in CCS advocacy

Mads Dahl Gjefsen

Thesis submitted for the degree of Ph.D.

December 2014

TIK Centre for Technology, Innovation and Culture

Faculty of Social Sciences

University of Oslo

Series of dissertations submitted to the
Faculty of Social Sciences, University of Oslo
No. 511

ISSN 1504-3991

Cover: Hanne Baadsgaard Utigard.
Printed in Norway: AIT Oslo AS.

Produced in co-operation with Akademika publishing, Oslo.
The thesis is produced by Akademika publishing merely in connection with the thesis defence. Kindly direct all inquiries regarding the thesis to the copyright holder or the unit which grants the doctorate.

Acknowledgements

A fondness for reading acknowledgements is probably the strangest by-product of my time as a graduate student. These sections are always welcome reminders that even the most polished and detached works of scholarship come from real people who needed help along the way. Sometimes they inspire good gossip. It is therefore both with a sense of gratitude and with a certain level of self-consciousness that I now sit down to write my own.

My first thanks go to my supervisor Göran Sundqvist, who has been an inspiring, generous, and encouraging source of guidance and support through the ups and downs of thesis work. Thankfully, supervising my MA thesis at the University of Oslo's TIK Centre for Technology, Innovation and Culture in 2009 did not dissuade him from taking me on as a PhD student at the same institution a few months later. Again and again, Göran has shown a remarkable talent for applying just the right mix of enthusiasm, criticism, complements, guilt, and pressure to make me go the extra distance, and it is thanks to him that I have made it through to the end.

My co-supervisor, Sheila Jasanoff, has also helped make my time as a graduate student an unforgettable experience. The two years spent with her at the Program on Science, Technology & Society at Harvard were filled with more opportunities and challenges than I could have imagined. As a co-supervisor and mentor, Sheila made this a formative time for me as a scholar. The care and wisdom she applies to all aspects of scholarship continues to be a source of inspiration.

I also wish to thank the many colleagues (some of whom have also become close friends) who have provided advice and support along the way and thereby also helped shape the direction of this thesis. At TIK, special thanks are owed to former Director Jane Summerton, who was patient as my research exiles grew increasingly longer, and who assisted in securing much-needed funding. Kristin Asdal and Knut Haukelid gave valuable feedback on an early thesis draft.

Regular meetings in TIK's STS and PhD groups, as well as a short stint in the Innovation group, provided advice and inspiration, as well as opportunities to discuss

and reflect on topics beyond my own immediate project. TIK has offered a supportive and creative environment that I am sad to be leaving. On the research side, special thanks are owed to Tone Druglitrø, Jens Hanson, Jarle Hildrum, Merle Jacob, Stefanie Jenssen, Ásdís Jónsdóttir, Christine Lie, Sylvia Lysgård, Sissel Myklebust, Håkon Normann, Hilde Nykamp, Hilde Reinertsen, Helge Ryggvik, Tina Talleraas, and Olav Wicken. From the administration, I also wish to give special thanks to Lene Angelskår, Bente Bleskestad, Tom Nekstad and Tina Næss, as well as former colleagues Ancha Wesnes and Jon Holm.

Outside TIK I have been welcomed into a larger community of scholars who with great patience read, listened, and gave constructive feedback on continuing work. Linda Soneryd did a tremendous job in assessing a late-stage draft of this thesis, and her questions and comments were a huge help in formulating a coherent contribution to the field. Brice Laurent, Lee Vinsel, Jason Chilvers, and Emma Frow all commented on various stages of unfinished written work.

Five anonymous referees and the editors of *Science & Technology Studies* and the *European Journal of Futures Research* gave constructive criticisms on the now published thesis articles. Several organizers and participants at a number of conferences and workshops along the way also influenced my work and thinking, especially at the Science and Democracy Network meeting in Paris, 2012, and at the session on CCS at the joint meeting of the Society for Social Studies of Science and the European Association for the Study of Science and Technology in Copenhagen that same fall.

Between the fall of 2011 and the summer of 2013, the STS Fellows Group at Harvard provided an especially stimulating environment for young scholars with overlapping interest. Special thanks are due to Erik Aarden, Saptarishi Bandopadhyay, Henri Boullier, Henry Cowles, Margaret Curnutte, Friederike Gesing, Connie Johnston, Wanda Katia Liebermann, Martin Mahony, Ingrid Metzler, Tolu Odumosu, Helen Pallett, Sebastian Pfotenhauer, Krishanu Saha, and Michelle Stewart, as well as to Shana Rabinowich. I also wish to thank James Bergman, Neal Akatsuka and Caroline DeVane for their collaboration in organizing stimulating workshops and events along

the way, as well as the pool hall crowd at Flat Top Johnny's for much-needed escape at some of the tougher times of PhD life.

Initial funding for this thesis project was provided through the TIK Centre and the Centre for Sustainable Energy Studies (CenSES, Research Council of Norway project 209697), with support from what was then the University of Oslo's interfaculty research area: Environmental Change and Sustainable Energy (MILEN, now UiO Energy). Later on, several grants and funds supported research and fellowship activities at Harvard: the Research Council of Norway (project 209247/V11), the Ryoichi Sasakawa Young Leaders Fellowship Fund, Legatet "Patrick Geddes-samlingen", Ella og Robert Wenzins legat ved Universitetet i Oslo, Jansons legat, as well as the Norway-America Association's Ragnhild Marianne Løkens Education Fund and King Olav V Stipend. Le Centre franco-norvégien en sciences sociales et humaines generously paid for a summer-long stay in Paris in 2012 as part of interview research in Paris and Brussels. Funding sources had no involvement in data interpretation or publication decisions, but their contributions are gratefully acknowledged.

The University of Wisconsin's Department of Geography and Urban Planning in Oshkosh, as well as the Holtz Center for Science & Technology Studies in Madison, provided supportive settings in which to complete the final year of thesis writing. A short training retreat organized by Arizona State University's Centre for Nanotechnology in Society in January 2014, as well as the opportunity to join the Norwegian Board of Technology as a Project Manager later that spring, helped show that there is a life after the dissertation, and that the world is full of opportunities for research-based interventions.

The study could not have been done without the informants who set aside time to answer my many questions about what they were doing and why. A few special key informants, who shall not be named, gave crucial assistance in opening doors, introducing me to other colleagues, and in identifying opportunities for further study. While they might not agree with everything I say in this thesis, I hope that they find the end result to be both interesting and truthful to their own experience.

The influence and advice from the colleagues listed here are gratefully acknowledged, but I am of course entirely responsible for any errors and limitations.

My parents Anne Gjefsen and Otto Dahl Olsen, and my brother Kjartan Gjefsen, deserve thanks for their unfailing support. My dear friends Morten Fosaas, Bjørn Hatterud, Chalak Kaveh, Solveig Skaland, Andreas Snildal, and Hege Rudi Standal, each helped in their own way, some offering couch space for completely unreasonable periods of time, others by just simply being there.

I owe my greatest thanks to my wife and intellectual sparring partner Elizabeth Sanna Barron, who, especially in the final frantic months, has shown incredible patience and support. I dedicate this thesis to our June addition. Before even joining us, she has provided the final piece of inspiration needed to complete this work.

Mads Dahl Gjefsen
Oshkosh WI, December 2014

Summary

My motivation for writing this thesis is an interest in the capacities of technological cultures to systematically respond to crises on the scale at which the crises are seen to unfold. Anthropocentric climate change is one such crisis. A systematic response to it is CO_2 capture and storage (CCS), a technology yet unrealized on the scale advocates claim are necessary for it to have a meaningful impact on climate change mitigation. Such large-scale deployment is said to depend not only on technological development, but also on political support, something that in turn is recognized to depend on a number of factors relating to regulatory frameworks, financial support, and social acceptability.

Support for CCS has been on the rise since the turn of the millennium, and the technology has become a priority for many of the world's political actors. Such support has been weighed and measured in quantitative terms, but has received comparably little systematic, qualitative attention. Qualitative studies of CCS have largely focused on CCS as a potential source of controversy and public scepticism.

In this thesis I seek to chart new territory through qualitative inquiry into three dimensions of CCS advocacy: *representations* of CCS as a public good, the design and outputs from new *organizations* founded as part of CCS support, and the cohesion and self-management of *communities* of CCS experts. I study dynamics between actors involved in the support for CCS in order to understand the capacity of heterogeneous actor alliances to promote large-scale sociotechnical transitions.

The thesis is comprised of three research articles. The first article compares geopolitical pursuits of CCS in the United States and European Union. It finds that CCS has become associated with distinct performances of statehood in the two sites, as a technological alternative to the Kyoto Protocol's regulation-based approach to climate change mitigation on one hand, and as a mechanism for European integration on the other. The second article investigates a new expert forum designed to advise the European Commission on research and development strategies for CCS. It finds that forum constituents strategically foreground environmental organizations to deliver portrayals of CCS as both safe and desirable, and as a technology serving the

interests of pan-European stakeholders – both industry and publics – as defined against the outside world. The third article examines training and recruitment efforts designed to strengthen the CCS expert community. It finds that non-university training venues utilize different forms of resources and sources of legitimacy to be drawn upon in community building. The term *Expert-Advocate* is proposed as a way of understanding how individuals in expert communities are primed for active performances of technology support by traversing "barriers" to technology in both the technical, political, and social realm.

In synthesising insights from these three dimensions of study, I conclude that CCS support is characterized by efforts to manage tensions and interdependencies. This is a conclusion that raises questions about the effectiveness of heterogeneous actor alliances in cases where constituent groups operate with different levels of urgency about the realization of technological visions. Where some actors benefit from simply expressing commitments to such visions in the present, discords in advocacy could hamper the potential for change. Understanding the conditions under which such discords arise should be a priority for research on societal transitions.

Table of contents

List of abbreviations

CCS	CO_2 capture and storage
EC	European Commission
EPOR	Empirical Programme of Relativism
ETP	European Technology Platform
EU	European Union
IEA	International Energy Agency
IPCC	UN's Intergovernmental Panel on Climate Change
NGO	Non-governmental organization
OECD	Organisation for Economic Co-operation and Development
SCOT	Social construction of technology
STS	Science and Technology Studies
UN	United Nations
US	United States
ZEP	Zero Emissions Platform

List of articles

Article 1

Gjefsen, Mads Dahl. 2013. "Carbon Cultures: Technology Planning for Energy and Climate in the US and EU," *Science & Technology Studies* 26(3).

Article 2

Gjefsen, Mads Dahl. 2013. "Limits to prediction: Europeanizing technology in an expert forum," *European Journal of Futures Research* 1(1).

Article 3

Gjefsen, Mads Dahl. "Creating the Expert-Advocate: Building Community for an Emerging Technology," in review.

Motivation and objective

My motivation for writing this thesis is an interest in the capacities of technological cultures to systematically respond to crises on the scale at which these crises are seen to unfold. The crisis is here represented by anthropocentric climate change, a problem that in its authoritative description by contemporary scientists shows that our current way of life is unsustainable. The systematic response is represented by the concerted efforts that are deemed necessary to develop and deploy technologies for CO_2 capture and storage, CCS, a technology that advocates argue could address climate change in two interlinked ways: by contributing to making necessary reductions in greenhouse gas emissions, and by doing so with only minimal disruption to our present reliance on cheap and abundant fossil fuels. The development and performance of CCS is thought to rely on interactions between technological systems and systems of governance. For this reason CCS has been said to depend not only on technological development, but also on Social Science![1]

CCS has gained significant political attention around the world in recent years. Since the turn of the millennium many of the world's countries have devoted resources and established support mechanisms for its development. How can we understand this trend? In order to explain what happens as part of CCS advocacy I draw on analytical resources from Science and Technology Studies (STS), a field of research investigating interactions and co-dependencies between the technical and the social.

To carry out my study I break down the general theme of CCS advocacy into three dimensions: representations, organizations and communities. I begin by investigating representations of *CCS as a public good* – that is, what societal purpose is CCS proclaimed to serve, and does this purpose also tell us something about ambitions for society? I go on to study the design and outputs from organizations of *CCS supporters*, and the cohesion of communities of *CCS experts*. These three dimensions signify different focus-points for activity and change, echoing Jasanoff's description

[1] de Coninck, H., "Successful CCS relies upon social science," *Climate Policy* 13(4) (2013).

of "instruments of co-production" as alternative entry-points to studying sociotechnical dynamics.[2]

I have modified the classification of these instruments and combined them in a single study both to gain a better understanding of what takes place in CCS advocacy, and to propose new ways forward for STS research on technological change. My multi-dimensional approach contributes to emerging research on social planning for energy transitions[3] by charting recurring features and dynamics that occur at different facets of technology advocacy. A central aim is to understand how tenable transition movements actually are. To unpack the overarching process shorthandedly referred to as technological change–or, more accurately in this case, the advocacy for such change–the thesis takes rising support for CCS as its point of departure, and asks:

How is support for CCS reflected in the formation of representational practices, new organizations, and expert communities?

The research question is premised on existing literature that describes the emergence of CCS as an object of support for policymakers, industry actors and non-governmental organizations in a relatively short span of time. It also complements this literature, by asking what, specifically, is taking place in different dimensions of such support. In the context of representations, what are the justifications for CCS? In the context of new organizations, what are the outputs of advocacy activity? And in the context of communities, how do CCS experts establish themselves as a group, and what resources and barriers influence in this process? These topics are addressed through three thesis articles. The overarching research question, which is the topic of this introductory chapter, lets us examine how recurring trends across these dimensions relate to features of the technical-social system CCS represents.

The multi-focused approach corresponds with the range of topics CCS advocates themselves consider relevant, and with the diverging levels of issues given attention

[2] Jasanoff, S., ed., *States of knowledge: the co-production of science and social order* (New York: Routledge, 2004). Jasanoff operates with the instruments of identities, institutions, representations and discourses.
[3] Miller, C.A., and J. Richter, "Social Planning for Energy Transitions," *Current Sustainable/Renewable Energy Reports* 1(3) (2014).

by the CCS community itself. In terms of research design, the multi-focused approach opens up for some divergent examinations, but also helps reveal important consistencies that shed light generalizable aspects of emerging technology support.

The research question is broken down to three sub-questions that focus on each of the three dimensions of representations, organizations and communities. Before presenting the sub-questions, two important decisions should be justified: the decision to focus on CCS, and the decision to focus primarily on support.

Why CCS? On the one hand CCS is only one of several climate change mitigation technologies currently in development. What sets the technology apart from renewable energy technologies, and from the range of more or less radical measures currently in development under the heading of geoengineering, is the arguable potential of CCS for reconciling aims of climate change mitigation with dominant energy regimes built around fossil fuels. Its compatibility with the same fossil fuel regime that has been identified as a primary culprit of global warming, is what distinguishes CCS from other technologies that jointly address the energy/environment nexus. Other examples, such as nuclear or renewable energy, both imply a replacement for or departure from fossil fuels. CCS has the potential to address two radically different framings of what the problem of climate change fundamental consists of: the threats it poses to nature on one hand, and the threats that it poses to our current ways of life on the other. The interpretative flexibilities that are afforded to CCS advocates by the arguable validity of each of these two claims, as well as the tensions between them, are at the heart of this thesis.

Why focus almost solely on advocacy? It is true that CCS is far from uncontroversial, and that many have contested its potential benefits, as they are described above. Many of the protests and arguments launched against CCS, both on the level of individual project plans and on the level of principled disagreements about the merits of CCS as a climate change mitigation option, might suggest that the obvious way to study CCS from an STS perspective is to study controversies–an established and productive approach within the STS-tradition. Reactions and mobilizations against CCS do have a place in each of the three articles presented in this thesis, especially insofar as

expectations of public fears and resistance affect the activities of CCS supporters, but the thesis is not a controversy study. Several studies dedicated to the controversies around CCS already exist. At the same time, little research has been done specifically on the internal tensions and contradictions between the overarching aims of those that join forces to promote the technology, and on how these tensions are managed within different dimensions of technological change.

In what follows I briefly introduce the focus of this thesis. I then present my sub questions and explain why they were selected, before positioning the thesis in relation to relevant literature. I go on to describe the research design and methodology of the project as it developed over time, and the key findings of the three articles that make up the thesis. The aim of this introductory chapter is not only to present the content of and relationship between the three submitted articles, however, but also to use their findings to make new contributions both to the STS literature and to Social Science research on CCS. In the synthesis I respond to the research question by discussing consistencies in the dynamics surrounding CCS support in the three dimensions studied, as identified in the thesis articles. This synthesis helps explain what happens as heterogeneous groups of actors envision technological futures. The main conclusion is that the study of shared envisioning of technological futures requires analytical tools that can account for discords in the timescales and envisioned pathways for future developments, against which actors' motivations and senses of urgency are formulated. To those ends, suggestions are made for topics and directions for future research.

Some elements of CCS advocacy

Before presenting the sub-questions of this thesis project, it is useful to briefly present some key features of CCS support as a research topic. This section explains what CCS is and provides some commonly accepted reasons for why certain groups advocate for the technology as a climate change mitigation option. The section also briefly introduces some of the factors that actors in the CCS community tend to present as crucial to the fate of the technology, in order to explain the choice of a cross-dimensional approach to the study of CCS support.

The UN's Intergovernmental Panel on Climate Change (IPCC) defines CCS as "a process consisting of the separation of CO_2 from industrial and energy-related sources, transport to a storage location and long-term isolation from the atmosphere."[4] It is not one single technology, then, and references to CCS in a singular form simply follow a convenient convention. Instead CCS is a set of technologies that could potentially contribute to climate change mitigation, by preventing CO_2 emissions from large stationary sources such as coal-fired power plants from contributing to human-induced climate change by injecting it into the ground for permanent storage, rather than releasing it into the atmosphere.

It is not entirely precise to refer to CCS as an emerging technology, although it is frequently described as such. CCS actually consists of a number of tried and tested technologies and processes, many of which have been in use for decades. When applied to CCS, the term *emerging* is not generally meant to imply that the technology is experimental, but rather to the fact that CCS currently does not exist on the scale and with the distribution that is seen as necessary for it to have a sufficient positive limiting effect on greenhouse gas emissions. In this sense of the word, the characterization of CCS as emerging *is* appropriate.

A 2014 status report on the global development of CCS puts the number of large-scale CCS projects in operation or under construction at 22 worldwide, with a combined capacity to capture 40 megatonnes of CO_2 per year.[5] The International Energy Agency (IEA), an OECD framework organization, have previously stated that this annual capture rate must increase to the range of thousands of megatonnes by 2050 in order to contribute to meeting the UN's goal of limiting the global temperature rise to 2 °C above pre-industrial levels.[6] Advocates of the technology often comment that the advancements towards goals for CCS is slow, and, as discussed in ARTICLE 3, attribute an apparently slow speed of development to a

[4] Intergovernmental Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage* (Cambridge: Cambridge University Press, 2005), 3.
[5] Global CCS Institute, *The Global Status of CCS: 2014* (Melbourne: The Global CCS Institute, 2014), 10.
[6] International Energy Agency, *Technology Roadmap: Carbon Capture and Storage. 2013 edition* (Paris: International Energy Agency, 2013), 22.

number of challenges variously defined as rooted in technical, political, commercial, or social reasons, or to some combination of these and other factors.

CCS advocates include unlikely alliances between actor groups who are often at odds with each other in other areas of climate change discourse. These groups include governments seeking to reconcile climate change mitigation policies with affordable energy production and fossil fuel extraction; fossil fuel-based industry actors seeking to continue present-day activities in the face of possible future political measures designed to restrict and/or penalize the emission of CO_2; environmental organizations who see CCS as a way of mitigating the negative climate effects of CO_2 emissions from fossil fuels; and researchers who work on different technical aspects of CCS and who might to different degrees affiliate or sympathise with aforementioned actor groups. These characterizations are somewhat crude, but illustrate the central justification for this thesis' focus on CCS *support*: The technology is considered by many of its supporters as uniquely reconcilable with two courses of action that are often thought of as being in conflict: ambitious action on climate change in the form of CO_2 emissions reductions on the one hand, and the continued use of fossil fuels as an energy source on the other.

CCS support warrants a multi-dimensional approach because it takes place in a variety of societal contexts. Some vignettes from an email list[7] serving the global CCS community illustrate the diversity of topics and domains of interest to CCS supporters. One bulletin cites financial news magazine Forbes: "As Obama Unveils New Regs, Coal Could Be Resurrected If Carbon Could Be Buried".[8] Days later the same email list quotes Australian news website Business Spectator as writing that Norway's outgoing government have dropped its plans "for a costly large-scale project to capture carbon dioxide that it once compared in ambition to sending people to the moon."[9] Later, from the Financial Times: "In 2008, the EU was the world

[7] "Daily News Clips," CSLF, last modified December 5, 2014, http://www.cslforum.org/pressroom/newsclips.html.
[8] "As Obama Unveils New Regs, Coal Could Be Resurrected If Carbon Could Be Buried," Forbes, last modified September 20, 2013, http://www.forbes.com/sites/kensilverstein/2013/09/20/coal-could-be-resurrected-if-carbon-could-be-buried/.
[9] "Norway abandons carbon capture plans," Business Spectator, last modified September 23, 2013, http://www.businessspectator.com.au/news/2013/9/23/policy-politics/norway-abandons-carbon-capture-plans.

leader in championing CCS. However, due to the economic crisis and low carbon price as part of the EU emission trading system, which currently does not provide the needed incentives to investors, CCS has not arrived at the scale and pace needed."[10] Finally, a headline from a small local newspaper in South Carolina: "Residents Weigh Global Benefits And Local Risks In Views of Climate Change Measures."[11]

These media statements offer just a small glimpse of the range of explanations and associations invoked to make CCS understandable to its supporters. The US administration's new regulations for coal-fired power plants, the metaphor of a moon landing characterizing a Norwegian government CCS initiative, the policy design underlying the EU's greenhouse gas emission trading system, and local residents weighing global benefits versus community risks, all appear to have some bearing on what is happening in the area of CCS. The ambitions for CCS seem to run up against not only technical challenges, but also against challenges in the social realm, such as legislative frameworks and public receptiveness to the technology. The examples illustrate how CCS support offers a rich starting point for a study of how technological change–and the expectations and hopes for such change–both influences and is influenced by social organization, institutional design, and the metaphors and narratives which we use to describe the problems that technologies are designed to address.

The relevancy of CCS support as an object of study lies in the technology's potential for addressing concerns that are often seen as mutually exclusive. The choice of a multi-dimensional approach to this topic of study reflects the range of levels that CCS advocates themselves deem interesting, as illustrated by the above media reports.

Research questions

While the previous section presented CCS support as a research topic, the formulation of research questions should also be justified with reference to concerns in the literature. The following section therefore presents sub-questions that will help

[10] "EU lags behind on carbon capture," Financial Times, last modified October 24, 2013, http://www.ft.com/intl/cms/s/0/43c0c48c-3b26-11e3-a7ec-00144feab7de.html.
[11] "Residents Weigh Global Benefits And Local Risks In Views of Climate Change Measures," Herald Online, last modified October 31, 2013, http://www.heraldonline.com/2013/10/31/5358978/residents-weigh-global-benefits.html.

address the thesis' overarching research question, and explain how they might contribute to established topics of research in STS.

An underlying assumption in this thesis is that CCS can be understood as having social (encompassing both political and symbolic) qualities, alongside material and technical ones. This assumption is grounded in an STS traditions for examining technologies as simultaneously embedded in and disruptive of societal structures, and for attempting to understand the features of *technological cultures*.[12] The overarching research question (*How is support for CCS reflected in the formation of representational practices, new organizations, and expert communities?*) is formulated as a starting point for de-naturalizing CCS and to move past a material, functional and unidirectional understanding of the purpose or set of purposes of a given technology. The aim is instead to identify arenas where understandings of technological purpose are negotiated, and to then explore the conditions and consequences of these negotiations. This attempt is reflected in the three sub-questions. Each question directs particular attention to one of the three aforementioned dimensions of representations, organizations and communities, but all three dimensions are also present within in each thesis article.

The first sub-question focuses on representations in international politics, where concerted and meaningful action on climate change might be expected to occur:

1: *How is CCS presented as a desirable public good within different political contexts?*

The question sets the stage for an investigation of CCS support from within the cross-national comparative tradition in STS. This tradition studies science and technology in society by identifying and contrasting how different national-level norms, institutions, and governance traditions affect the trajectories of knowledge and artefacts.[13] It allows us to explore whether CCS support is "the same" in different

[12] Bijker, W. E., "How is technology made?—That is the question!," *Cambridge Journal of Economics* 34(1) (2010).
[13] Jasanoff, S., *Designs on Nature: Science and Democracy in Europe and the United States* (Princeton: Princeton University Press, 2005).

countries, an investigation that in turn provides a basis for explaining the mechanisms and consequences of cross-national differences.

The question is addressed in ARTICLE 1, whose dimensional focus is on representations of CCS as a public good. The article compares political pursuits of CCS in the US and EU. The focus on federal entities in this article seeks to relate the rise of CCS to literature examining the role of science and technology in state making.[14] The article finds that CCS has become enrolled in site-specific polity-building efforts, in that its qualities have been emphasized as offering a technological alternative to the Kyoto Protocol's regulation-based approach to climate change mitigation in the case of the US, and as part of a project of Europeanization in the EU.

Question 2 focuses on organizational aspects of CCS expertise:

2: *How do expert organizations anticipate and address public concerns about CCS?*

This question is answered by drawing on the STS tradition for examining expert institutions that navigate boundaries between the technical and non-technical, as well as on literature that raises questions about the relationships between epistemic authority and representational legitimacy.[15] The literature on expertise and on the organizational frameworks in which experts operate, seeks to understand, amongst other things, the role of experts in articulating public meanings and the ways in which expert judgments are given legitimacy.

The question is addressed in ARTICLE 2, whose dimensional focus is on the organization of CCS supporters. ARTICLE 2 examines an institutional manifestation of the EU's increased interest in CCS: a semi-autonomous advisory body where experts from various stakeholder groups are charged with delivering recommendations and input about research and development priorities to the European Commission (EC). Its formal mandate is to advise the Commission on how to stimulate CCS

[14] Jasanoff, S. and S.H. Kim, "Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea," *Minerva* 47(2) (2009).
[15] Guston, D.H., "Boundary organizations in environmental policy and science: An introduction," *Science, Technology, & Human Values* 26(4) (2001: 399-408.

development efforts. However, the organization has also increasingly made a more public role for itself, and sought to portray CCS as an important technology for Europe. The article draws on the topic of boundary management, and explores how actors distinguish between the technical and non-technical in the production of outputs, particularly communication materials. The article uses the EUs pursuit of CCS as a basis for assessing the Commission's own stated ambitions for transparency, representation and legitimacy in expert institutions–ambitions that have been the subject of both research and policy change in recent years.[16]

The third sub-question is rooted in a view of CCS visions as visions of technical-social systems that carry implications for the technical and societal order, hereunder distributions of legitimacy, agency and resources. It directs attention towards how these orders affect the establishment of expert communities:

3: *How does the CCS technical-social system affect the formation of expert communities?*

Where sub-question 2 focused on the outputs of expert activity, sub-question 3 directs our attention to the internal self-management of expert communities. The question responds to literature on institutions, practices and governance mechanisms that embed technologies in expansive social systems.[17] It is formulated in such a way as to engage in a dialogue between STS perspectives on the cohesion of expert communities, and literature from related fields–in particular the field of International

[16] Sundqvist, G., and M. Elam, "Public involvement designed to circumvent public concern? The 'participatory turn' in European nuclear activities," *Risk Hazards & Crisis in Public Policy* 1(4) (2010), European Commission, *EC 2001 COM 428 European Governance: A white paper* (Brussels: European Commission, 2001), European Commission, *EC 2002. Communication from the Commission on the Collection and Use of Expertise by the Commission: Principles and Guidelines* (Brussels: European Commission, 2002), Felt, U., B. Wynne, M. Callon, M. Gonçalves, S. Jasanoff, M. Jepsen, P.B. Joly, Z. Konopasek, S. May, C. Neubauer, A. Rip, K. Siune, A. Stirling, and M. Tallacchini, *Taking European Knowledge Society Seriously. Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate General for Research, European Commission* (Brussels: European Commission, 2007).

[17] Winner, L., *The Whale and the Reactor: A Search for Limits in an Age of High Technology* (Chicago: University of Chicago Press, 1988). Wynne, B., "Unruly Technology: Practical Rules, Impractical Discourses and Public Understanding," *Social Studies of Science* 18(1) (1988). Hughes, T.P., "The evolution of large technological systems," in *The social construction of technological systems: New directions in the sociology and history of technology,* ed. Bijker, W., Hughes, T.P., and Pinch, T. (Cambridge: MIT Press, 1989).

Relations–that have produced separate analytical tools to understand the role of experts as actors in policy processes.

The question is addressed in ARTICLE 3, whose dimensional focus is on communities of CCS experts, and whose investigation is centred on the emergence of new forms of non-university professional training on CCS. The article explains how different ambitions and goals for CCS as well as their resources of different actor groups, influences the design of venues for professionalization. Approaching CCS as a technical-social system helps the article identify the range of interpretations sustained by this yet unrealized technology. Interpretative flexibility permits unlikely actor-coalitions to pool material and symbolic resources towards a shared technology advocacy project.[18]

While all of these questions speak to on-going research programmes in STS, they also invite dialogue with other Social Science fields predating the systematic study of science and technology in society. Question 1 opens up for incorporating insights from comparative politics, law and communication. Communication is also relevant for question 2, along with the field of Futures Studies, which shares STS' interest in expert/lay interactions in technology assessment and planning. Question 3 is, as mentioned, explicitly related to literature from International Relations on the role of expert communities in policy processes. Insights from these fields are thus important for the thesis as a whole, although the core literature remains firmly rooted in an STS tradition.

Charting the limits of flexibility

The three sub-questions address the dimensions of representations, organizations and communities by looking at the justifications, outputs and expert groups that populate the CCS advocacy arena. Responses to these questions are found in the individual thesis articles, which set the stage for a meaningful, if not comprehensive, inquiry into the manifestations of "CCS support" that take place across different registers of the sociotechnical.

[18] Pinch, T. J. and W.E. Bijker, "The Social Construction of Facts and Artifacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other," *Social Studies of Science* 14(3) (1984).

The synthesis section at the end of this chapter tries to connect the three lines of inquiry to address the main research question. CCS advocacy is characterized by both tensions and interdependencies. Heterogeneous actor alliances permit flexibility in the foregrounding of different sources of legitimacy, depending on the context. CCS advocacy coalitions are able marshal a range of material and symbolic resources in their advocacy efforts. This is evident both in the justifications and outputs used in communication activities, as well as in the very establishment of expert communities.

This study of CCS advocacy raises some new and important questions. Constituencies from different social groups might co-dependently ally around technology advocacy, but disagree about the timescales, objectives and desired closure mechanisms for technological trajectories. Such discords affect the prospects for actor alliances where some actors prefer sustained interpretative flexibility to progress towards closure. Differences in the timescales by which actors formulate their goals and interests, as well as the factors which limit the flexibilities that allow actor coalitions to sustain themselves in spite of these differences, could make important contributions to on-going research on societal transitions towards new energy futures.

Theoretical framework: CCS across dimensions

This section presents key concepts and introduces the literature to which this thesis seeks to contribute.

The first half of this section explains the thesis' analytic contributions both to research on the co-production of natural and social order, and to the growing literature on the technological visions in energy transitions. The thesis as a whole revolves around the three dimensions of representations, organizations and expert communities. These dimensions are an adaptation of what Jasanoff calls *instruments of co-production*, such as identities, institutions and discourses.[19] Such instruments are important areas of focus in STS research concerned with how the social and technical interacts to define a given research topic, but the relationships between them have not previously received systematic attention. I therefore study how interpretative flexibility both constrains and facilitates CCS advocacy across distinct dimensions of activity. The thesis identifies consistencies across these dimensions in order to formulate a contribution to the energy transitions literature. Specifically I emphasise the importance of understanding what resources actors use to influence such envisioning processes, the inequalities in how resources are distributed, as well as the strategic considerations concerning how they are used. These factors are important to the dynamics between actors allied around technological visions.

The second half of the theoretical framework section classifies three particularly relevant bodies of Social Science literature on CCS, namely the literature on CCS as an object of politics, a social object, and an object of expertise. I show that there are important connections to be made between these three strands, particularly when it comes to how amenable the technology is to being portrayed as a public good in political debate and in public communication materials, as well as in contexts of policy narrative rehearsals and identity-building within the CCS community itself.

Technology as social fabric

Implicit in the formulation of this thesis' research question, is the notion that CCS can be understood as a social and political object as well as a technical one. Instead of

[19] Jasanoff, *States of knowledge*, 39-43.

seeing CCS as a having serving a unidirectional purpose in relation to a given problem or set of problems, I approach CCS advocacy as signifying heterogeneous assemblages of materials, practices, institutional changes and representational forms that carries different meanings depending on who you ask, and on where and when you look. This view of technology support takes inspiration from several more or less distinct strands of literature within the field of STS, and adds to these strands by relating them to different facets of a particular technology's rise to prominence in international climate change mitigation.

Winner influentially asserted that "technical things have political qualities" by "embody[ing] specific forms of power and authority."[20] In his view, "inherently political technologies"[21] facilitate or sustain certain political relationships. They are distinct from technologies that are political by virtue of their arrangements, of which Winner's famous–if criticized[22]–discussion of low-hanging New York overpasses constructed to cement social divisions is one example. Emphasizing technological systems as not only political, but also as structuring social action, Wynne proposed the term *technical-social systems*, to focus analytical attention on the localized practices and departures from rule-bound behaviour that evolve alongside ways of operating technologies in given settings.[23] Along similar lines, Hughes' wrote of *large technological systems*,[24] as complex networks comprised of infrastructural and material features working together as meaningful wholes. More recently, Mitchell has sought to connect our understanding of the kinds of technical and material systems described by Winner, Wynne and Hughes, to the study of change and stability in geopolitical inequality, by showing how some technological systems and practices, and the distribution of the natural resources they utilize, facilitate regimes of power and control.[25] To this list I will also add regimes of symbolism through the rehearsal of narratives and establishment of linkages between technology and identity markers, particularly as shown on the state level in ARTICLE 1.

[20] Winner, L., "Do Artifacts Have Politics?," *Daedalus* 109(1) (1980): 121.
[21] Winner, "Do Artifacts Have Politics?," 128-134.
[22] Joerges, B., "Do Politics Have Artefacts?," *Social Studies of Science* 29(3) (1999).
[23] Wynne, "Unruly Technology."
[24] Hughes, "The Evolution of Large Technological Systems."
[25] Mitchell, T., *Carbon democracy: Political power in the age of oil* (London and New York: Verso Books, 2011), see also Mitchell, T., "Carbon democracy," *Economy and Society* 38(3) (2009).

Flexibilities and boundaries

Beyond the immediate material system of the CCS chain of techniques and processes, CCS could have far-reaching consequences for the organization of those industries and energy generation activities to which it is immediately applicable,[26] as well as for the societal structures and ways of life that are sustained by those activities. Its potential reconcilability with the continuation of currently dominant regimes of energy production, also means that CCS could facilitate certain forms of power and influence that are at work in the world today–forces to which aggressive climate change mitigation efforts penalizing those who emit CO_2 to the atmosphere pose a serious threat. The actors who support the technology do so for different reasons. Interpretative flexibility, boundary objects, and boundary organizations, are therefore helpful concepts in understanding contrasts and alignments in how actors mobilize around technological change.

The term interpretative flexibility lacks a consistent definition in the literature. Collins, writing from the perspective of the Empirical Programme of Relativism (EPOR), sees interpretative flexibility as what permits ambiguities and contrasting interpretations of observations in contexts of knowledge-production and controversies.[27] Later, drawing both on EPOR and on the strong programme proposed by Bloor,[28] Pinch and Bijker used the term interpretative flexibility to designate differences in how different actors, what they called relevant social groups, interpreted and made use of the same technologies within the social construction of technology (SCOT) framework.[29] Both of these uses consider interpretative flexibility as a temporary state, gradually diminished over time through reducing ambiguity and moving towards closure and material stabilization.

Winner has criticized Pinch and Bijker for focusing only on social groups that affect the trajectories of technologies, without considering broader societal implications, or

[26] MIT, *The Future of Coal: Options for a Carbon Constrained World* (Cambridge: MIT, 2007).
[27] Collins, H. M., "Introduction: Stages in the empirical programme of relativism," *Social studies of science* 11(1) (1981).
[28] See Bloor, D., *Knowledge and Social Imagery* (Chicago: University of Chicago Press, 1991 [1976]). Here, the symmetrical, sociologically based explanations of truth claims (explanations of scientific knowledge-production that do not accept validity as an independent explanation for why certain beliefs gain acceptance), was promoted as a central element in a programme for studying the production of scientific knowledge.
[29] Pinch and Bijker, "The Social Construction of Facts and Artifacts," 414.

groups who are affected by, but does not influence, technological change.[30] While this thesis does study possible adverse effects on affected groups in and of itself, it does examine how CCS proponents themselves perceive and respond to societal implications insofar as they seek to manage public fears and resistance. Perceptions about publics as barriers to CCS loom in the background in much of the activities and grey literature published by the CCS community. CCS supporters often interpret public scepticism towards the technology as expressions of misguided fears. This thesis recognizes that scepticism towards CCS is not simply an expression of fears about the technology's safety, but can also be a response to the *sociotechnical assemblages*[31] it is thought to imply.[32]

More recent literature has sought to clarify different uses of the interpretative flexibility concept. Doherty and colleagues argue that there is a gap in the literature when it comes to understanding the constraints posed on interpretative flexibility by technical characteristics, and that one-sided emphasis has been put on how human agents shape technical artefacts. They respond by distinguishing between the initial interpretations of the adaptability of a system's functionality, and later stages of activities that reinforce these initial interpretations.[33] To their emphasis on material constraints, this thesis adds the constraints of societal institutions, such as policy and regulatory frameworks, without which technological systems such as CCS have little meaning to its proponents. The remainder of the thesis talks of the pursuit of CCS not simply as the pursuit of a material technology, but also as the pursuit of technical-social systems in which such technologies might operate.

Another attempt at clarifying the interpretative flexibility concept is made by Meyer and Schulz-Schaeffer. They argue that the term is most useful in situations of contestation, of which they identify three different forms: contestations around *truth*

[30] Winner, L., "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology, & Human Values* 18(3) (1983): 368-370.
[31] Bijker, "How is technology made?"
[32] For this point, see also Corry, O. and H. Riesch, "Beyond 'for or against' environmental NGO-evaluations of CCS as a climate change solution," in *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar (London: Routledge, 2012).
[33] Doherty, N.F., C.R. Coombs, and J. Loan-Clarke, "A re-conceptualization of the interpretive flexibility of information technologies: redressing the balance between the social and the technical," *European Journal of Information Systems* 15(6) (2006).

(EPOR/Collins), contestations about *utility* (SCOT/Pinch and Bijker), and contestations about *relevance*.[34] The latter category is their innovation. It describes situations of disagreement about which alternatives to pursue in contexts of scientific research or technological development, when the consequences of different courses of action remain unclear, and the criteria for assessing them are themselves contested.

This three-fold distinction of interpretative flexibility has not gained much attention in the literature but is highly relevant for the focus of this thesis. The question of relevance in the face of uncertainty is germane to the case of CCS support, where some of the most common disagreements around whether or not to develop the technology revolve around possible undesirable consequences and lock-in effects, of which the diversion of funds away from renewable energy developments is one notable example. The question is not simply whether CCS is *useful* but also whether if it is useful for the right set of problems.

When speaking about interpretative flexibility it is relevant to also mention the role of boundaries, not only between science and non-science,[35] but also between the forms of legitimacy and credibility different claims to neutrality might imply. The concepts of *boundary objects*,[36] *boundary organizations*,[37] as well as the related term *stage management*,[38] all seek to capture the malleability of the technical as actors seek to distinguish between the purely descriptive and technical–and therefore uncontroversial–and the normative, subjective and non-technical–which might need other forms of legitimacy–in discussions about technology.

These terms are usually used to explain not only the different views that interpretative flexibility supports. In this thesis, however, they are also used to help us understand the *performative* aspects of interpretative flexibility. The display of support is not

[34] Meyer, U., and I. Schulz-Schaeffer, "Three Forms of Interpretative Flexibility," *Science, Technology & Innovation Studies* 1(1) (2006): 25.
[35] Gieryn, T.F., "Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists," *American Sociological Review* 48(6) (1983).
[36] Star, S.L., and J.R. Griesemer, "Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39," *Social studies of science* 19(3) (1989).
[37] Guston, D.H., "Stabilizing the boundary between US politics and science: The role of the Office of Technology Transfer as a boundary organization," *Social studies of science* 29(1) (1999).: , 87-111.
[38] Hilgartner, S., *Science on Stage: Expert Advice as Public Drama* (Stanford: Stanford University Press, 2000).

necessarily a direct reflection of belief about how to attain a given future. The display might also be an act that carries its own set of meanings and effects in the immediate present.[39] With CCS, the very *display* of support can be seen as a purposeful activity in its own right. The present study therefore shows special attention to advocates' production of outputs and representations that draw boundaries between epistemic and normative motivations for technology support.

Guston uses the term *boundary organization* to refer to institutional formations designed to facilitate interaction between different groups of actors, such as scientists and policymakers, where each group is accountable to their own domain, but where outputs such as evaluations and advice also function as *boundary objects* or *standardized packages*, which each group of actors can use for their own purposes.[40] In this he draws on previous work on the construction and maintenance of a public face for science through partially obscuring certain aspects of scientific practice and highlighting others, such as Hilgartner's study of expert advisory bodies.[41] Such organizations are comprised of different actor groups and address the needs and concerns of different audiences. They are important in fields like Environmental Politics, where complex interdependencies exist between science and decision-making, requiring interaction as well as the integrity of boundaries.

Arguing that the idea of boundary organizations is too grounded in the "hyperdifferentiated" separation between science and politics within US political culture, Miller suggests that *hybrid management* might be a more appropriate term for the broader array of institutional types existing in international contexts. He defines hybrids as "social constructs that contain both scientific and political elements, often sufficiently intertwined to render separation a practical impossibility."[42]

Boundary organizations, or hybrid forums, figure prominently in this thesis, where institutions designed as part of broader political engagement with CCS have come to play important roles as forums for expertise and knowledge sharing, and in

[39] Austin, J.L., *How to do things with words* (Oxford: Oxford university press, 1975 [1955]).
[40] Guston, "Boundary organizations in environmental policy and science."
[41] Hilgartner, *Science on Stage*.
[42] Miller, C., "Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime," *Science, Technology, & Human Values* 26(4) (2001).

legitimating decision making processes both through the advice they offer and through their very existence as a venue for deliberation between different groups of stakeholder groups. While the description of boundary organizations might suggest processes of dubious horse-trading and the compromising of important ideals and principles in science as well as in politics, the existence of such organization should not be a cause for worry, according to Guston: "The politicization of science is undoubtedly a slippery slope. But so is the scientization of politics. The boundary organization does not slide down either slope because it is tethered to both, suspended by the coproduction of mutual interests."[43] While the apparent efficiency of the boundary organization delivering policy ready knowledge in ARTICLE 2 seems to support this optimistic view, processes of exclusion that are also identified there, suggesting that the epistemic authority and representative legitimacy of boundary organizations cannot be accepted out of hand.

Co-production

As the introduction made clear, this thesis is motivated by an interest in how technological cultures respond mobilize and respond to crises. As a unit of analysis "technological cultures" are defined by Bijker[44] as distinct not only from the construction of singular artefacts, but also from the technological systems described by Hughes, and from Wynne's practice-oriented understanding of technical-social systems (which are similar to what Bijker calls sociotechnical ensembles). Technological cultures, Bijker argues, are a distinct unit of study, the analysis of which aims to connect understandings of the technical (including the systems, practices, norms and symbols that emerge around it), with understandings of the social, and analyse the mutual dependency of the two spheres.

Co-production is singled out by Bijker as a key concept with which to understand this unit of analysis. The term, in its authoritative description by Jasanoff,[45] is presented as an idiom, rather than a fully-fledged theory, and as "shorthand for the proposition that the ways in which we know and represent the world (both nature and society) are

[43] Guston, "Boundary organizations in environmental policy and science," 405.
[44] Bijker, "How is technology made?"
[45] Jasanoff, *States of Knowledge*.

inseparable from the ways in which we choose to live in it."[46] This definition sees knowledge and technology as tools for ordering how we know the world while also setting parameters for how we might act on it.

The co-production concept seeks to synthesize different ideas about the relationship between social and knowledge, and of agency and materiality. This synthesis involves a reconciliation of different perceptions of symmetry in STS. The principle of symmetry is most often understood as the emphasis on symmetry in *explanation* in the strong programme of the sociology of scientific knowledge,[47] where both successful and unsuccessful claims to knowledge can and should be explained sociologically. However, the principle of symmetry can also be seen as a principle of understanding *agency*, such as in actor-network theory, where both human and non-human actors are given equal treatment in the mapping of changing relationships,[48] and material objects are full-blown actors in their own right.

Earlier uses of the co-production concept can be seen in Latour's[49] discussion of Shapin and Schaffer's seminal study[50] of the epistemic conflicts between Thomas Hobbes and Robert Boyle in the early years of London's Royal Society. Latour's concern was the notion of modern-ness and the separation it implies between, on the one hand, the ordering of experience derived from the establishment of a scientific method and, on the other, the conceived "barbarian medley"[51] of pre-modern interdependencies between explanation of the world and justification of power. Latour argued that Shapin and Schaffer failed to appreciate the symmetrical and mutually constitutive relationship between power and knowledge, taking "great care to use the expression 'scientific fact' […] as a historical and political invention," but at the same time failed to apply the same contingent understanding to notions of influence, "[using] the words 'power', 'interest' and 'politics' in all innocence."[52] The implication is that STS cannot simply deconstruct the "scientific" or "technical", but

[46] Jasanoff, *States of knowledge*, 2
[47] Bloor, *Knowledge and social imagery*.
[48] Latour, B., *Science in action: How to follow scientists and engineers through society* (Cambridge: Harvard university press, 1987).
[49] Latour, B., *We have never been modern* (Cambridge: Harvard University Press, 1993), 134.
[50] Shapin, S. and S. Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1985).
[51] Latour, *We have never been modern*, 130.
[52] Latour, *We have never been modern*, 25-26.

must at the same time deconstruct "social" factors that lend meaning to different and changing conceptions of the technical or scientific in the first place.

This call for symmetry between approaches to knowledge production and the use of knowledge is what Jasanoff seeks to respond to. She too uses the term co-production with reference to the ways in which advances in the two spheres of science and social order are dependent upon each other. In Jasanoff's account, the object of study is not the process by which science in itself becomes established within a context of predefined social or political conditions, but rather the continually developing, inseparable and evolving relationship between the two spheres.

The research question's emphasis on the dimensions of representations, organizations and expert communities are an adaptation of Jasanoff's description of common "instruments of the co-production of natural and social order," which are key areas of focus for STS research concerned with how the "social" and "technical" interacts. Emphasizing the heuristic qualities of the idea of *co-production* term as an analytical aid, Jasanoff identifies four such ordering instruments where knowledge and social relations are mutually constituted: identities, institutions, representations and discourses.[53] Each of these instruments have served as entry-points for research into how science and technology are bound up with the way we govern our societies, express identities, allocate responsibilities, and distribute benefits and burdens. However, they have served as alternative starting-points for study, and the relationships *between* them have remained unexplored in the literature.

The multi-dimensional approach of this thesis represents a new approach in the co-production literature. The three thesis articles focus on largely distinct dimensions (or instruments of co-production) to explain the dynamics of advocacy for sociotechnical change, but also share the same object of study in CCS support writ large. This approach allows recurring themes to be identified in how CCS advocates operate, and identify important mechanisms that seem to affect the tenability of their advocacy project. As the synthesis chapter explains, there are recurring trends in how the interpretative flexibility of CCS as a yet-unrealized technology affords both benefits

[53] Jasanoff, *States of knowledge*, 39-43

and constraints to its supporters. The thesis describes these parameters with reference to different forms of material and symbolic resources relevant to CCS advocacy activity. Charting the limits of flexibility across dimensions of sociotechnical change around the same objects or processes of study could have important implications for the study of other technological projects as well. The same approach should be applicable to any situation where technological change is seen as relevant to grand societal challenges, such as in areas of health, production and energy. I therefore argue that multi-dimensional approaches would also give important contributions to the study of technology advocacy in other contexts, and particularly important for the growing literature on societal and energy transitions.

Before we get to that, a brief comment should be made about a common critique of the co-productionist approach, namely that the concept draws an artificial distinction between categories even as it seeks to show their interdependence. If the technical and social are inseparable, then why premise a study on their separation? The merits of this critique might depend on the context in which it is raised, and it is not a debate against this thesis seeks to position itself. The framework is selected as a theoretical resource precisely because CCS is so often portrayed as a "technical fix" to the global problem of climate change. It therefore seems productive, as Kleinman writes, to acknowledge that "although the social and technical are integrally related, for analytical purposes it is often profitable to make these distinctions and to examine the hierarchical priority of the social."[54]

Envisioning technological futures

It is CCS *advocacy*, and not CCS in its current material and emerging form, which is the primary topic of this thesis. This research topic calls for analytical perspectives that can help explain the significance of support for an on-going process of envisioning technological futures. The climate change mitigation potential of CCS is usually made legible through scenarios and technology roadmaps, which present visions for stages of technology development and contributions to global mitigation efforts in the upcoming decades, and where CO_2 storage is thought to be stable for

[54] Kleinman, D., *Impure cultures: University biology and the world of commerce* (Madison: University of Wisconsin Press, 2003): 139.

thousands of years. Hansson therefore calls CCS a "colonization of the future."[55] The idiom of co-production lets us explore normative dimensions of technological change, but in examining technology advocacy, this thesis also sets out to identify the *co-productionist implications* of envisioned technological futures.

There is already on-going exchanges in the literature between the field of STS and that of Futures Studies. Frow and Calvert, for instance, argue that STS can give important contributions to "opening up" discussions about the possible futures for emerging technologies,[56] and to help draw attention to normative assumptions and opportunities for agency that technological visions might imply.

One way of tracing the normative underpinnings of technological visions has been attempted through the recent turn towards studying *sociotechnical imaginaries*. Jasanoff and Kim directs attention towards the co-productionist implications of national technological futures in their study of nuclear power as a national public good in the US and South Korea.[57] They define sociotechnical imaginaries as "collectively imagined forms of social life and social order reflected in the design and fulfillment of nation-specific scientific and/or technological projects." They thus see visions or narratives about technological futures as something that is formulated in relation to norms and institutions, and thereby as something that is most clearly expressed at the level of nation-states, where it is thought that such features are pervasively shared, and therefore also amenable to study through comparison.[58] While their definition can be read as implying that perceptions about the "meaning" of technological futures are unanimously shared within nations, their intention is rather to show recurring themes around which deliberation is structured. Deliberation in this context also includes opposition, as shown in their case by how opposition to nuclear power has become structured around contrasting definitions of the state's responsibility to pursue the public good in the two sites studied.

---

[55] Hansson, A., "Colonizing the future" in *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar (London: Routledge, 2012).
[56] Frow, E., and J. Calvert, "Opening up the future (s) of synthetic biology," *Futures* 48 (2013). : 32-43. See also Stirling, A., "'Opening up' and 'closing down': power, participation and pluralism in the social appraisal of technology," *Science, Technology, & Human Values* 33 (2003).
[57] Jasanoff and Kim, "Containing the atom."
[58] Jasanoff, *Designs on nature*.

The term has in a short span of time become closely linked with literature on energy transitions, which is often seen as dependent on the large-scale societal transitions and on the negotiation of resistances in (national-level) norms, institutions and systems of governance.[59] In an article specifically addressing the applicability of the sociotechnical imaginaries concept to the energy transitions literature, Jasanoff and Kim state that such transitions might transform social structures and allocate risks, benefits and burdens differently than before, and that imaginations and articulations of technologies as a public good also influences how public policy adjudicates ownership of risks and benefits.[60]

Miller and Richter have given comprehensive and systematic overview of energy transitions literature where the interdependencies of material, social and symbolic aspects of such transitions are emphasized.[61] They propose the label *social planning for energy transitions* as a new framing for such literature and state that the term incorporates both understanding of and planning for the societal outcomes of energy transitions. Such planning, they argue, should address the four crucial elements of redistribution, reorganization, reauthorization and reimagination. Here, research on sociotechnical imaginaries contributes to the latter element by illuminating how justifications and disputes about energy futures also reflect normative visions for the societies that energy systems and technologies will serve.

Thesis contribution

A recurring theme in this thesis is the idea that CCS visions imply the continuation of certain forms of power and authority due to the reconcilability between CCS and contemporary energy regimes. Thus, sociotechnical imaginaries for CCS imply reauthorizations of forms of power and authority. An important ambition for Social

[59] Levidow, L., and T. Papaioannou, "State imaginaries of the public good: shaping UK innovation priorities for bioenergy," *Environmental Science & Policy* 30 (2013). Bridge, G., S. Bouzarovski, M. Bradshaw, and N. Eyre, "Geographies of energy transition: Space, place and the low-carbon economy," *Energy Policy* 53 (2013). Stirling, A., "Transforming power: Social science and the politics of energy choices," *Energy Research & Social Science* 1 (2014).
[60] Jasanoff, S., and S.H. Kim, "Sociotechnical imaginaries and national energy policies," *Science as Culture* 22(2) (2013). , 189-196.
[61] Miller and Richter "Social Planning for Energy Transitions."

Science research on CCS advocacy should be to make such reauthorization processes explicit and expose them to deliberate debate.

The three articles in this thesis all contribute to this aim. ARTICLE 1 and ARTICLE 2 show that CCS advocacy and visions of CCS futures have emerged in relation to polity-specific needs and concerns. Both articles show that justifications and outputs in CCS advocacy embed the interests of forceful fossil fuel voices into public narratives about what constitutes the public good that CCS is thought to serve. ARTICLE 3 goes one step further by also showing how resources are managed as CCS advocates establish a common community. Resources in this context include material, epistemic, as well as symbolic assets, to which the constituents of CCS advocacy communities have unequal access. The article thus addresses an important topic not discussed by Miller and Richter, namely the distribution of different types of resources actors use in their attempts to influence technological reinvisionings. ARTICLE 3 argues that expert community formation depends on forms of self-management that maximize positive synergies between the forms of material and symbolic resources brought to the table by different constituents of CCS advocacy coalitions.

CCS politics, publics, and experts

Accompanying the rise CCS advocacy in recent years is a growing body of Social Science literature on various societal dimensions of the technology. Symptoms include PhD theses,[62] monographs,[63] edited books,[64] and special issues in research journals.[65] Although it is not the intent here to attempt either to draw or to police the boundaries of academic fields, it is fair to say that only small portion of this research

[62] Hansson, A., "Kolets återkomst: Koldioxidavskiljning och lagring i vetenskap och politik" (PhD diss., Lindköping University, 2008). Tjernshaugen, A., "Fossil interests and environmental institutions: The politics of CO_2 capture and storage" (PhD diss., University of Oslo, 2010).
[63] Mills, R.M., *Capturing Carbon: The New Weapon in the War Against Climate Change* (New York: Columbia University Press, 2011).
[64] Markusson, N., S. Shackley, and B. Evar, eds., *The Social Dynamics of Carbon Capture and Storage: Understanding CCS Representations, Governance and Innovation* (New York: Routledge, 2012). Meadowcroft, J., and O. Langhelle, eds., *Caching the Carbon: The Politics and Policy of Carbon Capture and Storage* (Cheltenham: Edward Elgar Publishing, 1999). Shackley, S. and C. Gough, eds., *Carbon capture and its storage: an integrated assessment* (Hampshire: Ashgate Publishing, 2006).
[65] The journal *Energies* is planning a special issue on CCS for 2015. *Energy & Environment* hosted a special issue on CCS in May 2012, and *Global Environmental Change* ran an issue on CCS politics and policy in May 2011.

is primarily STS research,[66] and that most Social Science literature on the technology falls within related fields such as International Relations, Communication Studies, Innovation Studies, Political Science, Law, and Policy Studies.

A comprehensive review of Social Science literature on CCS would include the literature on innovation and value chains, reviews of the implications of different policy mechanisms for CCS, and literature that in different ways seek to compare and contrast CCS and other climate change mitigation initiatives.

However, the present focus is on identifying key perspectives from the literature most relevant to the multi-dimension approach to CCS advocacy. To those ends, I have identified three partially overlapping strands of Social Science literature that structure the following CCS literature review section. The first of these strands focuses on CCS as an object of political support. The second examines CCS in the context of public attitudes and beliefs. The third treats CCS as an object of expert knowledge. It is important to note that these strands of literature do not map neatly onto the three dimensions of representations, organizations and communities, but that all three strands are instead relevant to the study of every one of these dimensions. The utility of this three-fold classification of the literature is to recognize that the Social Science literature on CCS tends to cluster around some fairly distinct conceptions of what CCS is a case of. Identifying these clusters is a first step towards making new and important connections across the CCS technical-social system.

CCS as a political object

CCS is frequently talked about as a political object in the sense of being part of a portfolio of options that include technologies and policy measures to address climate change. Particularly in economics and policy studies, CCS is presented as a black box whose effects can be measured in quantitative terms–either by the amount of CO_2 emissions it is thought to potentially reduce, or by its expected economic impact–thus

[66] Though for notable exceptions see Hansson, "*Kolets återkomst*," as well as Narita, D., "Managing uncertainties: The making of the IPCC's Special Report on Carbon Dioxide Capture and Storage," *Public Understanding of Science* 21(1) (2010), Markusson, Shackley and Evar, *The Social Dynamics of Carbon Capture and Storage*, as well as Boyd, A.D. and T.B. Paveglio, "Front page or 'buried' beneath the fold? Media coverage of carbon capture and storage," *Public Understanding of Science*, 23(4) (2014).

providing a basis for direct comparison with other climate change mitigation options.[67] This literature, while reductive, provides important information about how policymakers view CCS. For example, it helps support common political arguments about the potential of CCS to provide the necessary technological "wedges" to stabilize the world's CO_2 emissions.[68] The same literature also offers important insights about the convergences between economic and political priorities–such as when fossil fuel interests remain uncompromised by climate change mitigation efforts–thus also showing the extent to which national-level political support for CCS correlates with national interests in fossil fuel reliance in the form of oil and gas production.[69] This literature helps set important parameters for how we might understand CCS as a political object, but rarely concerns itself with questions about the context-dependencies and interpretative flexibilities of CCS.

A complementary body of research that also treats CCS as a political object looks at the specific political tensions and alliances in which the technology has come to play a role. Pollak and colleagues have shown how CCS has become a potential source of collaboration between factions of the traditionally competing energy and climate coalitions in the US.[70] Similar dynamics in Norway has prompted Tjernshaugen and Langhelle to use of the label "political glue" to describe the potential for CCS to underpin unlikely coalitions of actors and interests around technology support, which include environmental organizations.[71] Environmental organizations have not been unequivocal in their support for CCS, however, and some have actively opposed the

[67] See for instance Pacala, S., and Socolow, R., "Stabilization wedges: solving the climate problem for the next 50 years with current technologies," *Science* 305(5686) (2004), and Stern, N. ed., *The economics of climate change: The Stern review* (Cambridge: Cambridge University Press, 2007).
[68] Pacala and Socolow, "Stabilization wedges," International Energy Agency, *Technology Roadmap: Carbon Capture and Storage. 2013 edition*.
[69] Giddens, A., *The politics of climate change* (Cambridge: Polity, 2009), 8, Tjernshaugen, A., "Political commitment to CO_2 capture and storage: evidence from government RD&D budgets," *Mitigation and Adaptation Strategies for Global Change* 13(1) (2008). Torvanger, A., and Meadowcroft, J., "The political economy of technology support: Making decisions about carbon capture and storage and low carbon energy technologies," *Global Environmental Change* 21(2) (2011).
[70] Pollak, M., S.J. Phillips, and S. Vajjhala, "Carbon capture and storage policy in the United States: A new coalition endeavors to change existing policy," *Global Environmental Change* 21(2) (2011).
[71] Tjernshaugen, A. and O. Langhelle, "Technology as political glue: CCS in Norway," in *Caching the carbon: The politics and policy of carbon capture and storage*, eds. Meadowcroft, J.R. and O. Langhelle (Cheltenham: Edward Elgar Publishing, 2009). See also Tjernshaugen, A., "The growth of political support for CO_2 capture and storage in Norway," *Environmental Politics* 20(2) (2011).

technology.[72] Corry and Riesch have suggested that the range of responses from non-governmental organizations (NGOs) to CCS can be understood as rooted in contrasting definitions of the socio-economic arrangements that CCS is thought to imply.[73]

In addition to the variety in which actors rally behind CCS, there is also variety in how the technology is supported politically. Meadowcroft and Langhelle's edited volume on the politics and policy of CCS provides a collection of case studies showing that political support often includes combinations of several measures, including government funding of research and development, the promotion of public-private partnerships, and the establishment of regulatory regimes with predictable liability requirements that can help justify private investments in technology development with uncertain returns.[74]

There are several ways to study a technology that is supported by heterogeneous actor alliances and pursued in part through a range of policy measures. For example, De Coninck and Bäckstrand argue that realist, liberal institutionalist, and constructivist approaches provide very different explanations for the organization of international-level political support for CCS. In characterizing the differences between the three approaches, they emphasize the power of fossil fuel industries and major emitter states, the fragmented nature of current "regime complexes," and the formulation of norms and preferences through new knowledge, respectively.[75] However, they do not attempt to synthesize these interpretations.

[72] Anderson, J., and J. Chiavari, "Understanding and improving NGO position on CCS," *Energy Procedia* 1(1) (2009). See also Greenpeace International, *False hope: Why carbon capture and storage won't save the climate* (Amsterdam: Greenpeace International, 2008).
[73] Corry and Riesch, "Beyond 'for or against'"
[74] Meadowcroft and Langhelle, *Caching the carbon*. See also de Coninck, H., et al., "The acceptability of CO_2 capture and storage (CCS) in Europe: An assessment of the key determining factors: Part 1. Scientific, technical and economic dimensions," *International Journal of Greenhouse Gas Control* 3(3) (2009).
[75] de Coninck, H., and K. Bäckstrand, "An International Relations perspective on the global politics of carbon dioxide capture and storage," *Global Environmental Change* 21(2) (2011). See also Shackley, S., "Introduction to Part II: Governance," in *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar (London: Routledge, 2012).

While the primary concern in much of the above literature is to characterize and explain the dynamics and effectiveness of CCS support in policy contexts, few attempts have been made at connecting political pursuits of CCS with other projects of state making.[76] This thesis therefore tries to connect knowledge about the resources of fossil fuel companies and states, with understandings of the types of symbolism and norms that is established in CCS advocacy and discourse. This is especially the case in ARTICLE 1, which compares how federal-level pursuits of CCS in the US and EU have corresponded with styles of governance, and in ARTICLE 2, which shows the interplay and exchange of resources between different CCS advocacy actor groups within a single organization.

CCS as a social object

Although there are no definite boundaries between literature on CCS as a "political" object and on CCS as a "social" object, the consistent focus in the above literature on actors and activities affecting formal political processes, contrasts with a body of literature chiefly concerned with how lay publics perceive and respond to CCS. In addition to the disagreements between environmental organizations mentioned above, CCS has been at the centre of public controversies about the safety and desirability of individual projects.[77] Literature on CCS as a social object encompasses survey and focus group research, risk-perception research, and case studies of individual projects and controversies, as well as media research.

Survey and focus groups research have found CCS to be a generally unknown and little understood technology compared to other climate change mitigation options and technologies.[78] This largely holds true also when comparing across countries and

[76] But see Stephens, J., "Technology leader, policy laggard: CCS development for climate mitigation in the US political context," in *Caching the carbon: The politics and policy of carbon capture and storage*, eds. Meadowcroft, J.R. and O. Langhelle (Cheltenham: Edward Elgar Publishing, 2009), who suggests that CCS, as a technology-based strategy, is particularly reconcilable with averseness to regulatory approaches to climate change mitigation in the US.

[77] Boyd, A.D., Y. Liu, J.C. Stephens, E.J. Wilson, M. Pollak, T.R. Peterson, E. Einsiedel, and J. Meadowcroft, "Controversy in technology innovation: Contrasting media and expert risk perceptions of the alleged leakage at the Weyburn carbon dioxide storage demonstration project," *International Journal of Greenhouse Gas Control* 14 (2013), Oltra, C., P. Upham, H. Riesch, À, Boso, S. Brunsting, E. Dütschke, and A. Lis, "Public responses to CO_2 storage sites: Lessons from five European cases," *Energy & Environment* 23(2) (2012).:, 227-248, Kuijper, M., "Public acceptance challenges for onshore CO_2 storage in Barendrecht," *Energy Procedia* 4 (2011).

[78] TNS Opinion & Social, *SPECIAL EUROBAROMETER 364 Public Awareness and Acceptance of CO_2 capture and storage* (Brussels: TNS Opinion & Social, 2011), Upham, P., and T. Roberts, "Public

regions,[79] though exceptions might occur in cases where local projects have previously gained public attention.[80] As discussed in ARTICLE 3, the general lack of public awareness has been framed as a key challenge for CCS, both because increased awareness of the importance of CCS for climate change mitigation could increase the demand for political support aimed to promote its development, and because low levels of awareness and understanding have been thought to make publics more susceptible to fears and scepticism about its health and safety implications. Low levels of public awareness are therefore often explicitly mentioned as a threat to CCS implementation,[81] and studies have sought to assess and improve upon the effectiveness of CCS communication efforts.[82]

While some studies assume that publics form normative stances about CCS by assessing its technical potential and risks, Terwel and colleagues have called for efforts to move "beyond judging the specific properties of CCS technology itself" as a source of explanation for how publics make sense of the technology.[83] Similarly, and based on a comprehensive review of research on public perceptions of CCS, Seigo and colleagues warn against expecting that "risk communication can produce acceptance" and that other variables are more important than knowledge.[84] Several

---

perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications," *International Journal of Greenhouse Gas Control* 5(5) (2011), Ha-Duong, M., A. Nadaï, and A.S. Campos, "A survey on the public perception of CCS in France," *International Journal of Greenhouse Gas Control* 3(5) (2009), Curry, T.E., "Public awareness of carbon capture and storage: a survey of attitudes toward climate change mitigation" (PhD diss., Massachusetts Institute of Technology, 2004).

[79] Oltra, C., R. Sala, R. Sola, M. Di Masso, and G. Rowe, "Lay perceptions of carbon capture and storage technology," *International Journal of Greenhouse Gas Control* 4(4) (2010).: 698-706, Itaoka, K., A.M. Dowd, A. Saito, M. Paukovic, M. de Best-Waldhober, and P. Ashworth, "Relating individual perceptions of carbon dioxide to perceptions of CCS: an international comparative study," *Energy Procedia* 37 (2013).

[80] Ashworth, P., E. Einsiedel, R. Howell, S. Brunsting, N. Boughen, A. Boyd, S. Shackley, B. Van Bree, T. Jeanneret, K., Stenner, J., Medlock, L., Mabon, C.F.J., (Ynke) Feenstra, and M. Hekkenberg, "Public preferences to CCS: How does it change across countries?," *Energy Procedia* 37 (2013).

[81] Van Alphen, K., Q. Van Voorst tot Voorst, M.P. Hekkert, and R.E. Smits, "Societal acceptance of carbon capture and storage technologies," *Energy Policy* 35(8) (2007), Bradbury, J.A., "Public understanding of and engagement with CCS," in *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar (London: Routledge, 2012).

[82] L'Orange, S. S., Dohle, L., Diamond, and M. Siegrist, "The effect of figures in CCS communication," *International Journal of Greenhouse Gas Control* 16 (2013).

[83] Terwel, B.W., F. Harinck, N., Ellemers, and D.D. Daamen, "Going beyond the properties of CO_2 capture and storage (CCS) technology: How trust in stakeholders affects public acceptance of CCS," *International Journal of Greenhouse Gas Control* 5(2) (2011): 182.

[84] Seigo, S.L., S. Dohle, and M. Siegrist, "Public perception of carbon capture and storage (CCS): A review," *Renewable and Sustainable Energy Reviews* 38 (2014): 855, 848-863, p. 855.

studies support this claim, having found that publics do not necessarily evaluate the technology in isolation, but that reactions such as support or scepticism is often tied to trust in the government and industry actors promoting the technology,[85] as well as to evaluations of the local impacts of CCS projects in questions such as local job growth and economic prospects.[86] However, self-interest is not a sole and exhaustive explanatory factor either. Survey research has also found CCS support to correlate with such variables as religious beliefs,[87] and worldviews.[88]

Rather than searching for more correlations, this thesis tries to identify underlying structures that influence and reinforce public attitudes in given contexts. Such structures include legal regimes and forms of representation, and require us to make new connections between "attitudes" and their context-specific causes and consequences.

The above literature often contains advice about what communication strategies might promote increased public awareness of, engagement with, and acceptance of, CCS. Much of this advice has informed case studies and been adapted into handbooks, guidelines and best practices commissioned and published by organizations involved in CCS support.[89] The existence of this grey literature suggests that CCS supporters

[85] Gough, C., and S. Mander, "Public perceptions of CO_2 transportation in pipelines," *Energy Policy* 70 (2014), Malone, E.L., J.J. Dooley, and J.A. Bradbury, "Moving from misinformation derived from public attitude surveys on carbon dioxide capture and storage towards realistic stakeholder involvement," *International Journal of Greenhouse Gas Control* 4(2) (2010), Terwel, B.W., F. Harinck, N., Ellemers, and D.D. Daamen, "How organizational motives and communications affect public trust in organizations: The case of carbon dioxide capture and storage," *Journal of Environmental Psychology* 29(2) (2009).
[86] Krause, R.M., S.R. Carley, D.C. Warren, J.A. Rupp, and J.D. Graham, "'Not in (or Under) My Backyard': Geographic proximity and public acceptance of carbon capture and storage facilities," *Risk Analysis* 34(3) (2014), Warren, D.C., S.R. Carley, R.M. Krause, J.A. Rupp, and J.D. Graham, "Predictors of attitudes toward carbon capture and storage using data on world views and CCS-specific attitudes," *Science and Public Policy* 41(6) (2014), Huijts, N., C.J. Midden, and A.L. Meijnders, "Social acceptance of carbon dioxide storage," *Energy policy* 35(5) (2007).
[87] Hope, A.L., and C.R. Jones, "The impact of religious faith on attitudes to environmental issues and Carbon Capture and Storage (CCS) technologies: A mixed methods study," *Technology in Society* 38 (2014).
[88] Mabon, L., S. Vercelli, S., Shackley, J., Anderlucci, N., Battisti, C., Franzese, and K. Boot, "'Tell me what you Think about the Geological Storage of Carbon Dioxide': Towards a Fuller Understanding of Public Perceptions of CCS," *Energy Procedia* 37 (2013).
[89] For a recent overview, see: Ashworth P, A.M. Dowd, S. Rodriguez, T. Jeanneret, L. Mabon, and R. Howell, *Synthesis of CCS social research: Reflections and current state of play in 2013* (Australia: CSIRO, 2013). Some of the most widely used guidelines and reports include: Feenstra, C.F.J., T. Mikunda, and S. Brunsting, *What happened in Barendrecht? Case study on the planned onshore carbon dioxide storage in Barendrecht, the Netherlands* (Petten: ECN and Global CCS Institute, 2010),

consider communication and public support to be important topics, and it seems probable that these publications influence how CCS advocates and project managers approach communication.

However, two related questions, which have not previously been asked in the literature, are how CCS advocates' focus on communication helps establish "low awareness" and "public opposition" as solvable problems, and to what extent CCS advocates' conceptions of publics as an obstacle to the realization of CCS affects the community's organizations, self-management, and agenda-setting. These questions are addressed in ARTICLE 2 and ARTICLE 3. ARTICLE 2 shows how the potential for controversy around CCS was incorporated into the organizational design and inclusion of members of a CCS expert advisory body to the European Commission. ARTICLE 3 shows how the capacity to address publics as an obstacle to CCS development have been sought incorporated into the skill set of CCS professionals. Together, these articles show that the "barrier" of public responses to CCS does not emerge by itself, but is instead actively created and reinforced by the CCS advocacy community.

CCS as an object of expertise

In contrast with the bodies of literature on public receptiveness to CCS, and on CCS as a political object–which are both substantial–the research on the experts implicated in CCS advocacy is comparatively scarce. Very little has been written about issues of self-organization and the dynamics between CCS experts, or about experts' relationship with the interests and world-views of the organizations, governments and industries that support CCS. This is especially surprising given the interesting compositions of actor-alliances that have formed around the technology, which suggest that research on CCS expertise would be a promising starting-point for

---

Wade, S., and S. Greenberg, *Social Site Characterisation: From Concept to Application. A review of relevant social science literature and a toolkit for social site characterisation* (Melbourne: Global CCS Institute, 2011), Ashworth, P., J. Bradbury, C.J.F. Feenstra, S. Greenberg, G. Hund, T. Mikunda, S. Wade, and H. Shaw, *Communication/Engagement tool Kit for CCS Projects* (Australia: CSIRO, 2011), Itaoka, K., A. Saito, M. Paukovic, M. de Best-Waldhober, A.M. Dowd, T. Jeanneret, P. Ashworth, and M. James, *Understanding how individuals perceive carbon dioxide: Implications for acceptance of carbon dioxide capture and storage: Implications for acceptance of carbon dioxide capture and storage* (Australia: CSIRO, 2012), World Resources Institute, *Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects* (Washington DC: WRI, 2010), World Resources Institute, *Guidelines Carbon Dioxide Capture, Transport, and Storage* (Washington DC: WRI, 2008).

investigating the normative implications of the advocacy for technical (and thus also social) change.

Stephens and colleagues is a notable exception.[90] They have investigated who the experts on CCS are, what professional arenas they populate, and where they publish. They find that members of the CCS expert community include members from academia, business, and government, as well as a small but consistent presence of CCS experts affiliated with NGOs. They also find that an emerging CCS community, or possibly separate CCS communities, to hold shared perceptions about the risks *to* and *of* the advancement of CCS in the areas of technical, political, economic, social and environmental risks. They also find the *International Journal of Greenhouse Gas Control Technology*–a peer reviewed journal for "scientific and engineering developments" related to CCS, which also publishes articles on "implementation issues" such as "public awareness/acceptance"[91]–to be an important, shared publication outlet for the community.

Another example of studies examining the expert communities of CCS is Narita,[92] who explores the sanctioning of CCS expert knowledge within the institutional context of the IPCC. Based on interviews and a detailed investigation into the processes that led up to the publication by the IPCC of a Special Report on CCS in 2005,[93] Narita characterizes the task of CCS experts as one of estimating key uncertainties on CCS in ways that were acceptable from criteria of scientific rigor as well as from criteria of policy relevance. Narita's examination illuminates how CCS experts are enrolled in organizational practices that require outputs amenable to scientific as well as political use.

[90] Stephens, J.C., A. Hansson, Y. Liu, H., de Coninck, and S. Vajjhala, "Characterizing the international carbon capture and storage community," *Global Environmental Change* 21(2) (2011), 379-390. See also Stephens, J.C., and Y. Liu, "The evolving international CCS community," in *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar (London: Routledge, 2012).
[91] "Full aims and scope," International Journal of Greenhouse Gas Control, accessed October 30, 2014, http://www.journals.elsevier.com/international-journal-of-greenhouse-gas-control/
[92] Narita, "Managing uncertainties."
[93] Intergovernmental Panel on Climate Change, *IPCC Special Report on Carbon Dioxide Capture and Storage* (Cambridge: Cambridge University Press, 2005).

More typically, literature on CCS as an object of expertise has primarily been concerned with assessing experts' views about the viability and prospects for CCS, as a basis for identifying and quantifying challenges to its broad-scale deployment. Nemet and colleagues use expert elicitations to model the costs of different CCS technologies under given policy scenarios.[94] Davies and colleagues use an opinion survey to show that CCS experts in the US consider fragmented regulation to be one the most significant barriers to the technology's deployment.[95]

Some of this literature has taken experts' claims as a basis for hypothesizing about the relationships between experts' statements and their dependence on alliances, or on securing external support and maintaining a view of the technology as viable. For example, Hansson and Bryngelsson use interviews with CCS experts to explore experts' perceptions about the uncertainties and possibilities of the technology. They find that experts generally share optimistic framings regarding the future of CCS–a finding that the authors suggest might be related to the expert community's dependence on generating outside interest and investment of resources.[96] Evar suggests a similar explanation for his survey and interview findings, which show pervasive optimism about the technology's future, even in the face of acknowledged uncertainties regarding challenges for CCS technology and policy.[97] Hansson speculates (but does not conclude) on whether CCS experts might conduct a certain degree of self-censorship when discussing the uncertainties of CCS in public settings, to avoid sending mixed signals about the potential and reliability of the technology, while being more open about the uncertainties facing CCS in more exclusive settings such as interviews.[98]

The presence of reflections such as these at the tail end or hypothesizing sections of studies based on CCS expert interviews and survey research, points towards the

[94] Nemet, G.F., E. Baker, and K.E. Jenni, "Modeling the future costs of carbon capture using experts' elicited probabilities under policy scenarios," *Energy* 56 (2013).
[95] Davies, L.L., K. Uchitel, and J. Ruple, "Understanding barriers to commercial-scale carbon capture and sequestration in the United States: An empirical assessment," *Energy Policy* 59 (2013), 745-761.
[96] Hansson, A., and M. Bryngelsson, "Expert opinions on carbon dioxide capture and storage—a framing of uncertainties and possibilities," *Energy Policy* 37(6) (2009), 2273-2282, Evar, B., "Conditional inevitability: Expert perceptions of carbon capture and storage uncertainties in the UK context," *Energy Policy* 39(6) (2011).
[97] Evar, "Conditional inevitability."
[98] Hansson, "*Kolets återkomst*," 211-212.

strategic choices of CCS experts as an interesting research topic in its own right. Moreover, there are signs in the literature that CCS experts reflect quite a bit on the societal responsibilities and significance of their activities, perhaps more so than the unidirectional "acceptance" focus in the aforementioned literature on public engagement with CCS might imply. In a recent article, Dowd and James find that CCS experts have a high level of awareness about the limitations to the "Social License to Operate" implicitly posed as the central objective in much of the CCS communication literature.[99] They suggest that these limitations partly follow from the tendency to assume that the public "stakeholders" in CCS are local publics that can be engaged at the level of individual CCS projects, rather than societies at a higher level of abstraction, from whom the acquisition of a "Social License" requires other forms and levels of engagement.

Thesis contribution

The challenges of applying the "Social License" idea to CCS suggests a need for new thinking about the relationships between CCS experts, publics, and sources of public legitimacy for CCS. The current thesis responds to this need and the need for a better understanding of the dynamics of CCS expert communities in ARTICLE 3, by drawing on the aforementioned research by Stephens and colleagues and on literature from International Relations on the role of expertise in policy. The article uses participant observation in CCS training as a basis for exploring on-going efforts at recruiting new members into a growing CCS expert community. It argues that the institutional frameworks and symbolic and material resources marshalled in this process are all important components in sustaining heterogeneous advocacy alliances around the technology.

As a whole, the thesis seeks to gain a better understanding of CCS advocacy by integrating literature about CCS politics, publics and experts, and to draw broadly on these literatures to explain what happens across different dimensions of advocacy activity. The literature on public attitudes, for instance, should not only inform us about what correlations can help us predict acceptance, but can also help us gain a more reflexive understanding of how CCS experts and advocates define public

[99] Dowd, A.M., and M. James, "A Social Licence for Carbon Dioxide Capture and Storage: How Engineers and Managers Describe Community Relations," *Social Epistemology* 28(3-4) (2014).

responses to CCS as a barrier to be solved. How CCS advocates in turn organize themselves and produce communication materials in order to act on and influence this "barrier" is explained in more detail in ARTICLE 2 and ARTICLE 3.

Research design and methods

In this section I explain my choice of methods for addressing the thesis' research questions within the above theoretical framework. I begin by describing the design process before discussing methodological choices and the stages of data collection. I provide further details on methodology in each of the thesis articles.

Design process

Like most STS research this thesis is inductive in scope. It seeks to develop analytic generalizations using a combination of qualitative methods and interpretative strategies. It draws on case study methods such as interviews and archival research, as well as on participant observation. It employs an emergent design, where the stages of the research process are not fixed, but where theoretical sampling, data collection, and analysis have been carried out in an iterative process. This process developed over time,[100] from an initial focus on the discursive framing of new energy technologies and the efficiency of science communication strategies, to a focus on the three dimensions of CCS support that are studied in the thesis' constituent articles.

The design process has been influenced both by the research literature on CCS discussed in the previous section, and by literature about the explanatory ambitions of STS research. As Bowden writes, STS as a field is characterized by a lack of dominating theoretical and methodological assumptions, and by eclectic use of methods for data collection in an "inclusive approach to open up the deficiencies in understanding that flow from the ways that different disciplines collect data."[101] In his view methods in STS are better described as methods of explanation, than as methods of data collection and analysis. A number of methods might be employed to trace the stabilization of facts and artefacts through adherence to a set of analytic principles, such as the aforementioned principle of symmetry. This is echoed in Jasanoff's

[100] The initial project description was entitled "Framing Public Engagement with New Energy Solutions." It was formulated in response to a call for applications to a PhD research fellowship in the area of sustainable energy technologies, where the candidate would receive support from a national centre for sustainable energy studies and a university-wide mobilization around sustainable energy and the environment–both results of strategic efforts at the national and university level respectively to stimulate social science research to the reconciliation of energy production and environmental stewardship.

[101] Bowden, G., "Coming of Age in STS: Some Methodological Musings," in *Handbook of Science and Technology Studies*, ed. Jasanoff, S., G.E. Markle, J.C. Peterson, and T. Pinch (Thousand Oaks: Sage Publications, 1995), 65-66.

description of the utility of the idiom of co-production, which, she writes: "fits most comfortably with the interpretive turn in the social sciences, emphasizing dimensions of meaning, discourse and textuality."[102] It is a common notion that one of the central explanatory potentials of STS lies in "opening up"[103] or "unpacking"[104] the "black boxes"[105] of knowledge-categories and technical devices previously defined only by their outputs, and to reveal the complexities (and politics) within them. Thus, Bowden writes, that although STS research incorporates a broad range of conventional approaches to data collection and analysis, this is not the result of methodological necessity, and might even impose artificial limitations with regards to the kinds of questions and topics STS scholars seek to address.[106] Descriptive richness is also emphasized by Jasanoff, who writes that the "ability to reframe the phenomena of the world in novel ways is what gives co-productionist stories their explanatory power."[107]

Inductive qualitative research is often categorized as belonging to either the positivist or constructivist traditions of grounded theory,[108] where coding and categorization emerge from data collected in an open-ended process. However, the present thesis is instead based on emergent design, which Morgan describes as a process where "research questions and goals change in response to new information and insights," and one where–in contrast with grounded theory–research does not seek to fill a blank slate, but to build on theory-informed assumptions about what constitutes interesting and relevant topics of study.[109] This approach is consistent with what Stebbins refers to as "qualitative-exploratory" research. The aim in qualitative-exploratory research is to construct new ideas and observations about a research topic and to move past what can be deduced from predefined premises. It is the preferred methodological approach

[102] Jasanoff, *States of knowledge*, 4
[103] Frow and Calvert, "Opening up the future(s) of synthetic biology", and Stirling, "'Opening Up' and 'Closing Down'"
[104] Asdal, K. and I. Moser, "Experiments in Context and Contexting," *Science, Technology, & Human Values* 37(4) (2012).
[105] Latour, Science in action, 2, Pinch, T.J., "Opening Black Boxes: Science, Technology and Society," *Social Studies of Science* 22(3) (1992).
[106] Bowden, "Coming of Age in STS," 78.
[107] Jasanoff, *States of knowledge*, 42
[108] Charmaz, K., "Grounded Theory: Objectivist and Constructivist Methods," in *Handbook of Qualitative Research, Second Edition*, ed. Denzin, N.K. and Y.S. Lincoln (Thousand Oaks: Sage Publications, 2000).
[109] Morgan, D.L., "Emergent design," in *The SAGE Encyclopedia of Qualitative Research Methods*, ed. Given, L.M. (Thousand Oaks: Sage Publications, 2008): 246.

in situations where a topic of study has been "largely examined using prediction and control rather than flexibility and open-mindedness."[110] In the case of CCS advocacy, the most illustrative example of this is the limited scope for understanding CCS as "social fabric" offered by literature treating the technology's potential for climate change mitigation and affordable energy production in strictly quantitative terms, as outlined in the previous section.

Methods and data collection

In the present study, initial assumptions about possible topics and research directions were formulated on the basis of the CCS and STS literature discussed in the theoretical framework section above. As that section made clear, there is a vast pre-existing literature on that implicitly treats CCS as an object of politics, an object of public responses, and as an object of expertise. STS literature on the dynamics of technology support and on the far-reaching implications of technologies for societal organization, group formation and forms of representation, also contributed to the identification of openings for new inquiries into the pre-existing CCS literature. In what follows, the choice and operationalization of different methods will be presented as integrated in the iterative research design cycle, which included deliberate choices as well as chance, and which–as a consequence of working towards an article-based thesis format–gradually concentrated the research efforts around three distinct areas of focus, the same areas that are in this introduction referred to as the dimensions of representations, organizations and communities. In the description that follows I explain when and how each of these dimensions were identified as a relevant focus of study over the course of the research process.

Several early observations were derived in part from the academic literature discussed previously, and in part through attendance at CCS and climate change-related conferences and informal conversations with other speakers and attendees. CCS appeared to have the potential to become the focus of public controversies and disagreements between environmental organizations. The technology also stood out in climate change mitigation discourse by potentially reconciling mitigation efforts with current energy regimes. By extension, CCS advocacy appeared to be characterized by

[110] Stebbins, R.A., "Exploratory Research," in *The SAGE Encyclopedia of Qualitative Research Methods*, ed. Given, L.M. (Thousand Oaks: Sage Publications, 2008): 329.

unlikely alliances between environmental organizations and actors from private industry. Finally, there appeared to be uncertainty about the technology's future, but also urgency in the arguments presented by its supporters.

These early observations were explored in semi-structured interviews with representatives from environmental organizations, research, industry and government, as well as through review of reports published by environmental organizations and think tanks operating in Europe and the United States (including The Bellona Foundation, Greenpeace International, and the Natural Resources Defence Council), research organizations such as the World Resources Institute and the Carbon Capture and Sequestration Technologies Program at MIT, and international organizations such as the International Energy Agency and the Global CCS Institute. Close attention was paid to conversations in the CCS community itself throughout the project period, by following email lists maintained by the Global CCS Institute, the Carbon Sequestration Leadership Forum, Carbon Capture Journal, and the National Energy Technology Laboratory in the US Department of Energy. These communication channels were helpful in monitoring concerns relevant to the CCS community, as well as in identifying opportunities for data collection.

Interviews are an established way for researchers to gain understanding of how the actors in a given field perceive their own activities and constraints. In a phenomenological sense, interviews thus offer a starting point for understanding the life worlds of actors in the field of study,[111] and thus also useful for understanding the normative considerations made by actors engaged in technology support. In a practical sense, interviews offer opportunities for gaining access to new informants through snowball sampling, and for calibrating the focus of other methods, such as document research and case study methods, discussed shortly. In consistence with the emergent design of the thesis, a semi-structured interview format was used in order to allow for continual adjustments of what themes were considered relevant topic of inquiry.

[111] Kvale, S., and S. Brinkmann, *Interviews: Learning the craft of qualitative research interviewing* (Thousand Oaks: Sage, 2009), 26-32.

A total of 37 semi-structured interviews were conducted between October of 2011 and November of 2013. The interviews ranged between 30 and 90 minutes in length. 20 interviews took place in person, usually at the interviewee's place of employment, while 17 were conducted via telephone or through videoconferencing. Notes were taken during the course of conversation. Interviews were recorded whenever possible and approved by the informants. In those situations interviews were transcribed shortly afterwards.

All of my informants were interviewed in their professional capacities, falling within Kvale and Brinkmann's categories of "elite" and "expert" interviewees.[112] They were in nearly all cases were highly experienced when it came to speaking to journalists and popular audiences, and often expressed a level of guardedness about the potential for misunderstandings or uncharitable interpretations about certain aspects of CCS support. There was, as Kvale and Brinkmann notes, a tendency for interviewees to try and steer the conversation into prepared "talk tracks" to promote established and well rehearsed standpoints. The interview design sought to counteracted this by attempting to build rapport (such as through promise of anonymity, mentioned below), but it was also often found that interviewees would speak more freely as the conversation progressed, and as questioning revealed that the study did not seek to take sides in debates about CCS.

At the earliest stages of data collection, informants were identified either as authors of documents, reports and publications that were frequently referred to in the CCS literature, or as speakers at the CCS-related professional events mentioned above. However, the project soon transitioned to identifying informants through snowball sampling, as early informants provided advice about colleagues and contacts that were thought able to shed further light on themes explored in conversations. As part of that process, a small number of informants became established as key informants who not only shared contacts and provided introductions to other potential informants, but who also were particularly understanding of the research interests and open to advise on how to pursue different lines of inquiry.

[112] Kvale and Brinkmann, *Interviews*, 147.

To encourage openness, a promise was volunteered to participants of not identifying them by name, and informants are referred to by organizational affiliation only. Approval was also sought for use of individual quotes before these quotes were included in thesis articles. In a small number of cases omissions or minor alterations were requested from interviewees. These were in all cases granted, as they were not judged to affect the analytical content of individual articles.

Interview protocols were adjusted throughout the research process to focus on topics of particular theoretical interest as they emerged. Retrospectively, four distinct phases of interviews can be identified, as explained below and in the APPENDIX: OVERVIEW OF INTERVIEWS. As a consequence of the emergent design process, some interviews were considered relevant for certain articles and not others, while some interviews were ultimately not considered directly relevant to any single thesis article, even if they informed the overall direction of the thesis research. For this reason, different numbers of informants are listed in the methods sections of ARTICLE 1 (23 interviews), ARTICLE 2 (11 interviews), and ARTICLE 3 (11 interviews).

The first phase of interviews took place between October 2011 and January 2012, primarily through videoconferencing. During the course of this interviewing phase the three themes outlined above were re-focused around two areas where particularly interesting boundaries appeared to be drawn between the technical and socio-political aspects of CCS.

Firstly, there appeared to be important differences in how CCS was pursued politically in the US and EU, including differences in the rhetoric, political support mechanisms, and in the types of public reactions to the technology. This topic appeared amenable to treatment drawing on STS literature on the ways in which technologies are presented as a "public good" in different political contexts. This focus would later emerge as one examining the distinct dimension of *representations* in CCS advocacy, when read alongside subsequent articles.

Secondly, a new expert advisory body in the EU, the Zero Emissions Platform (ZEP) appeared to be an important new actor and a reference-point for much of the CCS

activity in the EU. ZEP appeared to be an organization that had epistemic legitimacy as an expert body, but also as an organization that was gradually becoming established as an authoritative public voice in the EU, both within an EU-level public sphere–to the extent that such a sphere can be said to exist–and as a provider of communication materials for use in individual EU member states. ZEP's duality as both an expert body and a public reference-point appeared amenable to treatment by drawing on STS literature on boundary objects and boundary *organizations*–another distinct dimension of CCS advocacy.

The analysis of representations and organizations in CCS advocacy were further explored in a second phase of interviews in Washington D.C. between March and May 2012, and a third phase of interviews in Paris and Brussels between July and October 2012. Over the course of these interviews observations and interpretations were continually calibrated through dialogue with informants. While exploring the ZEP platform it became apparent that two additional categories of data could augment interview research. Firstly, archival material in the form of meeting minutes was publically available through the platform's website, recounting discussions between the platform's constituent members over a period of several years. Secondly, published reports and documents from the platform appeared to provide important insights about the platform's communication vis-à-vis different audience groups. Specifically, these publications appeared to shed light on what the platform chose to emphasize in its communication directed towards policymakers and its communication directed towards broader publics.

As these data sources came to attention, a decision was made to study ZEP using a case study approach. As Yin writes, a case study approach can be useful when seeking understand a phenomenon where the "boundaries between phenomenon and context are not clearly evident."[113] Although case study approaches do have important limitations in that they cannot identify causal relationships, they can, with a clear delineation, provide a basis for analytic generalizations about an appropriately defined phenomenon. Such generalizations were sought by defining ZEP as a case of an expert forum targeting both policymakers and broader publics, and thus as drawing

[113] Yin, R. K., *Case study research: Design and methods, Fourth Edition* (Thousand Oaks: Sage, 2009), 18.

distinctions and boundaries between its epistemic legitimacy as an expert forum, and from its representational legitimacy as an inclusive stakeholder platform.

In the study of ZEP different data sources were combined to understand the same object of study, what the case study literature often refers to as triangulation, or the mapping of convergence and non-convergence between different sources of evidence.[114] The word's geometrical origins suggest that triangulation allows for a combination of methods to be used to reach exact certitude. In the context of interpretative Social Science research, however, it is more accurate to say that triangulation allows for the formulation of gradually more refined hypotheses and interpretations of evidence in an iterative process that also includes collection and analysis of different categories of data.[115]

Concurrent with the second phase of interviews, a third potential object of study was identified in the form of a CCS training event for graduate students and early-career professionals, organized by one of the key informants. The ten-day training event was held in Alabama in June of 2012. It offered an opportunity to learn about CCS technology and visit sites where CCS research was taking place, as well as a chance to meet new potential informants amongst course speakers and attendees. Furthermore, attendance as a participant observer was seen as providing a possible starting point for research on aspects of community-formation amongst CCS experts. Admission to the event was secured in the early spring of 2012. In the time leading up to the participation in the training event, the place of this specific course as well as of university training and other professional gathering venues for the formation of CCS expert communities was gradually integrated in interview protocols, in order to understand the role of shared training venues for the formation of a community around CCS. This focus appeared to supplement the first two already mentioned, by adding the dimension of *communities* to the investigation of different features of CCS advocacy.

[114] Yin, *Case study research*, 117.
[115] Eisenhardt, K.M., "Building theories from case study research," *Academy of management review* 14(4) (1989), 538. , 532-550

Ethnographic methods have an important place in the history of STS as a basis of constructivist studies of knowledge production, where naïve observers seek to understand the significance of experts' activities in given settings using available resources.[116] In the present study, participant observation was used as part of a case study approach, and thus as a data collection strategy for forming and testing hypotheses formulated on the basis of several data categories. In this context, participant observation is closely related to interviewing as method, and involves a level of unstructured interviewing through short, fragmented and informal interactions.[117]

In the study of CCS advocacy, participant observation was seen as a particularly useful method in that it offered an opportunity both to explore earlier interpretations of interview data, and as a way of understanding the behaviour of individuals, social order, and cultural norms, within the community of "CCS experts" – a topic that had already been the subject of a limited amount of scholarly research using other methods.[118] As Hennink and colleagues write, a key advantage–and challenge–of participant observation is that the method challenges the researcher to adopt the social role similar to that of the community under study, while also maintaining analytic distance.[119] The objective was not thick description, but to use participant observation as a calibration mechanism within the context of a case study of CCS training. Participation in the training event in Alabama served several functions. It introduced technical concepts and concerns within the chain of CO_2 capture, transport and storage. It gave insights on the concerns and experiences of individual speakers from the public and private sector concerning the current status and future potential of CCS. The events also gave insights into what motivated younger scholars about to enter career trajectories tied to CCS, and about what motivated event sponsors to support comprehensive "CCS training" in an ad-hoc format only partially connected with institutions of higher education.

---

[116] Latour, B., and S. Woolgar, *Laboratory life: The social construction of scientific facts* (Beverly Hills: Sage, 1979).
[117] Fontana, A. and J.H. Frey, "The Interview: From Structured Questions to Negotiated Text," in *Handbook of Qualitative Research, Second Edition*, ed. Denzin, N.K. and Y.S. Lincoln (Thousand Oaks: Sage Publications, 2000).
[118] Stephens, Hansson, Liu, de Coninck, and Vajjhala, "Characterizing the international carbon capture and storage community."
[119] Hennink, M., I. Hutter, and A. Bailey, *Qualitative research methods* (London: Sage, 2011), 179-185.

Upon the completion of a third phase of interviews in October 2012, a high volume of data had been collected and a number of interpretations formulated that pertained to the aforementioned topics of an US-EU comparison and a study of ZEP. Using explanatory strategies from the STS comparative tradition, observations and interpretations of the material on US-EU comparisons was systematized and developed into a journal article manuscript, which was submitted to *Science & Technology Studies* in January of 2013 (the article was later accepted in October of 2013 after revisions), and is included as ARTICLE 1 in this thesis. Material on ZEP was developed into an article manuscript submitted to the *European Journal of Futures Research* in July of 2013 (the article was accepted in September of 2013 after minor revisions), and is included as ARTICLE 2 of this thesis. Further descriptions of the methodological basis of each paper are provided in the articles themselves.

During the course of developing these two manuscripts, field notes from participant observation at the CCS training event in Alabama were used as a basis for developing tentative observations about the dynamics of community-formation around CCS. Furthermore, over the course of the spring of 2013, new opportunities for attending comparable training and tutorial events were announced through various email lists mentioned above. I applied and gained admission to participate in a web-based tutorial group focused on legal and regulatory aspects of CCS, which took place in July of 2013, as well as to a CCS training event that took place in Western Norway in August 2013. In both cases I participated fully in all aspects of the training events. I maintained field notes about the factors that appeared to motivate early-career professionals to enter the field of CCS, and about the possible advantages the establishment of designated training events might have for organizers and funding organizations.

The possibility of comparing and contrasting different training events as distinct cases was considered but ultimately rejected due to the significant differences in format, duration, purpose and availability of data sources for the different events. A decision was instead made to study CCS training as a single case of non-university CCS training and community building.

Upon the completion of these events field notes were used as a basis for formulating interview protocols for a study focusing solely on the topic of community-formation amongst CCS experts. This research focus was theory-driven, and related to specific intersections between literature in STS and the field of International Relations pertaining to the role of experts in policy. A fourth and final phase of interviews took place with a selection of event organizers and attendees, almost entirely via teleconferencing, between September and November 2013. It focused specifically on the experiences and meanings attached to CCS training.

Interview, participant observation, and document data were organized between November 2013 and July of 2014. In this period a review was also conducted of the academic literature on the CCS expert community, as well as on general frameworks for understanding the role of experts in international policy, particularly in the field of International Relations. On-going conversations in the latter literature about the cohesion of expert communities provided a highly relevant focus for organizing observations about what appeared to influence community formation amongst CCS experts. An article manuscript focusing on how STS perspectives on the case study of CCS training could inform current concerns in International Relations was therefore devised in the summer of 2014 and submitted to *Research Policy* in August of that year.

The research thesis design process described above shows an emphasis on opening up black-boxed conceptions of what CCS "means" to different audiences and in different contexts. The thesis identifies and attempts to explain underlying mechanisms by which such meanings are negotiated. Its explanatory ambitions are to develop new connections between several established bodies of literature, and to use these connections as a basis for explaining empirical observations about three dimensions of CCS advocacy. This provides a richer understanding of what the aims and challenges in CCS advocacy actually are, but also allows us to identify new and important directions that should be pursued in future research. These directions are further explained in the synthesis, to which we will turn after brief summaries of key findings from the three thesis articles.

Findings

The thesis is comprised of three articles that share a common overarching theoretical focus on institutional and social organization around emerging technology and an empirical focus on CCS advocacy. ARTICLE 1 shows how CCS is enrolled in distinct state-building efforts on the international stage. ARTICLE 2 explains the considerations behind the public activities of an expert forum devoted to the technology. ARTICLE 3 argues that efforts to build a professional, expert community around CCS have resulted in the construction of a new kind of expert actor, the *Expert-Advocate*.

When read together in the context of this thesis, the three articles can be seen to respond to each of the sub-questions formulated at the beginning of this chapter.

The articles engage in conversations between STS and fields such as Political Science and Communication (ARTICLE 1), Futures Studies (ARTICLE 2), and International Relations (ARTICLE 3), and actively responds to on-going concerns and problems within each of these. A brief summary of each article follows.

ARTICLE 1

Gjefsen, Mads Dahl. 2013. "Carbon Cultures: Technology Planning for Energy and Climate in the US and EU," *Science & Technology Studies* 26(3).

In seeking to understand the how different actors interpret CCS, the first thesis article takes a comparative approach and investigates how the technology has been understood and contested on the macro-political arena. When read in the context of this thesis, ARTICLE 1 should be read as a response to the first sub-question: *how is CCS presented as a desirable public good within different political contexts?*

The empirical focus is on the US and EU, two major political units who have devoted significant attention to CCS in the past decade, and who have been a frequent topic of comparison for scholarship in environmental law and politics. This geopolitical level of analysis is chosen because it is an important frame of reference for global climate change research and for the assessment of technological mitigation measures. It thus provides a convenient starting point for thesis research on how CCS is interpreted,

whose interests are at stake, and of which governmental and institutional mechanisms are mobilized to influence the technology's trajectory.

The article is positioned in relation to a broad range of existing Social Science work on CCS. Two strands of research on CCS from the fields of Political Science and Communication are particularly relevant: literature focusing on how national-level political support for CCS relates to natural resource management (literature which often has a cross-national comparative dimension), and literature aiming to identify factors which influence levels of public understanding of and support for CCS. The former strand tends to take a rationalistic perspective on the quantifiable effects of CCS in relation to the needs and interests of individual nations. The second strand tends to focus either on case studies of public responses to CCS (such as in individual controversies), or on identifying recurring trends in public attitudes to the technology. While notable exceptions exist, few attempts have been made at synthesising them in order to connect political and public responses to CCS to styles of governance.

The article draws on literature review and semi-structured interviews with policy actors to identify distinctive co-productionist trends, where political pursuits of CCS express themselves through new organizations, narratives about the significance of CCS, legal-ontological definitions of CO_2, and through the implication of different publics and other groups as stakeholders in technological development. The article finds that the political support for CCS in the two sites has been expressed very differently, and that there are important contrasts in how the technology has been defended and in who has stood to be affected by it.

In the US, CCS has been championed as a technological alternative to government regulation of greenhouse gas emissions, and thus as offering an economical pathway to environmental protection. By forging multi-national alliances centred on technology development and knowledge sharing, the nation has sought to compensate for its controversial rejection of the Kyoto Protocol's regulation-based approach to climate change mitigation. Domestically, aims of local growth and the enrolment of private landowners as stakeholders in CCS have influenced how advocates operate when promoting the technology.

In the EU, by contrast, CCS has been promoted as a way for member countries to meet their commitments to ambitious climate change mitigation targets set down in the Kyoto Protocol. Federal-level pursuits of CCS have become tied to goals of European integration, and the establishment of a "stakeholder forum" representing European industry and other actors involved in the technology, has become an important supplier of authoritative representations of CCS as a joint, European venture. Member state legislation on land ownership differs from that seen in the US, and publics living in proximity to potential CO_2 storage sites have not had the same economic incentives to support CCS projects. Instead, public reactions and responses to CCS have been characterized by cases of strong vocal opposition and fear, and played into tensions between central governments and regional communities.

These characterizations should not be taken as definite and exhaustive descriptions of the histories of CCS in each site of comparison. Their function is to signal important contrasts in the co-productionist processes taking place around CCS in two political contexts, and to give a basis for making sense of the different factors and mechanisms at play in each site. This objective relates to the lack of connections between research on political motivations for pursuing CCS, and research on public responses to the technology. Here, comparison helps avoid naturalization and essentialist explanations. The resulting study integrates insights from these two strands. Persisting differences in governance styles, land ownership law, and political approaches to climate change mitigation seem not only to relate to differences in the rhetoric on CCS in the two sites, but also to the ways in which publics are implicated as stakeholders, with different degrees of legitimacy and assumed autonomy. The article concludes that awareness of such differences are important both for our understanding of political action on climate change, as well as for policymakers and other actors concerned with international coordination around issues in science and technology.

ARTICLE 2

Gjefsen, Mads Dahl. 2013. "Limits to prediction: Europeanizing technology in an expert forum," *European Journal of Futures Research* 1(1).

Following ARTICLE 1's examination of the role of macro-political actors in defining the purpose of technological pursuits, this second article moves on to explore one particular organizational expression of federal-level CCS activity. ARTICLE 2 should be read as a response to the second sub-question of this thesis: *how do expert organizations anticipate and address public concerns about CCS?*

The establishment of organizations can offer a productive starting point for analysing how expectations and tensions around technological change are foreseen and managed by political actors, such as through control of membership and of the different outputs produced by expert forums. The stakeholder forum identified in ARTICLE 1, which is one of several European Technology Platforms (ETPs) established to advise the European Commission on its research and development strategies in recent years, was selected as a topic of study both for the availability of important source material in the form of publicly available meeting archives, and for its importance as a reference point for a broad range of European actors involved in CCS. By focusing on a classic topic in STS, the expert forum, the article contributes to the broader thesis aims by looking at the dynamics and tensions between different actors invested in CCS, within the context of an institution seeking to establish itself as an authoritative source of expertise.

This article draws on literature from the field of Futures Studies on the topic of stakeholder participation in technology assessment, which appears to have influenced an increased emphasis on stakeholder inclusion in the expert institutions advising the European Commission. Technology assessment literature and European Commission guidelines on the use of expertise are compared with findings from a study based primarily on grey literature review, interviews and archival research. Particular attention is given to how ZEP, the expert body in question, has sought to understand and influence public perceptions on CCS, and on how these efforts relate to its formal function as a research advisor to the European Commission.

Findings indicate that ZEP has sought to establish a more visible public profile than what has generally been the case for earlier ETPs, and that both the epistemic authority of individual platform members, as well as their institutional affiliations, are

used strategically in order for the platform to play on different sources of credibility depending on the context. Communication materials designed for lay publics tend to present a pan-European perspective on CCS, defining its virtues as benefiting European industry or European energy security, defined against the outside world and seemingly without internal tensions or contradictions. Risks and uncertainties are framed as primarily technical and thus controllable by experts, while objections toward the more structural implications of CCS as a technical-social system, such as prolonged reliance on fossil fuels, go unanswered.

The latter form of scepticism towards CCS was also effectively excluded from ZEP, despite the European Commission's demands for NGO inclusion in the platform. The absence of such perspectives appear to be rooted in the requirement that ETPs present joint views and recommendations, which has led some CCS-sceptical NGOs to withdraw from the platform rather than risk being associated with its positions. This "consensus by design" also affects the dynamics between different factions of industry members, who might have different needs and interests in CCS, but who are forced to negotiate common positions amongst themselves in order to benefit from the institutional legitimacy of the ETP format.

These findings appear to confirm that institutional design matters, and that when communicating with lay audiences, experts might prefer to focus on the technical safety and controllability, rather than on their more chaotic and unpredictable societal implications. But more importantly, the findings also shows how the particular interpretive flexibilities and limits of alliance around CCS helps authorize some ideological strands within the environmental movement over others, in the context of expert institutions designed to include representatives of the variously defined social implications of science and technology. ZEP thereby illustrates important limitations in how the European Commission currently defines its ambitions for social inclusion in expert forums. In the broader context of this thesis, the article also shows how alliances around CCS are able to draw selectively on epistemic legitimacy and the credibility of environmental organizations, and how this coalition feature might enable advocates organized in expert institutions to also seek influence and authority in the public domain.

ARTICLE 3

Gjefsen, Mads Dahl. "Creating the Expert-Advocate: Building Community for an Emerging Technology," in review, *Research Policy*.

Having explored how actor coalitions around CCS seek to legitimize and advocate for the technology within an institutional setting in ARTICLE 2, ARTICLE 3 expands on the theme of actor coalitions to discuss expert communities in a broader sense. Instead of looking at a specific institution, the article looks at CCS training outside of academic contexts and examines them as entry points into a professional community for graduate students and early-career professionals. The article should be read as a response to the third sub-question of this thesis: *how does the CCS technical-social system affect the formation of expert communities?*

ARTICLE 3 connects the themes of the two preceding articles, by relating the dynamics of actor coalitions specifically formed around CCS, to the broader research theme of expertise in international policy coordination. The article's focus is a response to the study of expert influence in the field of International Relations. Conceptual frameworks such as Haas' *epistemic communities* have been developed in order to capture how knowledge-based authority can help redefine questions in policy and propose new courses of action. However, implicit assumptions abut the ability of abstract insights to both unite groups of practitioners around shared policy agendas and to influence decision makers by the validity of truth-claims alone, ignore STS literature on the complex ways in which alliances around expected technological developments both depend on the interpretative flexibility of such technologies, and gain force partly by virtue of the range of material and symbolic resources actors are able to mobilize to pursue it. Insights from the thesis' preceding articles are therefore drawn on, along with previously cited literature such as Wynne's concept of technical-social systems, in order to explore trends in CCS professionalization, thereby using a non-epistemic starting point for discussing processes of community formation.

The article uses grey literature to characterize current needs and priorities for CCS defined by prominent actors in the CCS community. However, the main empirical

focus is on findings from participant observation and subsequent interviews with organizers and participants at three short-term training events. Informants were asked about their motivations for taking part in the events as well as about their perceptions about the events' role for the broader expert community and for the development of CCS.

Not surprisingly findings show that funding bodies and organizers consider the training events as a mechanism for enrolling early-career professionals into an active project of promoting CCS, and that participants are motivated to attend the events to augment technical training in individual disciplines to learn about the broader "CCS chain." More importantly, however, the study also shows several distinctive features of the broader technical-social system around CCS to be relevant for how socialization into the professional community occurs. Public resistance against CCS appears to be seen as a threat to the technology's future, leading event organizers to include media skills as part of participants' training. Moreover, the high economic stakes attached to certain categories of private industry knowledge, means that training events provide professionals with an arena for sharing insider knowledge and semi-official information where access is restricted. It thus appears that the emphasis on shared knowledge as the sole mechanism for community cohesion, such as in the conceptual framework on epistemic communities, needs to be supplemented by understanding of how the particularities of different technoscientific developments implicate different groups as stakeholders, and by extension also different forms of resources on which actors can draw in order to pursue their policy projects.

ARTICLE 3 supplements the two preceding articles by relating their exploration of expertise and governance of CCS to the internal dynamics of the emerging professional community around the technology. While earlier articles focused on how the functions of CCS have been understood and portrayed by actors in the political sphere as well as by expert stakeholders and developers, this final article turns the focus around, and looks at self-reinforcing processes within the professional community itself. By showing how communities of technology professionals are both constrained and empowered by the technical-social system around their area of expertise, the article shows the importance of maintaining a sociological dimension to

the study of expert influence in contexts of decision-making. To those ends, the article proposes a new term, the *Expert-Advocate*, to describe participants in technology advocacy who actively seek to secure policy and regulatory support, and who (in the case of CCS) are able to anticipate and respond to public fears and concerns when such concerns are seen as barriers to the technology project.

Synthesis: Limits to flexibility in CCS advocacy

The above articles focus on each of the three dimensions of *representations* of CCS as a public good, the design and output of new *organizations* arising from CCS support, and the *communities* of CCS experts and respond to the three sub-questions formulated at the beginning of this chapter. In this synthesis section I connect insights from the three articles in order to respond to the main research question of the thesis: *How is support for CCS reflected in the formation of representational practices, new organizations, and expert communities?*

The research question is addressed by presenting tensions and interdependencies that occur in all three dimensions of inquiry. Specifically, justifications of CCS as a public good depend on finding common ground between actors with different ideas about the urgency and ultimate purpose of CCS. Public performances, communication outputs, as well as community self-organization, all depend on strategic management of the interpretative flexibility of CCS as a technical-social system. Such management avoids alienating those constituencies who contribute resources and credibility to the advocacy project and who thereby also maintain the important idea of CCS as an imminent technology and a feasible climate change mitigation option.

By looking simultaneously at the co-production of technical and social order within and across three dimensions (or instruments) of CCS advocacy, we are able to gain a more systematic understanding of the interpretative flexibility of CCS as a technical-social system. Individual dimensions/instruments are not mutually exclusive starting points for study, but also complement each other and help us identify recurring tensions that are negotiated across different dimensions of the same technology project. The reflections in this chapter on the utility of a multi-dimensional approach to the study of CCS provide a basis for future research, particularly so in the area of energy transitions, but potentially also for all research concerned with large-scale societal change.

Response to research question

CCS advocacy is characterized by tensions and interdependencies that are managed in the representations, organizations and communities around the technology. On the

one hand CCS advocacy is marked by actor-alliances that include environmental organizations, technical experts, and economically influential fossil fuel interests. This composition of actor groups permits flexibility in sources of legitimacy that can be foregrounded in a given context, and allows CCS advocates to draw on different forms of resources in their advocacy efforts. On the other hand, there are also tensions between these actors. CCS advocacy is characterized by the development of ways to manage these tensions through membership in organizations and through the sanctioning of narratives about CCS that are acceptable to different audiences.

Interpretative flexibility can designate the range of values, functions and meanings different actors attach to CCS, and the term appears to be relevant for understanding CCS support. Similar characterizations, such as Giddens' economic and political convergence,[120] and Tjernshaugen and Langhelle's descriptions of CCS as "political glue"[121] have already been mentioned. The concept interpretative flexibility also figures explicitly in the literature on CCS, as seen in Hansson and Bryngelsson, who argue that one of the key assets of CCS is its *inclusive* interpretative flexibility, which is compatible with a wide range of ideologies and rationalities.[122]

The present thesis departs from these authors however in questioning the assumption that what actors ally around is CCS in some future, realized form, where the technology jointly contributes to climate mitigation and cost-effective and emissions-free energy production. Instead, parallel study of different dimensions of CCS advocacy shows that actors continually negotiate how and on what grounds CCS should be advocated, who such advocacy should target, and who should be responsible for foregrounding and lending a public face to advocacy efforts.

The interpretative flexibilities of CCS might allow actor groups ranging from fossil fuel industries to environmental organizations to rally behind the technology, but it also allows arguments from both of these camps to be expressed in different contexts of advocacy. In the representation of CCS as a public good, discussed in ARTICLE 1,

[120] Giddens, *The politics of climate change*.
[121] Tjernshaugen and Langhelle, "Technology as political glue."
[122] Hansson and Bryngelsson, "Expert opinions on carbon dioxide capture and storage—a framing of uncertainties and possibilities," 2277.

policymakers in both the US and EU emphasised the ability of CCS to reconcile energy production and climate change mitigation in their expressions of support for the technology. Here, visions of a future with CCS appear to sustain imaginaries not only of the technology itself, but also of the position of the actors who support its development. In the US we saw an imaginary of responsible government as one that delegates to technology and to the market when seeking climate change solutions, rather than to impose the kinds of greenhouse gas emissions regulation prescribed by the Kyoto Protocol. In the EU we saw CCS pursuits merged with European integration, characterized by shared goals of energy security, a shared carbon market, and a deliberative forum constructing a shared European stakeholder community for CCS.

These contrasting performances of statehood in connection with CCS support indicate that the interpretative flexibility of CCS does more than just permit convergence between discrete and clearly defined rational interests. Symbolic qualities are also at play. As an ambitious technology project for the future, CCS support allows for projections of state-level decisiveness and commitment that contrast with displays of governance through regulation and interference with private industry. Moreover, material qualities factor in as well. As a technology whose purpose is partly defined by its compatibility with current energy production and distribution networks, CCS lends itself to pursuits of sovereignty and control through expansion or solidification of these networks.

Comparison gives a glimpse into how interpretative flexibility allows federal-level supporters to define different visions for CCS in different contexts. However, the integration of ARTICLE 1 with ARTICLE 2 and ARTICLE 3 in this multi-dimensional study, allows us to take our interpretation of representational flexibility one step further, by also relating it to the internal self-organization and management of CCS advocacy coalitions. CCS support can be interpreted not only as a means by which to reach an end, but also as an end in itself, where the imaginary of CCS facilitates certain *performances* of support that to some advocates are meaningful and rewarding in their own right.

To calibrate this interpretation, which so far rests on a study of state actors alone, ARTICLE 2 examined a different dimension of CCS support, namely its institutionalization in a new organization founded as part of the EU's increasing interest in the technology. By studying the design and dynamics of ZEP, an organization of CCS supporters, the article explains how actors negotiate the design of outputs from CCS advocacy activities. Such outputs include expert advice as well as public communication materials. As ARTICLE 2 makes clear, ZEP's members have sought to establish a more public image than previous European Technology Platforms, whose outputs have traditionally only been directed at the EC. The ZEP platform has devoted significant energy and resources to developing communication materials for distribution amongst platform members, with intended use in EU member countries. Its publications highlight not only the epistemic authority one might expect from an expert forum, but also the representational legitimacy implied by the inclusion of environmental organizations as platform members alongside industry actors. As were indicated in interviews, from the EC's perspective the inclusion of environmental organization implies a certain degree of "neutrality" in the platform's perspectives. As a tool in CCS advocacy, ZEP serves as a boundary organization where the credibility and legitimacy of different constituencies are carefully managed, so that appropriate authority can be claimed depending on the context. Here, the performances of support are not mainly done by state actors, as in ARTICLE 1, but by broader coalitions of CCS supporters primarily made up of industry, research, and environmental organizations.

Where ARTICLE 2 emphasized the management of outputs from CCS advocacy activity, ARTICLE 3 takes a yet different approach by focusing on issues of cohesion and self-management within the dimension of CCS expert communities. The article examines the mechanisms through which this community recruits new members through venues for non-university training. This training supplements postgraduate training in universities, and other professional venues such as conferences and professional association meetings. The venues allow sponsoring organizations to utilize the material and symbolic resources at their disposal and to cater to a spectrum of motivations for potential recruits considering entering the CCS field. These motivations include ideological ambitions for contributing to climate change

mitigation, as well as more traditional motivations for young professionals entering fossil fuel-related engineering and management positions.

Organizers control access to privileged knowledge about back-stage developments in policy and industry. Moreover, potential recruits are primed for performing as active *Expert-Advocates* in an on-going project of technology support, and equipped to traverse "barriers" to the advancement of CCS. Such barriers include not just technical, but also social barriers in the form of envisioned sceptical publics whose potential opposition to CCS is seen as a contributing factor to low levels of political commitments to the technology. Through the establishment of new training and community recruitment venues, the community rehearses shared narratives of what CCS is, what the challenges to its advancement are, and how these challenges can be managed. As the article states, these events benefit from the diverse set of resources supplied by different constituencies of advocacy coalitions, without alienating either.

Taken together, the three articles shows different dimensions in which the flexibilities and interdependencies of CCS are utilized and managed as part of CCS support.

Contributions to the literature

The two main contributions of this thesis to the STS literature is to show the usefulness of multi-dimensional study across instruments of co-production, and to show the need for a clearer understanding of interpretative flexibility in the context of envisioned technological futures.

The co-production of natural and social order has been said to occur along more or less established pathways, of which Jasanoff highlights identities, institutions, discourses and representations as ordering instruments that provide different starting points for co-productionist research.[123] The dimensions identified in the present chapter serve a similar function by allowing us to study the representations, organizations and communities of CCS advocacy. However, more than providing alternative starting-points for study, synthesizing observations across these dimensions also give a fuller picture of the advocacy project itself.

[123] Jasanoff, States of knowledge.

The multi-dimensional approach taken in this thesis helps foreground the process of CCS advocacy as a meaningful whole, rather than its individual expressions along any one pathway of co-production. By simultaneously studying representations of CCS as a public good, the establishment of a new organization founded as part of CCS support, and the internal self-management of the CCS community, we gain a better understanding of how CCS as an envisioned but yet unrealized technical-social system enables and constrains certain lines of argument, certain organizational structures, and certain mechanisms of community formation, rather than others. The approach taken in this thesis thereby contributes to the co-production literature by showing how parallel observations and analyses between dimensions, or instruments, can give complementary perspectives on a given object of study. The co-productionist implications of CCS advocacy for each dimension studied are different, but also share important similarities. This is most clearly seen in how the interpretative flexibility of CCS shapes advocacy activity within each of the three dimensions studied.

In the SCOT framework, interpretative flexibility is a stage in a process that leads towards closure and stabilization. The multi-dimensional approach to studying CCS advocacy allows us to make two adjustments to this view. Firstly, the interpretative flexibility of CCS is not simply about the range of meanings of a material artefact, as in the case of bicycle development initially used by Pinch and Bijker to demonstrate their analytical approach.[124] With CCS, interpretative flexibility not only sustains competing interpretations of contemporary material objects. It also sustains visions of yet unrealized technological futures. Secondly, conflicting senses of urgency appear to be at play amongst CCS advocates, and perhaps also conflicting levels of commitment to reach the kinds of closure generally seen as the ultimate resolution of questions of interpretative flexibility.

Current interpretations of CCS support as an unproblematic expression of genuine interest in reaching such closure, risks overlooking the very expression of CCS support as a meaningful activity for actors in its own right. The question that arises is whether CCS supporters consider CCS advocacy to be the means by which to reach

[124] Pinch and Bijker, "The Social Construction of Facts and Artifacts," 423.

an end–CCS realization–or if, to some actors, CCS advocacy is an end in itself. If so, discords in CCS advocacy alliances should raise important questions about the technology's future prospects.

Some of the previously cited research on coalitions of CCS supporters indicates that there are conflicting views about the urgency of CCS, even within alliances of CCS supporters.[125] Focusing on the US, Pollak and colleagues identify a "climate coalition" and "energy coalition" that appear to hold different levels of commitment to promoting the kinds of change in present-day policy and regulatory frameworks that will help make CCS a functional–in the sense of being profitable in the face of political constraints on greenhouse gas emissions–technology. The former group's support of CCS is motivated by minimizing the harm to fossil fuel energy industries *if* climate policy were to be enacted, while the latter group seeks to maximise the reductions of greenhouse gas emissions using CCS *when* climate policy is enacted.

Thus, within the range of ideologies and rationalities converging on support for CCS, conflicting views remain on CCS as either a technology helping to realize desirable and ambitious political measures to reduce greenhouse gas emissions, or a technology that can minimize undesirable economic constraints in the face of the implementation of such measures. The former position reflects an acute interest in provoking change in societal structures–of which policy and regulatory change are two examples–and is at odds with the latter, which is arguably, and according to Pollak and colleagues, favoured by the policy regime already in place. Similarly, de Coninck and Bäckstrand suggest that in certain CCS advocates stand to benefit simply from displaying commitments to the technology's realization in the present.[126]

In these accounts, the support of diverse actor groups converge on the same rational understanding of what broad-scale deployment of CCS would ultimately look like, without exploring in detail the performative signalling of CCS support as a meaningful, strategic act in its own right. Here, the present multi-dimensional study of

[125] Pollak, Phillips, and Vajjhala "Carbon capture and storage policy in the United States," de Coninck and Bäckstrand, "An International Relations perspective on the global politics of carbon dioxide capture and storage."
[126] de Coninck and Bäckstrand, "An International Relations perspective on the global politics of carbon dioxide capture and storage"

CCS advocacy makes a new contribution by showing how tensions and interdependencies between different actor groups are actually managed–both in contexts of CCS community membership, and when it comes to the production of outputs in policy and the public sphere. The study thus also illustrates the need for a clearer understanding of what interpretative flexibility means in the context of emerging technologies and the sociotechnical imaginaries with which they become associated.

What if the different social groups who ally in their expressions of support for an emerging technology, have conflicting levels of interest in progressing towards such stabilization? The discords in advocacy presented thus far, indicates the importance of understanding the limits of interpretative flexibility in the context of emerging technologies.

The tensions and interdependencies in CCS advocacy, suggest at least three ways of understanding the idea of interpretative flexibility. First of all, flexibility sustains different interpretations about the envisioned function of CCS. Secondly, flexibility lends meaning to different performances of CCS advocacy. Thirdly, flexibility is constrained by material networks and practices (i.e. CCS advocates acknowledge that the technology has no inherent and independent purpose except when combined with continued energy production from fossil fuels, even if such production is only temporary as part of a large-scale energy transition, and their advocacy narratives must therefore acknowledge and implicitly support such continued use). The first of these traits is the conventional way of thinking about interpretative flexibility, and is representative of how the interpretative flexibility of CCS[127] and its function as "political glue"[128] is often cited. However, the second and third meanings have received far less attention.

While some CCS advocates see their advocacy activities as a means to reach an end, where CCS contributes to climate change mitigation, other actors stand to benefit simply from sustaining the idea that CCS is realizable within given governance

[127] Hansson and Bryngelsson, "Expert opinions on carbon dioxide capture and storage—a framing of uncertainties and possibilities," Evar, "Conditional inevitability."
[128] Tjernshaugen and Langhelle, "Technology as political glue."

frameworks, and ensuring that CCS continues to be included in lists of available measures by which to tackle climate change – measures which in turn serve as focus points for climate change politics, policy support, social mobilization and other forms of concerted action available in technological cultures. Together, the efforts of these actors can be seen to support claims such as that made in Pacala and Socolow's paper in the journal *Science*, "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies," whose abstract illustrates the strong appeal of arguments founded on the assumption of technologies' imminence, and deserves to be quoted in full:

> Humanity already possesses the fundamental scientific, technical, and industrial know-how to solve the carbon and climate problem for the next half-century. A portfolio of technologies now exists to meet the world's energy needs over the next 50 years and limit atmospheric CO_2 to a trajectory that avoids a doubling of the preindustrial concentration. Every element in this portfolio has passed beyond the laboratory bench and demonstration project; many are already implemented somewhere at full industrial scale. Although no element is a credible candidate for doing the entire job (or even half the job) by itself, the portfolio as a whole is large enough that not every element has to be used.[129]

Sustaining ideas of technological imminence might require efforts to sustain advocacy alliances that by their very existence indicate that a certain level of social legitimacy and mobilization is underway around a given technology. Across the dimensions studied here, different actor groups contribute with epistemic authority, material resources and ideological legitimacy to a project of CCS advocacy, while also benefitting from what allied groups bring to the table. Constituencies from different social groups might co-dependently mobilize around technology advocacy, but still disagree about the timescales, objectives and desired closure mechanisms for technological trajectories. Such disagreements have received far too little attention, given that they raise important questions about what the prospects are for actor alliances where important constituencies have a vested interest in sustaining interpretative flexibility over progressing towards closure. As discussed in ARTICLE 1 and ARTICLE 3, environmental organizations in the US have gradually incorporate support for enhanced oil recovery in their CCS advocacy strategies in order to

[129] Pacala and Socolow, "Stabilization wedges."

maintain alliances with private companies, as the failure of key pieces of greenhouse gas control legislation took away incentives for private actors to invest in CCS development. What are the limits to such adjustments in CCS advocacy narratives?

I argue that a key quality of a multi-dimensional approach to understanding emerging technology advocacy is that it helps us gain a fuller picture of how, when and why internal tensions between supporters need to be managed. This also helps us understand what makes advocacy coalitions stay together, as the categories of resources brought to the table by various actor groups might play different roles at different times.

Advocacy helps solidify sociotechnical imaginaries, and is integral to the processes of re-invisioning and re-authorizing regimes for distributing benefits and opportunities that societal energy transitions imply.[130] For this reason, it is important to understand the degrees to which discords amongst technology advocates, such as different levels of urgency and different emphases on the performance of support, influence prospects for technological change.

Implications for future research

A key concern for future research should be to move towards an iconography of technology support. I use the word iconography because narratives and symbolism around risks, benefits, and technological utopias share important dramaturgical elements regardless of what specific technology is being talked about. Such an iconography should be founded on two important acknowledgements. Firstly, differences in the perceived urgency between actor-groups within a given alliance, as well as differences in the values attached to *performances* of support between these groups, fundamentally affect the prospects for technological change. Secondly, these differences are constrained by interpretative flexibilities, the degrees of which will inevitably vary both between individual material technologies and between more broadly conceived technical-social systems that lend themselves to different narratives of risks and benefits. Further research might examine the conditions that constrain or enable such flexibilities.

[130] Miller and Richter, "Social Planning for Energy Transitions."

One way forward is to undertake multi-dimensional research on different emerging technologies, as this thesis has done. While Tjernshaugen suggests that comparative studies of the ideologies of CCS support might be a productive avenue for future research,[131] the present study suggests that the envisioning of CCS is tied not only to abstract ideologies, but also to different technological cultures, where both material, organizational, performative, and symbolic factors affect the degree to which a single technology can be envisioned as a public good in any given context. Different legal regimes surrounding land ownership, discussed in ARTICLE 1 as influencing both the incentives for CCS support at the local level and as a driving force behind the establishment of new, private sector "epistemic consultants" who facilitate dialogue between communities and private companies, is a particularly illustrative example.

For the growing research on sociotechnical imaginaries and the potential for societal transitions to new energy futures, differences in the timescales by which actors formulate their goals and interests, could provide a productive focus. The interest in maintaining status quo for certain actors who are involved in envisioning technological futures, is a factor with serious potential implications for the tenability of actor coalitions.[132] It seems plausible that all efforts to provoke change can be delayed by conservative forces that combine expressions of commitments to change with feet dragging to stop visions for the future from interfering with the present.

[131] Tjernshaugen, "Fossil interests and environmental institutions," 49.
[132] Kuchler, M., "Sweet dreams (are made of cellulose): Sociotechnical imaginaries of second-generation bioenergy in the global debate," *Ecological Economics* 107 (2014).

Conclusion: The convergence trap

Studying technology advocacy lets us make important observations about the capacities of technological cultures to mobilize and respond to crises. Amid current concerns about anthropocentric climate change, emerging technologies that are intended to address expected developments in the relationships between humans and their habitats, offer a rich starting point for examining how technological promise is understood and acted upon by groups relying on different institutional and representational resources, and whose legitimacy rests, in part, on their claims to knowledge-based expertise.

This thesis studies three dimensions of what is at one level the same technology advocacy project: CCS. All three dimensions show actors portraying CCS development as an on-going and future-oriented venture. CCS is important and urgent but also an endeavour whose eventual payoff still lies decades into the future. Across the dimensions of representations, organizations and communities, CCS advocates appear to consider public support either as a barrier to CCS in its own right, or as a factor contributing to the related barrier of insignificant levels of policy support. In all three dimensions the forms of legitimacy and the forms of resources brought to the table by different factions of CCS supporters are carefully managed.

The performance of CCS support itself appears to be a meaningful activity to several key actors. For fossil fuel industries, visible expressions of CCS advocacy show commitments to corporate responsibility, while support by policymakers is consistent with displays of good government.

The idea that the display of commitment to technological change is itself an end – the destination, rather than the vehicle – has serious implications not only for CCS but for all technological, or even societal, projects requiring concerted action by heterogeneous actor coalitions. It also raises serious questions about the allure of convergences between factors such as the "political" and "economical", which is at the heart of influential writing on successful climate change mitigation efforts.[133] Most importantly, and especially relevant in the case of climate change, is the

[133] Giddens, *The politics of climate change*.

question of to what extent the display of support is at odds with commitments to realization. Such discords could have important implications for the prospects for technological and societal change. For research on the potential for large-scale societal transformations to new energy futures, investigating the conditions under which such discords hamper change should be a high priority.

Appendix: Overview of interviews

Phase*	Locations	Organizations represented** ***	Key focus in interview phase	Questions and concerns in interview protocol
1 (5)	Telec.,**** Cambridge, MA, USA	Bellona, Gassnova, MIT, NRDC, ZEP	Exploratory phase aiming to calibrate first assumptions about topic of CCS support and identify interesting topics for further research	How did you come to work on CCS? / How would you characterize your organization's efforts on CCS? / What immediate changes are you working towards? / Who are your audiences? / What are the differences in how CCS is advocated on regional, national and international levels? / What are the major barriers to the development of CCS?
2 (12)	Telec., Washington D.C., USA	ARPA-E, Bellona, CATF, CSLF, EnTech - Energy Technology Strategies, NRDC, Norwegian Embassy in Washington D.C., U.S. DoE, World Bank, WRI, ZEP	Further exploration into two distinct topics: US/EU comparative dimensions, and the role of ZEP in the EU's CCS efforts	Who initiated the founding of ZEP? / Do some environmental organizations fit better in ZEP than others? / Which government agencies does your organization seek to influence and how? / What role does technical expertise play in your advocacy efforts? / Are there different challenges to CCS advocacy in the US and EU?
3 (9)	Telec., Paris, France, Brussels, Belgium	Bellona, U.S. DoE, EC, IEA, ZEP	The history, organizational structure and working methods of ZEP, as well as ZEP's relationship with the EC	Explain ZEP's organizational structure: Who makes decisions, and what is the role of the EC? / What has influenced ZEP's communication efforts? / How important is communication to ZEP's overall mission, and how do you measure the success of communication? / What does the EC expect from technology platforms such as ZEP?
4 (11)	Telec., Oslo, Norway	JHU, NORDICCS, GCCSI, RECS, SINTEF*****	The design and purpose of non-university training on CCS, from the perspective of organizers as well as from the perspective of participants	Who initiated and funded the CCS training programme, and why? / What is the purpose of training? / How was the event planned? / What is the purpose of community building around CCS? / What did you gain from participating in the training event? / What was your motivation for applying? / Have you stayed in touch with other course participants?

* Number of interviews in brackets
** Informants would often speak about experiences from several organizations in a single interview. In those cases all relevant affiliations are cited
*** ARPA-E: Advanced Research Projects Agency - Energy, CATF: Clean Air Task Force, CSLF: Carbon Sequestration Leadership Council, EC: European Commission, GCCSI: Global CCS Institute, IEA: International Energy Agency, JHU: Johns Hopkins University, MIT: Massachusetts Institute of Technology, NORDICCS: Nordic CCS Competence Centre, NRDC: Natural Resources Defence Council, RECS: Reseach Experience in Carbon Sequestration, SINTEF: Stiftelsen for industriell og teknisk forskning (Norwegian), U.S. DoE: U.S. Department of Energy, WRI: World Resources Institute, ZEP: Zero Emissions Platform
**** Telec: Teleconferencing was used either over the internet (Skype) or via telephone
***** In addition six particpants at the training events run by GCCSI, NORDICCS, and RECS were interviewed in this phase

Bibliography

Anderson, J., and J. Chiavari. "Understanding and improving NGO position on CCS." *Energy Procedia* 1(1) (2009): 4811-4817.

Asdal, K. and I. Moser. "Experiments in Context and Contexting." *Science, Technology, & Human Values* 37(4) (2012): 291-306.

Ashworth, P., J. Bradbury, C.J.F. Feenstra, S. Greenberg, G. Hund, T. Mikunda, S. Wade, and H. Shaw. *Communication/Engagement tool Kit for CCS Projects*. Australia: CSIRO, 2011.

Ashworth P, A.M. Dowd, S. Rodriguez, T. Jeanneret, L. Mabon, and R. Howell. *Synthesis of CCS social research: Reflections and current state of play in 2013*. Australia: CSIRO, 2013.

Ashworth, P., E. Einsiedel, R. Howell, S. Brunsting, N. Boughen, A. Boyd, S. Shackley, B. Van Bree, T. Jeanneret, K., Stenner, J., Medlock, L., Mabon, C.F.J., (Ynke) Feenstra, and M. Hekkenberg. "Public preferences to CCS: How does it change across countries?" *Energy Procedia* 37 (2013): 7410-7418.

Austin, J.L. *How to do things with words*. Oxford: Oxford university press, 1975 [1955].

Bijker, W. E. "How is technology made?—That is the question!" *Cambridge Journal of Economics* 34(1) (2010): 63-76.

Bloor, D. *Knowledge and Social Imagery*. Chicago: University of Chicago Press, 1991 [1976].

Bowden, G. "Coming of Age in STS: Some Methodological Musings." In *Handbook of Science and Technology Studies*, edited by Jasanoff, S., G.E. Markle, J.C. Peterson, and T. Pinch, 64-80. Thousand Oaks: Sage Publications, 1995.

Boyd, A.D., Y. Liu, J.C. Stephens, E.J. Wilson, M. Pollak, T.R. Peterson, E. Einsiedel, and J. Meadowcroft. "Controversy in technology innovation: Contrasting media and expert risk perceptions of the alleged leakage at the Weyburn carbon dioxide storage demonstration project." *International Journal of Greenhouse Gas Control* 14 (2013): 259-269.

Boyd, A.D. and T.B. Paveglio, "Front page or 'buried' beneath the fold? Media coverage of carbon capture and storage," Public Understanding of Science, 23(4) (2014): 411-427.

Bradbury, J.A. "Public understanding of and engagement with CCS." In *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, ed. Markusson, N., S. Shackley, and B. Evar, 45-73. London: Routledge, 2012.

Bridge, G., S. Bouzarovski, M. Bradshaw, and N. Eyre. "Geographies of energy transition: Space, place and the low-carbon economy." *Energy Policy* 53 (2013): 331-340.

Business Spectator. "Norway abandons carbon capture plans." Last modified September 23, 2013. http://www.businessspectator.com.au/news/2013/9/23/policy-politics/norway-abandons-carbon-capture-plans.

Charmaz, K. "Grounded Theory: Objectivist and Constructivist Methods." In *Handbook of Qualitative Research, Second Edition*, edited by Denzin, N.K. and Y.S. Lincoln, 509-536. Thousand Oaks: Sage Publications, 2000).

Collins, H. M. "Introduction: Stages in the empirical programme of relativism" *Social studies of science* 11(1) (1981): 3-10.

Corry, O. and H. Riesch. "Beyond 'for or against' environmental NGO-evaluations of CCS as a climate change solution." In *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, edited by Markusson, N., S. Shackley, and B. Evar, 91-108. London: Routledge, 2012.

CSLF. "Daily News Clips." Last modified December 5, 2014. http://www.cslforum.org/pressroom/newsclips.html.

Curry, T.E. "Public awareness of carbon capture and storage: a survey of attitudes toward climate change mitigation." PhD diss., Massachusetts Institute of Technology, 2004.

Davies, L.L., K. Uchitel, and J. Ruple. "Understanding barriers to commercial-scale carbon capture and sequestration in the United States: An empirical assessment." *Energy Policy* 59 (2013): 745-761.

de Coninck, H. "Successful CCS relies upon social science." *Climate Policy* 13(4) (2013): 530-532.

de Coninck, H., and K. Bäckstrand, "An International Relations perspective on the global politics of carbon dioxide capture and storage," *Global Environmental Change* 21(2) (2011): 368-378.

de Coninck, H., et al., "The acceptability of CO_2 capture and storage (CCS) in Europe: An assessment of the key determining factors: Part 1. Scientific, technical and economic dimensions," *International Journal of Greenhouse Gas Control* 3(3) (2009): 333-343.

Doherty, N.F., C.R. Coombs, and J. Loan-Clarke. "A re-conceptualization of the interpretive flexibility of information technologies: redressing the balance between the social and the technical." *European Journal of Information Systems* 15(6) (2006): 569-582.

Dowd, A.M., and M. James. "A Social Licence for Carbon Dioxide Capture and Storage: How Engineers and Managers Describe Community Relations." *Social Epistemology* 28(3-4) (2014): 364-384.

Eisenhardt, K.M. "Building theories from case study research." *Academy of management review* 14(4) (1989): 532-550.

European Commission. *EC 2001 COM 428 European Governance: A white paper*. Brussels: European Commission, 2001.

European Commission. *EC 2002. Communication from the Commission on the Collection and Use of Expertise by the Commission: Principles and Guidelines*. Brussels: European Commission, 2002.

Evar, B. "Conditional inevitability: Expert perceptions of carbon capture and storage uncertainties in the UK context." *Energy Policy* 39(6) (2011): 3414-3424.

Feenstra, C.F.J., T. Mikunda, and S. Brunsting. *What happened in Barendrecht? Case study on the planned onshore carbon dioxide storage in Barendrecht, the Netherlands*. Petten: ECN and Global CCS Institute, 2010.

Felt, U., B. Wynne, M. Callon, M. Gonçalves, S. Jasanoff, M. Jepsen, P.B. Joly, Z. Konopasek, S. May, C. Neubauer, A. Rip, K. Siune, A. Stirling, and M. Tallacchini. *Taking European Knowledge Society Seriously. Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate General for Research, European Commission*. Brussels: European Commission, 2007.

Financial Times. "EU lags behind on carbon capture." Last modified October 24, 2013. http://www.ft.com/intl/cms/s/0/43c0c48c-3b26-11e3-a7ec-00144feab7de.html.

Fontana, A. and J.H. Frey. "The Interview: From Structured Questions to Negotiated Text." in *Handbook of Qualitative Research, Second Edition*, edited by Denzin, N.K. and Y.S. Lincoln, 645-672. Thousand Oaks: Sage Publications, 2000.

Forbes. "As Obama Unveils New Regs, Coal Could Be Resurrected If Carbon Could Be Buried." Last modified September 20, 2013. http://www.forbes.com/sites/kensilverstein/2013/09/20/coal-could-be-resurrected-if-carbon-could-be-buried/.

Frow, E., and J. Calvert. "Opening up the future (s) of synthetic biology." *Futures* 48 (2013): 32-43.

Giddens, A. *The politics of climate change*. Cambridge: Polity, 2009.

Gieryn, T.F. "Boundary-work and the demarcation of science from non-science: strains and interests in professional ideologies of scientists." *American Sociological Review* 48(6) (1983): 781-795.

Global CCS Institute. *The Global Status of CCS: 2014*. Melbourne: The Global CCS Institute, 2014.

Gough, C., and S. Mander. "Public perceptions of CO_2 transportation in pipelines." *Energy Policy* 70 (2014): 106-114.

Greenpeace International. *False hope: Why carbon capture and storage won't save the climate.* Amsterdam: Greenpeace International, 2008.

Guston, D.H. "Boundary organizations in environmental policy and science: An introduction." *Science, Technology, & Human Values* 26(4) (2001): 399-408.

Guston, D.H. "Stabilizing the boundary between US politics and science: The role of the Office of Technology Transfer as a boundary organization." *Social studies of science* 29(1) (1999): 87-111.

Ha-Duong, M., A. Nadaï, and A.S. Campos. "A survey on the public perception of CCS in France." *International Journal of Greenhouse Gas Control* 3(5) (2009): 633-640.

Hansson, A. "Kolets återkomst: Koldioxidavskiljning och lagring i vetenskap och politik." PhD diss., Lindköping University, 2008.

Hansson, A. "Colonizing the future." In *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, edited by Markusson, N., S. Shackley, and B. Evar, 74-90. London: Routledge, 2012.

Hansson, A., and M. Bryngelsson. "Expert opinions on carbon dioxide capture and storage—a framing of uncertainties and possibilities." *Energy Policy* 37(6) (2009): 2273-2282.

Hennink, M., I. Hutter, and A. Bailey. *Qualitative research methods*. London: Sage, 2011.

Herald Online. "Residents Weigh Global Benefits And Local Risks In Views of Climate Change Measures." Last modified October 31, 2013. http://www.heraldonline.com/2013/10/31/5358978/residents-weigh-global-benefits.html.

Hilgartner, S. *Science on Stage: Expert Advice as Public Drama*. Stanford: Stanford University Press, 2000.

Hope, A.L., and C.R. Jones. "The impact of religious faith on attitudes to environmental issues and Carbon Capture and Storage (CCS) technologies: A mixed methods study." *Technology in Society* 38 (2014): 48-59.

Hughes, T.P. "The evolution of large technological systems." In *The social construction of technological systems: New directions in the sociology and history of technology,* edited by Bijker, W., Hughes, T.P., and Pinch, T., 51-82. Cambridge: MIT Press, 1989.

Huijts, N., C.J. Midden, and A.L. Meijnders. "Social acceptance of carbon dioxide storage." *Energy policy* 35(5) (2007): 2780-2789.

Intergovernmental Panel on Climate Change. *IPCC Special Report on Carbon Dioxide Capture and Storage*. Cambridge: Cambridge University Press, 2005.

International Energy Agency. *Technology Roadmap: Carbon Capture and Storage. 2013 edition*. Paris: International Energy Agency, 2013.

International Journal of Greenhouse Gas Control. "Full aims and scope." Accessed October 30, 2014. http://www.journals.elsevier.com/international-journal-of-greenhouse-gas-control/

Itaoka, K., A.M. Dowd, A. Saito, M. Paukovic, M. de Best-Waldhober, and P. Ashworth. "Relating individual perceptions of carbon dioxide to perceptions of CCS: an international comparative study." *Energy Procedia* 37 (2013): 7436-7443.

Itaoka, K., A. Saito, M. Paukovic, M. de Best-Waldhober, A.M. Dowd, T. Jeanneret, P. Ashworth, and M. James. *Understanding how individuals perceive carbon dioxide: Implications for acceptance of carbon dioxide capture and storage: Implications for acceptance of carbon dioxide capture and storage*. Australia: CSIRO, 2012.

Jasanoff, S., ed. *States of knowledge: the co-production of science and social order*. New York: Routledge, 2004.

Jasanoff, S. *Designs on Nature: Science and Democracy in Europe and the United States*. Princeton: Princeton University Press, 2005.

Jasanoff, S. and S.H. Kim. "Containing the Atom: Sociotechnical Imaginaries and Nuclear Power in the United States and South Korea." *Minerva* 47(2) (2009): 119-146.

Jasanoff, S., and S.H. Kim. "Sociotechnical imaginaries and national energy policies." *Science as Culture* 22(2) (2013): 189-196.

Joerges, B., "Do Politics Have Artefacts?," *Social Studies of Science* 29(3) (1999): 411-431.

Kleinman, D. *Impure cultures: University biology and the world of commerce*. Madison: University of Wisconsin Press, 2003.

Krause, R.M., S.R. Carley, D.C. Warren, J.A. Rupp, and J.D. Graham. "'Not in (or Under) My Backyard': Geographic proximity and public acceptance of carbon capture and storage facilities." *Risk Analysis* 34(3) (2014): 529-540.

Kuchler, M. "Sweet dreams (are made of cellulose): Sociotechnical imaginaries of second-generation bioenergy in the global debate." *Ecological Economics* 107 (2014): 431-437.

Kuijper, M. "Public acceptance challenges for onshore CO_2 storage in Barendrecht." *Energy Procedia* 4 (2011): 6226-6233.

Kvale, S., and S. Brinkmann. *Interviews: Learning the craft of qualitative research interviewing*. Thousand Oaks: Sage, 2009.

Latour, B. *Science in action: How to follow scientists and engineers through society*. Cambridge: Harvard university press, 1987.

Latour, B. *We have never been modern*. Cambridge: Harvard University Press, 1993.

Latour, B., and S. Woolgar. *Laboratory life: The social construction of scientific facts*. Beverly Hills: Sage, 1979.

Levidow, L., and T. Papaioannou. "State imaginaries of the public good: shaping UK innovation priorities for bioenergy." *Environmental Science & Policy* 30 (2013): 36-49.

L'Orange, S. S., Dohle, L., Diamond, and M. Siegrist. "The effect of figures in CCS communication." *International Journal of Greenhouse Gas Control* 16 (2013): 83-90.

Mabon, L., S. Vercelli, S., Shackley, J., Anderlucci, N., Battisti, C., Franzese, and K. Boot. "'Tell me what you Think about the Geological Storage of Carbon Dioxide': Towards a Fuller Understanding of Public Perceptions of CCS." *Energy Procedia* 37 (2013): 7444-7453.

Malone, E.L., J.J. Dooley, and J.A. Bradbury. "Moving from misinformation derived from public attitude surveys on carbon dioxide capture and storage towards realistic stakeholder involvement." *International Journal of Greenhouse Gas Control* 4(2) (2010): 419–425.

Markusson, N., S. Shackley, and B. Evar, eds. *The Social Dynamics of Carbon Capture and Storage: Understanding CCS Representations, Governance and Innovation*. New York: Routledge, 2012.

Meadowcroft, J., and O. Langhelle, eds. *Caching the Carbon: The Politics and Policy of Carbon Capture and Storage*. Cheltenham: Edward Elgar Publishing, 1999.

Meyer, U., and I. Schulz-Schaeffer. "Three Forms of Interpretative Flexibility." *Science, Technology & Innovation Studies* 1(1) (2006): 25-40.

Miller, C. "Hybrid Management: Boundary Organizations, Science Policy, and Environmental Governance in the Climate Regime." *Science, Technology, & Human Values* 26(4) (2001): 478-500.

Miller, C. A., and J. Richter. "Social Planning for Energy Transitions." *Current Sustainable/Renewable Energy Reports* 1(3) (2014): 77-84.

Mills, R.M. *Capturing Carbon: The New Weapon in the War Against Climate Change*. New York: Columbia University Press, 2011.

MIT. *The Future of Coal: Options for a Carbon Constrained World*. Cambridge: MIT, 2007.

Mitchell, T. *Carbon democracy: Political power in the age of oil*. London and New York: Verso Books, 2011.

Mitchell, T. "Carbon democracy." *Economy and Society* 38(3) (2009): 399-432.

Morgan, D.L. "Emergent design." in *The SAGE Encyclopedia of Qualitative Research Methods*, edited by Given, L.M., 246-249. Thousand Oaks: Sage Publications, 2008.

Narita, D. "Managing uncertainties: The making of the IPCC's Special Report on Carbon Dioxide Capture and Storage." *Public Understanding of Science* 21(1) (2010): 84-100.

Nemet, G.F., E. Baker, and K.E. Jenni. "Modeling the future costs of carbon capture using experts' elicited probabilities under policy scenarios." *Energy* 56 (2013): 218-228.

Oltra, C., R. Sala, R. Sola, M. Di Masso, and G. Rowe. "Lay perceptions of carbon capture and storage technology." *International Journal of Greenhouse Gas Control* 4(4) (2010): 698-706.

Oltra, C., P. Upham, H. Riesch, À, Boso, S. Brunsting, E. Dütschke, and A. Lis. "Public responses to CO 2 storage sites: Lessons from five European cases." *Energy & Environment* 23(2) (2012): 227-248.

Pacala, S., and Socolow, R. "Stabilization wedges: solving the climate problem for the next 50 years with current technologies," *Science* 305(5686) (2004):968-972.

Pollak, M., S.J. Phillips, and S. Vajjhala. "Carbon capture and storage policy in the United States: A new coalition endeavors to change existing policy." *Global Environmental Change* 21(2) (2011): 313-323.

Pinch, T.J. "Opening Black Boxes: Science, Technology and Society." *Social Studies of Science* 22(3) (1992): 487-510.

Pinch, T. J. and W.E. Bijker. "The Social Construction of Facts and Artifacts: or How the Sociology of Science and the Sociology of Technology might Benefit Each Other." *Social Studies of Science* 14(3) (1984): 399–441.

Seigo, S.L., S. Dohle, and M. Siegrist. "Public perception of carbon capture and storage (CCS): A review." *Renewable and Sustainable Energy Reviews* 38 (2014): 848-863.

Shackley, S. "Introduction to Part II: Governance." In *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, edited by. Markusson, N., S. Shackley, and B. Evar, 111-126. London: Routledge, 2012.

Shapin, S. and S. Schaffer. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life.* Princeton: Princeton University Press, 1985.

Shackley, S. and C. Gough, eds. *Carbon capture and its storage: an integrated assessment*. Hampshire: Ashgate Publishing, 2006.

Star, S.L., and J.R. Griesemer. "Institutional ecology, translations' and boundary objects: Amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907-39." *Social studies of science* 19(3) (1989): 387-420.

Stebbins, R.A. "Exploratory Research." In *The SAGE Encyclopedia of Qualitative Research Methods*, edited by Given, L.M., 327-331. Thousand Oaks: Sage Publications, 2008.

Stephens, J. "Technology leader, policy laggard: CCS development for climate mitigation in the US political context." In *Caching the carbon: The politics and policy of carbon capture and storage*, eds. Meadowcroft, J.R. and O. Langhelle, 22-49. Cheltenham: Edward Elgar Publishing, 2009.

Stephens, J.C., A. Hansson, Y. Liu, H., de Coninck, and S. Vajjhala. "Characterizing the international carbon capture and storage community." *Global Environmental Change* 21(2) (2011): 379-390.

Stephens, J.C., and Y. Liu. "The evolving international CCS community." In *The social dynamics of carbon capture and storage: Understanding CCS representations, governance and innovation*, edited by. Markusson, N., S. Shackley, and B. Evar, 127-148. London: Routledge, 2012.

Stern, N. ed. *The economics of climate change: The Stern review*. Cambridge: Cambridge University Press, 2007.

Stirling, A. "'Opening up' and 'closing down': power, participation and pluralism in the social appraisal of technology." *Science, Technology, & Human Values* 33 (2003): 262–294.

Stirling, A. "Transforming power: Social science and the politics of energy choices." *Energy Research & Social Science* 1 (2014): 83-95.

Sundqvist, G., and M. Elam. "Public involvement designed to circumvent public concern? The 'participatory turn' in European nuclear activities." *Risk Hazards & Crisis in Public Policy* 1(4) (2010): 203-229.

Terwel, B.W., F. Harinck, N., Ellemers, and D.D. Daamen. "How organizational motives and communications affect public trust in organizations: The case of carbon dioxide capture and storage." *Journal of Environmental Psychology* 29(2) (2009): 290-299.

Terwel, B.W., F. Harinck, N., Ellemers, and D.D. Daamen. "Going beyond the properties of CO_2 capture and storage (CCS) technology: How trust in stakeholders

affects public acceptance of CCS." *International Journal of Greenhouse Gas Control* 5(2) (2011): 181-188.

Tjernshaugen, A. "Political commitment to CO_2 capture and storage: evidence from government RD&D budgets." *Mitigation and Adaptation Strategies for Global Change* 13(1) (2008): 1-21.

Tjernshaugen, A. "Fossil interests and environmental institutions: The politics of CO_2 capture and storage." PhD diss., University of Oslo, 2010.

Tjernshaugen, A., "The growth of political support for CO_2 capture and storage in Norway," *Environmental Politics* 20(2) (2011): 227-245.

Tjernshaugen, A. and O. Langhelle. "Technology as political glue: CCS in Norway." In *Caching the carbon: The politics and policy of carbon capture and storage*, edited by Meadowcroft, J.R. and O. Langhelle, 98-125. Cheltenham: Edward Elgar Publishing, 2009.

TNS Opinion & Social. *SPECIAL EUROBAROMETER 364 Public Awareness and Acceptance of CO_2 capture and storage.* Brussels: TNS Opinion & Social, 2011.

Torvanger, A., and Meadowcroft, J. "The political economy of technology support: Making decisions about carbon capture and storage and low carbon energy technologies." *Global Environmental Change* 21(2) (2011): 303-312.

Upham, P., and T. Roberts. "Public perceptions of CCS: Emergent themes in pan-European focus groups and implications for communications." *International Journal of Greenhouse Gas Control* 5(5) (2011): 1359-1367.

Van Alphen, K., Q. Van Voorst tot Voorst, M.P. Hekkert, and R.E. Smits. "Societal acceptance of carbon capture and storage technologies." *Energy Policy* 35(8) (2007): 4368-4380.

Wade, S., and S. Greenberg. *Social Site Characterisation: From Concept to Application. A review of relevant social science literature and a toolkit for social site characterization*. Melbourne: Global CCS Institute, 2011.

Warren, D.C., S.R. Carley, R.M. Krause, J.A. Rupp, and J.D. Graham. "Predictors of attitudes toward carbon capture and storage using data on world views and CCS-specific attitudes." *Science and Public Policy* 41(6) (2014): 821-834.

Winner, L. "Do Artifacts Have Politics?" *Daedalus* 109(1) (1980): 121-136.

Winner, L. "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology." *Science, Technology, & Human Values* 18(3) (1983): 362-378.

Winner, L. *The Whale and the Reactor: A Search for Limits in an Age of High Technology.* Chicago: University of Chicago Press, 1988.

World Resources Institute. *Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects*. Washington DC: WRI, 2010.

World Resources Institute. *Guidelines Carbon Dioxide Capture, Transport, and Storage*. Washington DC: WRI, 2008.

Wynne, B. "Unruly Technology: Practical Rules, Impractical Discourses and Public Understanding." *Social Studies of Science* 18(1) (1988): 147-167.

Yin, R. K. *Case study research: Design and methods, Fourth Edition*. Thousand Oaks: Sage, 2009.