PhD Thesis:

A Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of Carbon Capture and Storage (CCS) within the People's Republic of China (PRC)

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Abstract

As a suite of emerging technologies, carbon capture and storage (CCS) holds the potential to abate huge quantities of emissions from fossil fuel sources, making it appealing to industrialised nations seeking to mitigate climate change. Holding uncertainties around its technical viability and facing competition from low-carbon energy options, there is a need to enhance global learning and increase information sharing while removing hesitations through large-scale demonstrations. As international projects ran into difficulties, we saw a sharp increase in cooperation with China, hoping the country's unique characteristics and circumstances might facilitate accelerated deployment. Despite showing enthusiasm, China demonstrated unclear appetite for the technologies, thus frustrating international partners.

This research seeks to identify how motivated international entities can use international cooperation and communications to influence CCS development and decisions within China. It examines how the international CCS community is structured, how it functions, and how it communicates to influence CCS-related policy processes. It assesses the means and methods international parties use to cooperate, collaborate, and communicate to share information with Chinese parties about their experiences of CCS. Additionally, it seeks to better understand the motivations and behaviours of the Chinese parties engaging in CCS-related activities and what this tells us about the current and future domestic development of the technologies. Key to this investigation is to understand how international entities can employ various types of communication channels to diffuse CCS-related information that may influence Chinese decision making.

This research has advanced Everett Rogers' Diffusion of Innovations theory. Diffusionism has long been criticised as a form of elitist colonialism where linear channels are usually used to communicate pseudo-scientific arguments in order to influence a subject community. Even Rogers holds the view of a 'centralised' diffusion system, with expert sources using one-way communications to diffuse an innovation as a uniform package to relatively passive acceptors. Conversely, other scholars like Donald Schön, believe in 'decentralised' diffusion, where innovations emerge from numerous local sources and evolve as they are diffused across horizontal networks. This research challenges both theories by putting forward the proposition of a hybrid model of diffusion, which includes both centralised and decentralised elements.

On the basis of a desktop scoping study of CCS-related projects and events, 840 Chinese stakeholders from Chinese government departments and agencies, state-owned enterprises and private industry, the Chinese Academy of Sciences and universities were identified. 16 case studies were conducted based on 71 quantitative data sets from an online Communications Survey, 40 qualitative semi-structured interviews in ten Chinese cities and secondary data.

Understanding the structure, functions and communication influences of the International CCS Community, this thesis reveals parallel sources of CCS-related information, diffusion networks that create developed-developing country partnerships, and western strategies to influence Chinese decision-making. Moving beyond traditional CCS communications studies and investigating the emergence of new communication mechanisms, it lays out the sequencing of communication channels that have different effects on China's CCS adoption. Through providing a comprehensive qualitative assessment of China's appetite for CCS and the prospects for domestic adoption, it recognises the need to appeal to multiple Chinese stakeholder motivations and to bring them around a common goal. Responding to others, who have called for further analysis into how soft-governance can contribute to global diffusion frameworks and mechanisms for collaboration, I consider how alternative innovation-diffusion frameworks are employed to promote information sharing and learning by doing, acknowledging the flow of knowledge through social networks.

Discovering that a hybrid model of innovation diffusion does exist, this incorporates linear and convergent communication channels. Diffusing an innovation as a uniform package that allows for reinvention, this provides opportunities for different parties to create and share information to reach a mutual understanding. As the decision making is shared between those at the top and those who may or may not wish to adopt, this holds potential to hasten the rate of adoption and accelerate technological deployment.

Keywords: carbon capture and storage, international diffusion, soft governance communications, innovation development, innovation decision making.

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Chapter One: Introduction – Research Direction, Questions, & Proposition

Carbon capture and storage (CCS) is a collection of technological components which aims to avoid the release of harmful CO_2 emissions from point sources, such as fossil-fuel power plants and other large industrial facilities. When captured, emissions are then gasified and/or liquidised and transported by pipeline or ocean tanker to an appropriate geological or oceanic sequestration site, such as abandoned oil and gas wells, deep coal beds, or saline aquifers, with the intention of utilisation and/or storage for a lengthy period of time.

The various technological components have been used as far back as the 1930s (Ever *et al.*, 2012) but the possibilities for CCS to be used as a means of mitigating climate change were only first proposed by Cesar Marchetti in the 1970s (de Coninck and Bäckstrand, 2011). Spotting the link, Marchetti (1977) was early to acknowledge that the climatological effects of CO_2 had begun to attract much attention, as did the question of how much fossil fuel can be consumed before its detrimental consequences are felt on the current and future generations. Given these links, recent years have seen a gradual and then sharp rise in CCS technologies' popularity but the great uncertainty around their potential still remains.

This increase in attention led to an increase in international cooperation and the need to share both technological and social learnings. Although activities had primarily been taking place in (and between) western industrialised nations, there had also been a phenomenal rise in CCS-related cooperation with China between 2005 and 2012. The initial assumptions are that this could be down to the need to reduce the country's burgeoning Greenhouse Gas (GHG) emissions, but it could also be argued that other countries were hoping to convince China to lead the way in terms of CCS advancement, primarily due to its ability to make more rapid policy progress and infrastructure projects. However, as it was largely unknown what the country's appetite was for these technologies and what could be done to make them appear more attractive, this was something I set out to investigate further.

Scope of Research

Through spending quite some time reviewing the, somewhat limited CCS academic literature within the social sciences (most of which was centred around the period under research and emerged when CCS was a thriving prospect between 2005 to 2014), I began to notice a number of highly-relevant thematic areas and subject-specific topics that would lead the overall direction of my research.

One – International CCS Community and Motivations for Engagement

It has been no coincidence that the link between fossil fuels and climate change created a rapid surge of interest in CCS, and with it an unprecedented enlargement of the international CCS community. As pointed out by Stephens (2011), what is less known is how the International CCS Community is structured, how it functions, how it communicates, as well as its influence on the CCS-related policy process. This, in particular, is important when you acknowledge the degree of carbon lock-in evident within some nation states and the vested interests in retaining their existing energy systems, capitalist structures, and political regimes.

Following mounting international pressures, growing public demand, and CCS presenting itself as a possible solution, many national governments globally (but particularly those western industrialised nations with significant fossil fuel interests) were searching for the certainty they needed to find the most timely and cost-effective pathway towards GHG emission reductions possible. Faced with a range of low-carbon technologies but with limited economic resources, these governments need to make hugely and also timely political decisions and strive to remove any technical uncertainties and policy hesitations, to fund the best innovations, promote the acceleration of their development, and work towards encouraging the deployment of these more "climate-friendly" technologies. Unfortunately, compared with other low-carbon technologies, the uncertainties around CCS are much larger and varied.

Being already in-use but not mature enough to provide certainty, CCS has the added disadvantages of being enormously expensive, consuming vast amounts of energy, failing to provide an energy by-product, and being considered a risk to people, property and the environment – despite having huge GHG abatement potential. It was no wonder that governments, corporations, and investors are clearly hesitant and need to be reassured through the testing, pilots, and demonstration under different configurations and circumstances. However, despite the urgent calls for global learning and information sharing at an international scale, the number of CCS projects planned (even those countries that had advocated for it) took a nosedive, particularly when public expenditure on such expensive initiatives became more challenging following the 2008 global financial crisis.

Two – Sino-International CCS Cooperation and Collaboration

CCS has been struggling within the international climate negotiations and national projects have been stalling globally. Fortunately, there had been a rise in multilateral CCS-related cooperation and international-bilateral cooperation, particularly between western-industrialised nations and developing and emerging economies. Acknowledging the huge opportunities for accelerated learning and cost sharing, we must also recognize that such relationships are often either intertwined with international diplomacy and/or as a result of fragile domestic politics, so we should keep such realities in mind when we examine these interactions. However, given the attention during this time being focused on cooperation with China (perhaps due to its openness to collaborate and its suggested strong capability for large-scale demonstration), the focus of this investigation is around the lack of hard (financing and regulatory) functions and the prevalence of soft governance and their real-world influence on the country. It is unmistakable that there is a lack of global CCS awareness and that much of the technical capabilities lay in western industrialised nations, however, there is also a realisation that an emerging industry needs both technical and social learning through CCS demonstration at scale. It seems only logical that such knowledge and skills would be transferred through building capacity and learning opportunities offered by workshops, summer schools, and symposia. Often seen as non-committal activities within arenas to take action against shared problems, these non-threatening activities often assist in creating CCS-related norms and setting standards.

Three – Chinese CCS Community and Opportunities/Challenges for Development

Fully acknowledging that there had been an increase in international CCS cooperation, collaboration, and communications with China, we should not only recognise the opportunities available to others (enormous GHG reduction potential to meeting international obligations, while maintaining fossil-fuel dependency to maintain domestic stability) but the barriers (lack of government support, private sector hesitation, and outright opposition, and possible impacts on economic development) towards CCS development, demonstration and deployment within the country. There have been positive signs from China's Central Government in the form of policies and funding to support research and small-scale pilots, while at the same time there were also clear signals that if China was to take a role in CCS development, then the international community would have to pay the significant sums needed.

However, offering little in terms of financial incentives, which could prove diplomatically sensitive and politically difficult at home, often the only real offerings available were to enter into increased multilateral and bilateral cooperation for technical development and information sharing. Recognizing the value of exchanging information and sharing knowledge while building capacity and generating new findings too had the added value of motivating influential stakeholders, generating support, and mobilising resources with the intention to hasten global development while potentially inducing deployment within China. Significant efforts have taken place over recent years; therefore, it also needs to be recognised that this is very much a continuous process and much more needs to be done to narrow the gap with the advanced international levels and to allow China to share its findings with the world.

Four – Removing CCS Uncertainties and Accelerating the Technologies' Deployment

Recognising the urgent need to ramp up CCS-related activity internationally, particularly around demonstration, there were increasing calls within the CCS community for greater investment and coordination, particularly around sophisticated engagement strategies that would employ credible partners, trusted sources, and high-profile public figures. Crucially, however, it was realised that by tailoring these communications towards targeted influential stakeholder audiences, the CCS community could create a positive profile around the technologies, gain group consensus more widely, and mobilise the vital resources needed for CCS advancement. Given that CCS communications and messages were often overwhelmingly optimistic for the successful transition towards a low-carbon energy system and positively promising the mitigation of climate change, the framing of CCS was important through adopting different languages to create a discourse around the technologies themselves. In order to mainstream various arguments that emphasise its mitigation potential and environmental and safety, while downplaying the costs and risks, the intention here was to foster legitimacy around the technologies and to increase the chances of its acceptance, particularly while its practicality and value have yet to be successfully demonstrated. However, it should be recognised that technologies are often developed and opinions of them are shaped not through the provision of hard factual information but through the sharing of subjective evaluations by way of personal interactions, which often relies on the transferring of values, opinions, interests and experiences.

Research Questions

The outline of the research areas (above) should provide the context and framing for my research questions (below).

International CCS Community as the 'More Knowledgeable and Experienced Parties'

When considering the emergence of the International CCS Community, its motivations for cooperation, and its need for clarity around the technologies' potential, we need to ask how the international CCS Community is structured, how it functions, and how it communicates to influence the CCS-related policy processes. In that same vein, it is important to examine where messages regarding CCS originate and whether they are from expert sources (a centralised system) or numerous local sources (a decentralised system) that allow for it to diffuse via horizontal networks. This is important to identify if the drive for CCS diffusion and deployment in China is being led by the International CCS Community towards China, as the reluctant adopter of the technologies, or if there is a mutually beneficial and cooperative relationship.

Employing Everett Roger' theory of the 'Diffusion of Innovations' (2003), I introduce the theoretical theme of 'more knowledgeable and experienced parties' that are often the original primary source(s) of information. Rogers teaches us about diffusion networks, change agents, and paraprofessional aides, which can be used by those who seek to diffuse an innovation to assist them in their diffusion activities. Keeping these questions in mind, Chapter Six of this thesis will respond to research questions one and two (as seen in the following boxes).

1. How is the International CCS Community structured, how does it function, and how does it communicate to influence the CCS-related policy processes?

2. Do the messages regarding CCS originate from expert sources (a centralised system) or numerous local sources (a decentralised system) via horizontal networks?

Sino-International CCS Cooperation and Collaboration as the 'Communication Channels'

When investigating Sino-international cooperation, collaboration, and communications, it is important to examine whether the communications models are primarily one-way/linear where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system), or through two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system). Again, Rogers teaches us about communication campaigns, communication channels, and exemplary and experimental demonstrations, which parties can use to assist in their diffusion activities (Roger, 2003). In Chapter Seven of this thesis, I'll be answering research questions three and four (as seen in the following boxes).

3. By what means or through what methods do international parties cooperate, collaborate and communicate with Chinese parties to share information about and their experiences of CCS?

4. Are the communications channels primarily one-way/linear where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system) or two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system)?

Chinese CCS Community as the 'Less Knowledgeable and Experienced Parties'

When investigating the Chinese CCS community and the opportunities and challenges for CCS development within China, it is important to assess whether Chinese stakeholders are relatively passive acceptors of CCS (a centralised system) or whether they actively participate in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system). By applying Rogers' theoretical theme of the less knowledgeable and experienced parties and by looking in-depth at the Chinese CCS community as a social system (Roger, 2003), throughout Chapter Eight I will be exploring the Chinese CCS innovation development process and attempt to better understand the real-world opportunities and challenges for CCS within the country. For this research area, please see research questions five and six (as seen in the following boxes).

5. What are the motivations and behaviours of the Chinese parties engaging in CCS-related activities and what does this tell us about the current and future domestic development of the technologies?

6. Are Chinese stakeholders relatively passive acceptors of CCS (a centralised system) or do they actively participate in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system)?

Removing CCS Uncertainties and Accelerating the Technologies' Deployment

By returning to the essence of this research (Governments' attempts to remove the uncertainties around CCS through development cooperation with China and with the ultimate goal of accelerating the technologies' deployment globally), the final research area under investigation will be whether key decisions are made by technically-expert officials near the top of the diffusion system (a centralised system) or if such decisions about diffusion should be made shared with this who may or may not wish to adopt (a decentralised system). While giving reference to Rogers' concept of the innovation-decision process, I focus more on the hierarchy of communication effects, and their possible effects on the rate of adoption (Roger, 2003). Therefore, Chapter Nine of this thesis will be answering research questions seven and eight (as seen in the following boxes).

7. How can international entities employ various types of communications channels to diffuse different kinds of CCS-related information that may influence Chinese decision-making processes?

8. Are key decisions made by technically-expert officials near the top of the diffusion system (a centralised system) or if such decisions about diffusion should be made shared with this who may or may not wish to adopt (a decentralised system)?

Research Proposition – Developing a Hybrid Model of Innovation Diffusion

From a theoretical perspective, if we are considering how best to influence China's acceptance of CCS technologies, we need to look more closely at the key socio-political conditions within which the technology develops (its key institutions, structures, and networks), as these can facilitate and/or impede its pathway towards deployment. Therefore, key to this investigation going forward is the rejection of the traditional theoretical understanding that technological innovation systems are linear, with the acknowledgement that the traditional "technology push and market pull" models no longer truly capture the realities of innovation diffusion.

Ultimately important for this research is to also acknowledge that information and technologies flow through social networks and by way of interactions between different actors throughout the innovation development process. Acknowledging calls for technology innovation and diffusion research to move away from the traditional economics analysis, there is now a need to explore alternative frameworks, such as social system-led innovation diffusion, which is what has been investigated here.

Holding the intention to apply Everett Rogers' theory of the "Diffusion of Innovations (DOI)" (2003) within the context of international CCS cooperation with China and to adapt the DOI Paradigm to consider the potential for a truly hybrid model of diffusion, this research is therefore focused to explore the following overarching proposition. That is, the overarching proposition of this research should explore whether a truly 'hybrid' model of innovation diffusion, where there are elements of both centralised and decentralised diffusion, would not only allow different parties to find a common language and to communicate around CCS technologies, but also provide the potential for a quickening of the technological development, demonstration, and deployment process.

Chapter Ten provides a model of 'hybrid diffusion,' which allows current practitioners and policy makers to plan for the diffusion of CCS within China. Providing the possibility to be used for the diffusion of other technological innovations within similar social systems, there is also the potential to use this model to strategize for an accelerated speed of technological development and to increase the prospects of future deployment of other low-carbon technologies.

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Chapter Two: Literature Review of CCS in the Social Sciences

Emergence – The CCS Community & the Need for Clarity

Despite earlier opportunities, CCS was skipped over as a pollution abatement option, perhaps due to its direct links to fossil fuels whereby carbon was seen by some as the source of the problem and therefore was neglected when seeking a solution (Meadowcroft and Langhelle, 2009). Left isolated within academia, the scientific community, and policy circles until the 1990s (Ever *et al.*, 2012), one might then ask: Why was CCS pushed to one side for so long? Who re-discovered the technologies as a mitigation option? And, why did they see potential in further development and analysis of the technologies' potential at that point in time?

With growing speculation around climate change and its links to fossil fuels, there was a rapid surge in interest around CCS (Meadowcroft and Langhelle, 2009) from governments (de Coninck and Bäckstrand, 2011) and the climate community, who saw it as a viable mitigation option (perhaps the only option) in times of scientific urgency and slow political response (Meadowcroft and Langhelle, 2009). Naming this emerging informal network the international CCS community, Stephens and Liu (2012) remark at how the community had grown in size, breath of expertise, geographical scope and capacity to influence policy over recent years by embracing a diverse network of international professionals from the scientific and expert community, government, business, academia and the non-profit sector, all of whom have a professional interest in CCS (Stephens *et al.,* 2011). Although this meteoric rise is no surprise considering the increased attention towards climate change and carbon emissions, behind all emerging technologies there are groups and communities involved in the innovation process (Stephens and Liu, 2012). Stephens offers various typologies of such formations, such as a community of experts, thought collectives, discourse coalitions, advocacy coalitions, and epistemic communities (Stephens and Liu, 2011, Stephens, 2012). Given previous research on epistemic communities exploring several different types of international problems, including climate change (Paterson, 1996), nuclear arms control (Adler, 1992) and ozone depletion (Haas, 1992), Stephens (2011) admits that this framework provides for the most direct and in-depth lens through which to view and examine the nature of the international CCS community, focusing on its structure and functions and how it communicates, as well as the influence it has on the policy process.

As the influence of this CCS community is something that will be investigated further through this research, it is important to point out here that not all motivations towards CCS are wholly altruistic, as many interested in CCS do not – *only* – endeavour to decarbonise the current energy system. Having reached the point of technological or carbon lock-in (Unruh and Carrillo-Hermosilla, 2006), according to Markusson *et al*. (2012), many parties have vested interests to retain the current technologies, social practices, regulatory standards, skills and management systems and seek to maintain the survival, prosperity and competitiveness of the capitalist economic regime. Thus, these expectations and motivations have allowed CCS to edge its way into the climate policy documents of many countries as a cornerstone of their mitigation strategies (Markusson *et al.*, 2012). It is precisely this dual climate mitigation and continued carbon lock-in functionality of CCS that led Shackley and Evar (2012) to see both its promise and its criticism. With the rise of interest in CCS internationally, particularly in western developed fossil-fuel producing nations, it is then imperative to ask: who will benefit most from the further development and proposed deployment of CCS in the long run?

Noting this increase of western industrialised nations becoming increasingly engaged in CCS activities, Torvangerm and Meadowcroft (2011) reviewed the political economy of governments' choices around low-carbon emissions energy technologies, including CCS. With the ultimate goal of finding the most timely and cost-effective pathway towards GHG emission reductions possible, they tell how governments are continuously required to make unavoidable political choices by deciding on how to best allocate their often very limited economic resources towards providing more or less support to one (but not the other) energy and/or mitigation technology. Confronted with enormous pressures, in terms of the scale of their GHG emissions and the levels of reductions needed, governments also face great uncertainties around the rate of technological progress and hesitations around future policy regimes, as well as fluctuating carbon prices. For Torvangerm and Meadowcroft (2011), additional challenges around the limited availability of knowledge, the complexities of 'learning-by-doing,' and an unknown social learning curve make decisions around promoting innovation, accelerating development, and encouraging deployment very difficult. Faced with great policy, technical, and financial uncertainties, often accompanied by great cost and substantial risk, governments then crave the level of certainty needed to allow their domestic stakeholders to feel confident enough to move away from existing regimes and familiar structures (and for their populations to be reassured) to shift towards more climate-friendly technologies.

Therefore, the need for technological certainty which informs governmental choices becomes an important aspect of this investigation. However, before I go into the ways in which these governments can use cooperation, collaboration and communications to remove the uncertainties and hesitations around CCS, it is important to understand more about what these are and how they can affect the technologies' development, demonstration, and prospects for future deployment.

Uncertainty – Great Risks, Greater Challenges & an Even Greater Urgency

Knowing what we know about the increased interest in CCS internationally, Hannson (2012: 98-114) told us that humankind stands at a historical fork in the road on whether or not to adopt CCS as a tool for mitigating climate change. Among scholars who also begin to focus on the real-world practicalities of CCS advancement, Stephens *et al.* (2011) paid a lot of attention to the 'risks of' CCS to society (and/or to the energy systems), as well as ‘risks to’ the future prospects of CCS development. These authors see these risks as obstacles, barriers, problems, or challenges related to the technology, as well as negative impacts or implications of the technology, and categorise them into five groups: technical, political, economic, social and environmental. Although it is not possible to address them all in great detail here, below are some of the most frequently discussed risks and uncertainties. To begin, while the technologies involved in CCS are frequently declared mature and already in-use, many technological and geological combinations have still to be tested and demonstrated at full-scale. Markusson *et al.* (2012) termed this as double exposure, whereby technologies are ready, yet still need further development in various combinations and within particular geological localities. However, we must also acknowledge that it is not only the individual technologies and their various combinations that need further development and testing, as the risks associated with CCS can also be curtained and/or resolved through the formulation, trial and implementation and of suitable policies and appropriate regulatory measures, adding further layers of uncertainty.

Another significant risk to the development and deployment of CCS are the financial or economic challenges. Markusson *et al.* (2012) argued that the international CCS community has been facing great difficulties in raising the capital needed for the development and demonstration of CCS. Referring back to our earlier discussions on the political choices of governments around technological options, the public funds promised for CCS projects often do not materialise (Ever *et al.*, 2012), with persistent and prevalent obstacles to capturing private sector investment also prevalent. This is mainly due to a lack of suitable public-sector partners and scepticism that CCS will not be widely deployed, leaving many potential investors reluctant to gamble with such uncertainties. This then leads us to question, if CCS is a necessity, as its proponents like to proclaim, then how (and by who?) will the future development of CCS be financed? It should also be recognised, however, that some of the most significant arguments against CCS come from those who favour cleaner sources of energy production, such as renewables, nuclear and energy efficiency. However, against these rivals, CCS has a number of distinct disadvantages, as not only is it a much more expensive means of climate mitigation due to large initial installation costs, it also endures a substantial energy penalty due to the additional fuel required (20-30 percent increase in coal consumption) to run additional equipment (Morse *et al.*, 2009), while producing no by-product (energy production that would aid in financing their development and deployment significantly), and also contributing to the carbon lock-in. These disadvantages are then exasperated by the fact that, although some pre-existing facilities can be used (Ever *et al.*, 2012), considerable large-scale investment in new infrastructure will be needed if CCS is to be realised in time to make a substantial impact (Stephens and Liu, 2012).

Moving on from the more techno-economic uncertainties, significant scholarly attention has also been paid to the public concern for the health and safety of the people, property and the environment, particularly related to leakage and water contamination in the proximity of CCS projects (Ever *et al.*, 2012), and the effects of such opposition can have an impact on the success of projects. de Coninck (2011) attributes this to insufficient global learning and impeded knowledge sharing on not only regulatory and legislative issues, but also on many issues related to CCS. Perhaps the greatest challenge to CCS, however, is that of 'time.' Although CCS is considered to be the "most urgent technology transfer task in history" (Drahos, 2009:125), there is an increasing likelihood that CCS will not be deployed in time to make the significant emissions reductions needed to successfully mitigate climate change (Markusson and Shackley, 2012). With reductions sought in order to stabilise atmospheric CO_2 concentrations to 450ppm by 2050, it has also been argued that any diversion of scarce funds and valuable resources from other options of climate mitigation could be very risky. However, the counter argument is that the current costs of CCS abatement may make future mitigation costs almost trivial (Drahos, 2009:125). These potential risks led Shackley and Evar (2012) to re-name CCS from the silver bullet that will resolve our climate and energy problems to a convoluted 'Gordian Knot' of fearsome proportions.

Bearing these risks in mind, Bradbury (2012) argues that many of the uncertainties surrounding CCS will only be fully resolved through real-world demonstration and the dissemination of findings and lessons learned. However, as with many small-scale demonstration plants are now being constructed in many parts of the world, due to the global financial crisis a huge slow-down with projects already planned has taken place (Shackley and Evar, 2012). With the first fully integrated commercial-scale CCS power plant not built and successfully demonstrated (until 2015) (de Coninck *et al.*, 2009) and 100 projects needed globally by 2020 and 3000 needed by 2050 (Best and Beck, 2011), Markusson *et al.*, (2012) reminds us that in order for uncertainties to dissipate, there is an essential need for large-scale demonstrations with different configurations (various capture technologies) and/or within different contexts (within storage in saline aquifers, oil fields, coal beds). More importantly, however, there is a necessity to share lessons learned from demonstration projects and other activities on issues such as technological performance, infrastructure needs, health and safety, public perception, environmental impacts and funding, as well as legal and regulatory aspects.

Acknowledging the tendency within the international CCS community to articulate lofty learning goals without detailing comprehensive mechanisms or plans for achieving the goals, Markusson *et al.* (2012) called for deeper understanding of the learning processes surrounding CCS demonstration and the risks and uncertainties faced. They said that the learning required for demonstration projects does not simply involve technical experts learning about the technological configuration of the project, rather the situation calls for a broader process of social learning that includes different types of knowledge and expertise and that involves engagement with a wide variety of stakeholders. They did, however, point out that there is, understandably, tension between the need for knowledge sharing to boost learning and the need for knowledge protection to secure competitive advantage (Markusson *et al.*, 2012). However, if a meaningful reduction in emissions is to be achieved, some believe efforts need to be made in "banishing the ghosts of past ideological debates over intellectual property rights" (Drahos, 2009:125). On a broader scale, Markusson *et al.* (2012) also recognises that for CCS to be deployed there is a need for the transfer of new skill-sets, industrial capabilities, standards and regulations, in order to affect changes in the socio-technical regime.

Regardless of the motivations of those behind the promotion of CCS, without real efforts to resolve (or curtail) the technological risks and regulatory uncertainties, the development and future deployment of CCS may be limited. Key to this process, however, is how risks and uncertainties (as well as benefits and opportunities) are communicated, and to whom they are communicated. This is of essential importance to further CCS-related research, which needs to be explored further.

International – Global Governance, Multilateral Cooperation, Bilateral Collaboration

Going back to our earlier discussions around the interplaying political and economic factors that affect governmental decision-making on the development of emerging technologies, Torvangerm and Meadowcroft (2011) said that governments should ideally concentrate investments along one or a few promising technologies. However, with this option not always possible, they must diversify investments and therefore spread the risk across numerous options, although they will gain less learnings but for less cost on each. What is important in this process is the learning rate (the gradual accumulation of knowledge and decrease in costs), which is a central part of this process and determines government support as a driver for 'path dependency' (with increased returns, economies of scale, adaptive expectations, network economies, or learning economies) towards lock-in. According to Torvangerm and Meadowcroft (2011), the important issue here is to have the best possible knowledge base when making such decisions, particularly with regard to alternatives, long-term consequences, implied risks, and possible robust and flexible strategies. Taking this advice into account, for CCS to move forward successfully then needs to make these incremental learnings, and fast. Referring to the countries where CCS development has historically had the greatest political drive (Australia, Norway, and Canada), these scholars then stated that (given the large and uncertain investments needed to combat human-made global warming, to hedge against risks, and to exploit different national competencies and comparative technological advantages), international collaboration or, at the very least, co-ordination was needed.

Acknowledging the need for enhanced global governance, multilateral cooperation, and bilateral collaboration, the realities of global learning and information sharing (as a means to speed up these CCS development, demonstration, and deployment), had not been without its challenges. With the 2009 United Nations Framework Convention on Climate Change (UNFCCC) 15th Conference of Parties (COP15) leaving international climate negotiations in a state of chaos until the 2015 Paris COP21, during this time CCS technologies had been struggling to find its role within the international climate regime. As the gap continually widened between developed and developing countries with regard to their international commitments and Intended Nationally-Determined Contributions (INDCs), improved multilateral cooperation and bilateral collaboration was needed more than ever. In order to bridge the gap, Duan *et al.* (2013) determined that there was an urgent need for a more bottom-up approach to international cooperation, with the hope to make sure development and deployment was optimised until 2030. de Coninck *et al.* (2009) reviewed the capacity and effectiveness of past and existing initiatives to deliver and execute CCS demonstrations. Seeing an overall increase in international CCS cooperation around demonstration, they determine that such initiatives were not only likely to offer accelerated technical learning but a more globalised and evenly distributed learning, while also expanding social awareness of CCS and formulating an acceptability discourse around the technologies, as well as creating consistent standards for project safety and integrity. By identifying four guiding principles (global coordination, transparency, cost-sharing, and communication) that should feature in all international cooperation for CCS demonstration, they also recognized that the large sums of money required and that any cost-sharing nature of such arrangements might be diplomatically challenging internationally and politically difficult domestically.

Very little has been written on global CCS governance but de Coninck and Bäckstrand (2011) began mapping CCS-related organisations and collaborative activities, while explaining the growing diversity, overlap, and fragmentation within the international CCS community. Applying the theories of realism, liberal institutionalism and constructivism to their findings, de Coninck and Bäckstrand (2011) hoped to learn the extent to which global CCS governance might be led by the fossil fuel industries and energy communities, be part of a larger climate change regime complex, or perhaps something knowledge-based beyond these power-driven and interest-centred interpretations of the evolution of the CCS community. As all three accounts provide complementary to the fragmentation of CCS governance, they determine that at different times, different parties can intervene to provide different governance functions (such as information and capacity building), to suit their intended objectives at the time. Importantly, each of the organisations studied appeared to have their own primary goals with regard to CCS and held either positive, neutral, or negative positions on the technologies, often with conditions, which determines whether or not they are active or passive in the CCS community and if the messages they share are neutral.

Around the same time, Hagemann *et al.* (2011) had also noticed the growth of international multilateral initiatives and bilateral partnerships which held some relevance to CCS. Noting the common theme of industrialised, wealthier, and more advanced countries hoping to meet their commitments under the UNFCCC to share knowledge, provide financing, and ultimately transfer technologies to those developing, poorer, and less advanced countries, these authors categorised these initiatives and partnerships into four groups (Figure 2.1.).

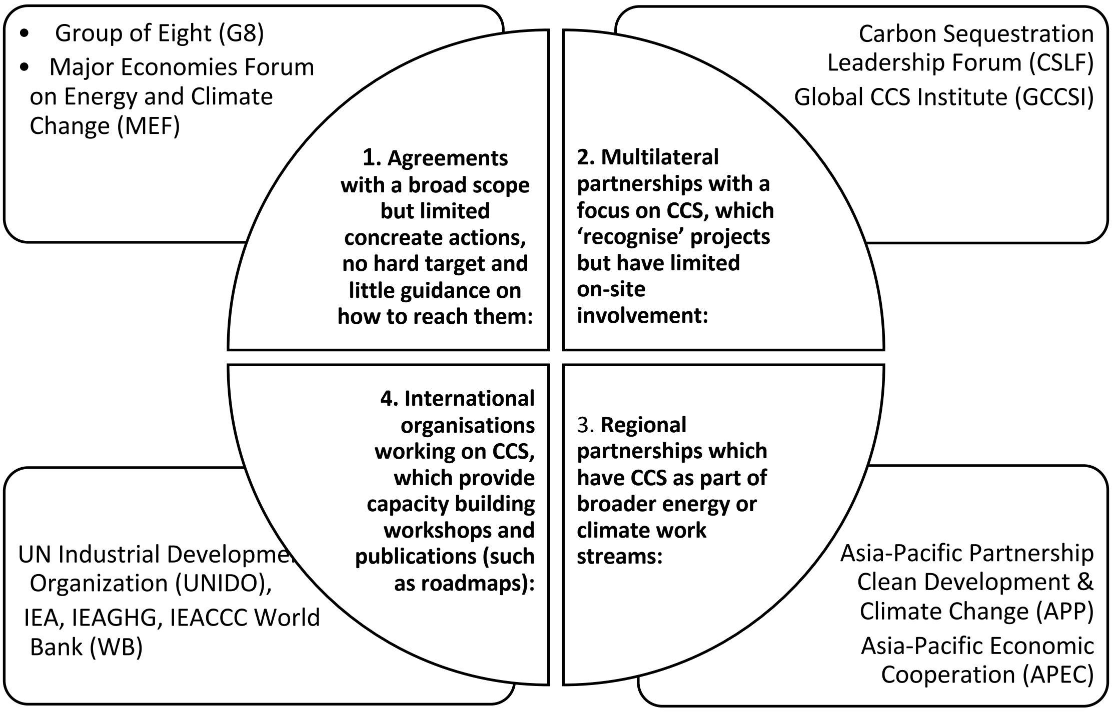

Figure 2.1. Multilateral initiatives and bilateral partnerships (Hagemann *et al.*, 2011)

Hagemann *et al.* (2011) also noted a particular increase in bilateral CCS partnerships between western countries and China, which were often linked to multilateral initiatives. For example, the European Union (EU) was leading the way with Cooperation Action with CCS China-EU (COACH), and Near-Zero Emissions Coal (NZEC), and the Support to Regulatory Activities for CCS (STRACO_2) projects. The United States (US) formed a number of agreements with China, such as the Fossil Fuel Protocol and the US-China Clean Energy Research Centre (CERC). Likewise, Australia had a number of initiatives with China, such as the Joint Coordination Group on Clean Coal Technology (JCG) and China-Australia Geological Storage of CO_2 Project (CAGS), whereas Japan had cooperated on Enhanced Oil Recovery (EOR) projects. Seeing this as a clear demonstration that the primary focus of the international CCS community was undoubtedly bilateral partnerships with China, Hagemann *et al.* (2011) believed this to be a result of China's openness to cooperating and its strong capability for large-scale demonstration. Interestingly, these scholars also found that the functions performed by both multilateral and bilateral initiatives were largely the same, as there was little real evidence of funding and project financing and only a few instances of support to develop regulatory frameworks and public communications, which may be more politically sensitive and/or hard to transfer between jurisdictions. With primary activities of multilateral initiatives and bilateral partnerships often focusing on setting the technical directions, facilitating information exchange, building networked partnerships, and building capacity through workshops, summer schools, and symposia, it is the lack of hard (financing and regulatory) functions and the focus on soft governance that is the focus of the next section.

Learning – Soft Governance & Socio-Technical Lessons for a New Regime

As an emerging CCS industry would require skilled professionals in the long-term, if the technologies were to be widely deployed there is an urgent need for technical and social learning through CCS demonstration at scale, particularly around project management and financing in the near-term. For some time, scholars, such as Beck and Gale (2009) had recognised that there is a lack of global awareness and low levels of general education around CCS, as most existing capacity has been confined to the developed world. For them, if the technologies are to make a significant impact on global emissions, then educational programmes and capacity building efforts need to be transferred to or initiated in the developing world, particularly in large emitters like China, India, Brazil and South Africa. Around the same time, in discussing the lack of knowledge and understanding of CCS and the shortage/absence of skilled technical and scientific workforces in these particular countries and by examining the Asia-Pacific Economic Cooperation (APEC) and the Carbon Sequestration Leadership Forum (CSLF) training activities and capacity building programmes provided to developing economies around the Pacific Rim, Bachu (2009) offered some key learnings that could be applied to future efforts.

However, while acknowledging the urgent need for such activities, de Coninck (2011) determined that international CCS cooperation had been dominated by low-effort actions towards 'soft' governance functions, such as studies, capacity building activities, workshops and conferences. These functions, she said, have provided support to both states and non-state actors by assisting in the management of CCS operations, and setting norms or standards, as well as neutralising or laundering the national flavour of monies, while pooling finances. With little centralised global CCS governance, these activities are essentially non-committal against shared problems and are non-threatening against the sovereignty of states on what are seen to be sensitive issues, such as information on energy security and subsurface geology and resources. However, as pointed out earlier, this also means that they often lack teeth in terms of enforcement and regulatory powers. As a result, when controversial managerial and/or financial decisions need to be made on 'hard' governance issues, such as investment, R&D, regulation and implementation, are not adequately addressed (de Coninck, 2011). Unfortunately, this again does little to overcome the real barriers faced by CCS towards further development and deployment.

With the international CCS community recognising the urgent need for CCS demonstration, Ashworth *et al.* (2010) tell of the 2009 International Energy Agency (IEA)/CSLF call for 20 projects globally by 2020, which by coincided with an increase in national funding allocations within the EU, US, UK, Canada and Australia. Seeing these announcements as a strong indication of an international call for action and recognition that serious financial investment and coordinated communications around CCS is needed globally, Ashworth *et al.* (2010) examined the CCS-related activities that had taken place since 2002 and provided recommendations for the future. By suggesting a maximisation of cross-country synergies, the segmentation of stakeholders into key groups, and the targeting of stratified audiences, such an approach hoped that this would provide a much more strategic approach to CCS communication activities. Also recommending the engagement with high profile public figures, partnering with credible partners, and working with trusted sources to develop tailored CCS-related communications materials, this was to create a more positive profile around the technologies and to highlight their potential for GHG abatement and climate change mitigation. Of the four key audiences (influential others, community, education, and project specific), the 'Influential others' stakeholder group (i.e., politicians, CEOs, the media, NGOs, and those in the finance industry) was considered to have the largest impact on the way that CCS is communicated or integrated into the community. Requiring a more sophisticated engagement strategy than the others, these particular stakeholders are considered critical for mobilising finances which would enable the further advancement of CCS project development.

Critically important, CCS communications studies and engagement strategies had predominantly focused on the media and the general public, although Bäckstrand *et al.* (2011) pointed out that there have been calls amongst researchers to move on to CCS communications more generally. Stephens and Liu (2012) had determined that, in recent years, there has been an emergence of a multitude of new communication mechanisms 'within' the CCS community. This, they argue, has allowed for the increase of information sharing and a nurturing of a shared perspective on the potential and challenges of CCS technology extending the international reach both within and outside the community, suggesting a potential enhanced capacity for policy influence within the community, which has not been studied. With a greater understanding of the intentions of these communications, it is then important to examine the messages they hope to communicate.

Framing – Overwhelming Optimism, Perceived Pragmatism, & Risk Amplification

When thinking about how international cooperation, collaboration and communications may influence the development of CCS globally, we should think about how people learn about the technologies and components and what (or better still who) influences them to engage in CCS-related activities. Quite some time ago, Bradbury and Dooley (2005) began to explore the concept of 'thought leadership' within CCS communications and reviewed 154 media articles that mentioned CCS to understand the key issues around the technology. These national-level articles attributed to state organs and governmental activity were overwhelmingly positive for these coal-based technologies to be deployed widely, while optimistically promising a transition towards a low-carbon energy system and the mitigation of climate change. A year later, Mander and Gough (2006) talked about the emergence of CCS in the media and how its portrayal can determine how it's received by governments and business, as well as the public, and how this could radically affect the technologies' success during implementation. Outlining the potential for "risk amplification," these authors also looked at how different sources of information (in this case print media sources in Australia, Canada, New Zealand, the UK, and US) adopted different languages to frame CCS, which created a discourse around the technologies.

With the vast majority of these articles being triggered by international agreements, the release of scientific reports, and the launch of demonstration projects, a number were neutral and informative, but most were positive in nature and mainstreamed the arguments to continue the significant use of coal, while emphasising the advantages for doing so.

A few years later, Hansson and Bryngelsson (2009) noted that along with the momentum for CCS endorsement amongst powerful actors, came the support for the technologies' commercialisation, particularly by influential parties such as the European Commission (EC). Often manifested in increasingly positive media coverage, the scientific community aimed to demonstrate the certainty of the technologies' mitigation, environmental and safety. However, in the absence of full-scale integrated demonstration, several significant knowledge gaps would lead to further hesitation. These authors also found that, on occasion, significant details (such as cost and risk) were either scarce and/or misleading, with uncertainties often not seen as significant enough to justify rejection. Again, this optimism was seen more as a pragmatic perspective with the belief that in the face of fossil fuel reliant future and looming climate change, humanity would have to develop CCS as the easiest (not best) solution to an otherwise insolvable equation. In reality, the authors argue, such optimism in technology development builds expectations and increases the possibility to attract financial resources and start a positive cycle, with uncertainties leaving policy makers with a 'wait and see' approach to strategic decision making. This, in essence, was the effect they had hoped to achieve.

Building on these previous studies on CCS communications, Buhr and Hansson (2011) talk about how the development and deployment of CCS are sensitive to public debates that socially frame the technologies. By placing two companies (Norwegian Statoil and Swedish Vattenfallin) that were involved in CCS at the centre of a qualitative investigation, the authors compared national media debates around the technologies' media framing through corporate statements to identify issues/controversies, oppositional writings, metaphors, values and feelings, diversity of ideas, basic assumptions, alternative perspectives, and stories about concrete projects. Identifying common concepts and patterns, they found that messages were not necessarily linked to technological failures or successes but did often respond to criticism and attempted to foster legitimacy around the technologies' future viability. Important to remember, these supporting arguments were often shaped in response to the individual countries' national politics and energy realities and framed differently towards domestic and international markets. In their conclusion, they proclaimed that social science research needs to direct attention to the sense-making processes that formulate perceptions of CCS to grasp ongoing activities and its future potential, which is what we hope to do here.

When discussing how CCS is optimistically framed and positively perceived, Markusson and Shackley (2012) argue that, quite often all other motivations (other than climate mitigation) are downplayed, in order to increase its chances of acceptance. They determine that the creation of these expectations is important for developing shared visions of the technology and its place in the future, creating expectations and producing strong convictions for the technology, and gaining political consensus and mobilising the necessary resources, particularly when the practicality and value of CCS has yet to be demonstrated. However, it must be questioned how these learning and information sharing exercises may be used to influence, even manipulate, others into supporting CCS. Markusson *et al.* (2012) argue that people often look beyond the traditional view of hard facts and internal logic when thinking about technological problem solving, design and development, thus he claims that technologies are often developed and shaped through the interactions of actors. Similarly, Bradbury (2012) also states that people do not evaluate technologies in isolation from their real-life experiences and social affiliations, often relying on their values, interests and experiences, as well as the opinions and influences of others in decision making. With this in mind, Bradbury (2012) recognized that in order to engender trust and increase the chances of CCS acceptance, it is possible to employ experts who are likely to be perceived as independent to provide good quality information, through a mix of formal and informal contexts. She goes on to say that numerous factors may also influence the communication, with timing of consultation and the type of material being communicated, and the potential for two-way dialogue. It is exactly this type of two-way dialogue that we hope to better understand through this research on international CCS cooperation, collaboration, and communications with China.

China – Eagerly Seeking Opportunities or Hesitantly in Need of Convincing?

In order to understand the opportunities and barriers to CCS development, demonstration and deployment within China, we need to understand the factors behind the technologies' possible adoption. As the world's largest carbon emitter since 2011 (Fan, 2011), China is expected to increase its emissions by 100 percent within the next 50 years (Wilson, 2011), making it crucial that the country take real efforts towards reducing its emissions (Morse *et al.,* 2009). It only seems logical that China would see value in CCS adoption as a means of its emissions reductions and climate mitigation. Conveniently, CCS will also enable China to maintain its current development path by consuming large quantities of its vast fossil-fuel resources in the generation of electrical power to drive its industries (Fan, 2011). However, heavily dependent on its abundant domestic coal supply to power its spiralling electricity generation, with a 13-14 percent increase in coal consumption annually, China is increasingly looking towards coal imports (Wilson, 2011), thus threatening not only its energy security but also its economic development. The advancement of carbon capture technologies, despite a 20-30 percent increase in coal consumption, may be of strategic importance to China as some low-carbon technologies under development, such as coal-to-gas technologies, aim to seek ways to improve the efficiency of coal consumption (Wu *et al.,* 2013). There are also additional opportunities for carbon utilisation through EOR, enhanced gas recovery (EGR) and enhanced coal-bed methane (ECBM) retrieval, as well as selling captured CO_2 for industrial use. It is perhaps the technological learnings on energy efficiency and low-carbon technologies that motivate China towards international cooperation with developed countries for knowledge, support and most of all funding on CCS development, demonstration and deployment (Seligsohn, 2013).

Government support for CCS has been considered inadequate and inconsistent, leaving CCS development in the hands of the private sector. The IEA estimated an additional 200-300 million tonnes of coal needed annually for CCS operations (Morse *et al.,* 2009), therefore it seems only reasonable that CCS would be welcomed by the coal industry in China. At the same time, this estimated 20-30 percent increase in coal consumption would undoubtedly strain the already pressurised coal infrastructure (Morse *et al.,* 2009). Unfortunately, CCS has not garnered much support with the power generation companies in China, with installation costs and infrastructure expenditure estimated at between US$300-600bn over the next thirty years. Additionally, as annual operating costs are expected to rise by between 50-100 percent (Morse *et al.,* 2009), the additional financing needed by the private sector would significantly reduce their already narrow profit margins. As power market reform is unlikely in the foreseeable future and an estimated 40-80 percent increase to the cost of power generation (Wilson, 2011), it appears unlikely that the CCS can gain support within the private sector. Likewise, CCS may also prove unpopular with state-owned enterprises and officials at the lower levels of government, who depend on the availability of affordable energy to drive their local economies. The big question then is how will CCS development, demonstration and deployment in China be financed?

In 2011, Xie Zhenhua, the Chinese Minister for Climate Change, first referred to CCS as a possible option for China and the National Development and Reform Commission (NDRC) began formulating policies in support of pilot demonstration projects in 2013. Launching a host of CCS pilot demonstration projects at various stages of planning, construction and implementation, the Ministry of Science and Technology (MOST) had provided the initial capital for smaller research and demonstration projects through special funding and niche subsidies (Morse *et al.,* 2009). However, recognising the potential opportunities that would arise from international cooperation on CCS, Minister Xie was clear that under current conditions, if the international community expects China to adopt CCS as a tool of climate mitigation, it would be up to the international community to support such efforts financially (Seligsohn, 2013; Morse *et al.,* 2009). Confirmed by the IEA who provides evidence to suggest that China will only participate in CCS-related activities if all direct and indirect costs are covered (Drahos, 2009), it appears that China's approach was to showing enthusiasm but not too much at that point in time (Jaccard and Tu, 2011). It then seems likely that if CCS is not incentivised in China, then the full-scale deployment of the technologies remains unlikely in the near future (Wilson, 2011).

The Chinese Government's approach has caused frustration within the international community, as many entities that have been cooperating, collaborating, and communicating with China feel they do not fully understand the country's appetite for the technologies and its longer-term potential for demonstration and deployment. Liang and

Reiner (2013) surveyed the views of Chinese parties involved in CCS to determine their perceptions and behavioural issues towards the technologies in 2006, 2009, and again in 2012, finding that knowledge of CCS and an acknowledgement of its potential had grown dramatically, particularly as climate change was increasingly perceived a priority. The expectation of international financial support to provide a majority of the incremental costs of CCS to be gradually diminishing over time, this might be a reflection that an enhanced awareness of its functionality and benefits might then lead to an increased willingness to pay and less reliance on others to support large-scale demonstration projects in China. Unfortunately, Liang and Reiner's (2013) surveys were highly quantitative and didn't tell us much about both the current appetite for CCS in China and the potential for the country's longer-term adoption of the technologies. This study intends to look at this from a qualitative approach.

According to Gu (2013), China's CCS policy places a premium on international cooperation as a key component of promoting its domestic CCUS industry, with the country hoping to better understand international trends through collaborative efforts. Identifying the many joint statements, Memorandum of Understanding (MoU) and cooperation agreements with the Global CCS Institute (GCCSI), the CSLF, the Asian Development Bank (ADB), NZEC and US-China Five Initiative Plan Agreement, Gu (2013) also recognized that these initiatives largely entailed technical exchanges and capacity building activities and efforts towards promoting demonstration and developing regulatory frameworks domestically in order to overcome the obstacles towards deployment. Outlining the very quick progress and achievements made in the past decade, Li *et al.* (2016) sees it necessary for China to continue strengthening and intensifying these international exchanges and cooperation for both technical and financial support at both the bilaterally and multilaterally, in order to narrow the gap with the advanced international levels. Crucially, to advance the technologies through successful R&D and demonstration, Li *et al.* (2016) provides recommendations for overcoming several important influential factors, such as technological maturity, stakeholder coordination, and information sharing.

In short, China's huge GHG emissions and massive coal consumption presents a real opportunity for CCS to advance in the country, which is attractive to many western industrial countries who seek opportunities for pilot projects and large-scale commercial demonstration. In doing that, the biggest challenge will be overcoming the barriers related to the Chinese Government's political hesitation to be an early mover in this space and the economic barriers towards convincing Chinese public and private sector partners to invest in these costly projects that have uncertain outcomes.

Theoretical Entry Point

When considering the international diffusion of CCS, Vallentin's (2007) study concentrates on the influence of policy incentives within the power sector of a number of countries, including China. Paying specific attention to the various international and national instruments that might stimulate adoption, he also investigated the various technological variants, the conditions of each market, and existing institutional frameworks that might induce deployment. He concludes that CCS incorporates immense uncertainties which may make it hard for the technologies to be diffusible at a broad scale, both nationally and internationally. He goes on to say that this might be the case, unless there is a combination of stringent carbon reduction targets, intensive international collaboration, a global policy framework which could act as a CCS deployment strategy (such as a cap-and-trade CO_2 market), effective provisions and mechanisms for the inclusion of developing and emerging economies into the climate regime, and policy incentives for CCS R&D and demonstration, learning and dissemination.

Lai *et al.* (2012) analysed the structure of China's CCS efforts from a Technological Innovation System (TIS) perspective by examining the key socio-political components, such as institutions, actor-networks, and technology development, whilst providing policy recommendations to formulate a robust innovation system in order to avoid the valley of death scenario between the innovative R&D and large-scale commercial deployment stages. Noting that the traditional theoretical understandings of technological innovation systems are linear, Lai *et al.* (2012) found the technology push and market pull models used by Bush (1945) and Godin (2006) do not fully capture the trajectory of innovation diffusion. As scholarly attention had been moving away from economic systems towards social systems, alternative innovation diffusion frameworks were now acknowledging the flow of knowledge and technology through social networks and interaction of actors in the innovation process. Using the TIS to outline the supportive nature of China's distinct national institutional infrastructure towards CCS, Lai *et al.* (2012) then used actor-network analysis, which can be critical for the success of the technologies' development, to examine the composition and strength of the Chinese CCS innovation system. As well as finding a highly centralised system around government supported R&D initiatives, they identified several functional weaknesses with various actors within the CCS innovation system suggesting it was not as strong in its entirety. Although performing well in terms of knowledge development, the Chinese CCS innovation system was weak in terms of knowledge diffusion, market creation, resource mobilisation and large-scale adoption. With international institutions and government programmes seen as driving domestic development, there was acknowledgement of the need for inter-organisational consortiums, cross-sector collaboration, and mechanisms to legitimise the technology in order to bridge through the 'valley of death.'

Contributions to the Literature

My contributions to the CCS literature are as follows:

Firstly, this research builds on and extends the work of Stephens (2011) as we know less about how the international community around CCS is structured, how it functions, and how it communicates, as well as how it might influence policy processes. This thesis seeks to fill that knowledge gap, while focusing on the influence of the International CCS Community on China.

Secondly, considering the challenges of global CCS governance and the emergence of multilateral CCS cooperation, as well as the phenomenal rise of bilateral collaboration with China, I investigate the various methods international entities have used to communicate and the impact such communications might have on the country's acceptance of the technologies. Specifically, I respond to the call from Bäckstrand *et al.* (2011:277) for CCS researchers to move beyond communications studies related to public perception and respond to the prompt from Stephens and Liu (2012:146-148) to investigate the multitude of new communication mechanisms within the CCS community and their possible influence on CCS-related policy processes, which these scholars say has not yet been studied.

Thirdly, I aim to respond to the frustrations of those international partners that are cooperating, collaborating, and communicating with China, as they are unsure of the country's real appetite for CCS and the potential of Chinese demonstration and deployment (Wilson, 2011). Therefore, I will build on Liang and Reiner's (2013) earlier quantitative surveys on Chinese stakeholders' perceptions and behavioural issues towards CCS by supplementing a more comprehensive qualitative assessment of China's appetite for CCS and the prospects for the country's longer-term adoption of the technologies.

Finally, this chapter complements Vallentin's (2007) international CCS diffusion study by focusing on soft-governance diffusion to better understand how these functions can contribute to a global CCS diffusion framework, initiatives, and mechanisms for collaboration, learning, and information sharing. Additionally, it complements the Lai *et al.* (2012) study on Chinese CCS development by focusing on the alternative innovation diffusion frameworks that acknowledge the flow of knowledge and technology through social networks and interaction of actors in the innovation process.

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Chapter Three: Theoretical Framework – The Diffusion of Innovations

The focus of this research is how the more-experienced International CCS Community has used cooperation, collaboration, and communications with China to influence the country's CCS-related policy processes and its domestic uptake of CCS technologies. Everett Rogers' "Diffusion of Innovations (DOI)" (2003) provides many theoretical themes and concepts that lent themselves well to this research, such as change agents, diffusion networks, communication campaigns, and the innovation decision process. Traditionally, diffusionism has been considered to be a one-way linear process whereby a completed innovation is transferred from motivated experts to more passive adopters. Conversely, others believe that innovations emerge from numerous local sources and then evolve as they diffuse along more horizontal networks. I believe that these two diffusion processes are not mutually exclusive and that a hybrid model of diffusion exists, one that includes both elements and characteristics of both centralised and decentralised diffusion systems. This chapter begins with a review of Rogers' model of innovation diffusion and goes on to look at the critique of that particular theory before going on to propose the existence of a hybrid model of innovation diffusion, which responds to Rogers' limitations.

Rogers (2003:5) defines the DOI as "the process by which an innovation is communicated through certain channels over time among the members of a social system." Through providing highly-relevant theoretical themes with associated conceptual components, the DOI theory provides traditionally-held beliefs (discussed earlier) that technological innovation diffusion systems are centralised (from the international community into China in our case) and explores how knowledge and technologies may flow through social networks and by way of interactions with different actors throughout the innovation development process. While offering theoretical and conceptual guidance on which to structure this research, there are significant opportunities to challenge Rogers' theory and to adapt the DOI paradigm in an attempt to capture the realities of innovation diffusion to the emerging economies. Criticised for being "pro-innovation" (believing that technologies *should* be adopted, *not* rejected, and *never* re-invented), Rogers tells us how he has been accused, along with this DOI theory, of allowing "source bias" (where parties promoting such technologies are considered more knowledgeable of the benefits and consequences of adoption that those adopting), as well as not fully considering the methodological incompatibility and issues around cross-culturally validity (Rogers, 2003:118). Lambasted for his polarised "inside" and "outside" views of the world and for portraying diffusion as an "elitist" exchange of ideas from a progressive and enlightened westernised centre to lesser developed "subject community," Rogers' theory was also likened to modern-day imperialism and colonialism and earned him the title of "Arch-Diffusionist" (Blaut, 1987:30).

Taking this into account, this research aims to challenge Rogers' concepts of 'centralised' diffusion and Donald Schön's (1971) 'decentralised' diffusion systems and then to explore the possibility of a truly hybrid model of diffusion. As my overarching theoretical contribution to the DOI paradigm, this idea of a 'hybrid diffusion system' allows me to challenge the assumption of linear, western, and elitist propositions of innovation diffusions. Importantly, for the advancement of CCS, a truly hybrid model of diffusion would not only allow all parties to find a common language and to communicate around the technologies but provide the very real-world potential of quickening technological development, demonstration, and deployment. However, before we go too deeply into these aspects of this research, it is important to give a brief history on the development of the theory and to expand on the main criticisms of both DOI and Rogers, while also demonstrating more clearly the application and adaptation of the DOI paradigm within the context of international CCS cooperation with China.

Everett Rogers' "Diffusion of Innovations (DOI)" (2003) and its Development

According to Rogers, modern diffusion research owes its roots to Gabriel de Tarde and his book *The Laws of Imitation* (1880; 1903). de Tarde made many insightful and practical observations of macro societal-level phenomena (Kinnunen, 1996:431), such as the adoption of innovations through "imitation." Criticised for being "altogether too mechanistic and unthinking," de Tarde placed an emphasis on individual "follow-the-leader" voluntary adoption, while neglecting external (normative and coercive) constraints and pressures (Katz, 2006:4). Another early diffusion scholar, Georg Simmel, in his book *The Web of Group Affiliations* (1955), examined the idea of individual thought and action, with the role of relations and networks (Dearing, 2008:101). His most notable contribution was the concept of 'stranger.' Considered to be objective, while gaining information from the system, the stranger is "not radically committed to the unique ingredients and peculiar tendencies of the group, and […] is bound by no commitments which could prejudice his perception, understanding, and evaluation of the given" (Simmel, 1955:404-405).

The term 'diffusion' itself was popularised through the 1943 hybrid seed corn study conducted by Bryce Ryan and Neal C. Gross. This study is considered to have made the greatest impact on the DOI paradigm (Rogers, 2003:31-35), creating an academic template to be mimicked in many later studies (Roger, 1983:56), and credited to have "broken the damn" on diffusion research, while also identifying the role of communication channels and change agents at different stages of the innovation-decision process. With a need to first recognize the role played by Beal and Bohlen's (1957) synthesis of diffusion investigations for popularising diffusion research and enabling it to gain academic and financial support (Valente and Rogers, 1995:252), the second most "influential" study, according to Rogers, is the Columbia University drug diffusion investigation conducted by Coleman, Katz, and Menzel (1957). This study's greatest paradigmatic contribution was the addition of 'subjective evaluations,' 'opinion leaders' and 'interpersonal diffusion networks,' showing that more than anything else, it is the social power of peers that often leads to the adoption of the new ideas, confirming that diffusion is indeed a social process (Rogers, 2003:65-68).

Expanding within many "intellectual enclaves," the once "formerly impermeable boundaries" began to break down in the 1960s. This created a more "unified cross-disciplinary viewpoint" with integrated concepts and interdisciplinary generalisations (Rogers, 2003:39-40). These concepts and generalizations (Rogers, 2003:104) became the components of the DOI paradigm, bridging methodologies used by both academics and practitioners interested in seeking the solutions to real-world problems (Dearing, 2008:102). This unity of view point can, in part, be attributed to Rogers' continuous development, refinement, and expansion of his theory, manifested in his 1963 book, "Diffusion of Innovations" (Kinnunen, 1996:437), and its subsequent editions. Since its publication, Rogerian research on diffusion has become increasingly interdisciplinary, taking place globally (Downs and Mohr, 1976:701) and incorporating a much larger range of innovations. While offering many advantages to diffusion scholars throughout the years, the DOI theory had been relatively free from critique until the 1970s (Rogers, 2003:102).

Arch-Diffusionist and Elitist Diffusionism: Criticisms of Rogers and a Critique of the DOI

Prior to 2003, most scholarly attention had been largely centred around debating the smaller and less significant methodological criticisms of the DOI theory. Recognizing that this lack of real critical engagement with the DOI theory was one of its greatest weaknesses, Rogers (2003:106) saw it as healthy to confront any criticism head on. Acknowledging himself the more conceptual critique of the theory, other (less-forgiving) scholars identified the more substantial theory-based critiques which are highly relevant to this research.

In the 2003 edition of his book, Rogers identifies a number of prominent weaknesses in his theory. Firstly, he mentions a "pro-innovation bias," which he defines as "the implication in diffusion research that an innovation should be diffused and adopted by all members of a social system that it should be diffused more rapidly, and that the innovation should be neither re-invented nor rejected" (Rogers, 2003:106). He attributes this pro-innovation bias to the study of many successfully-diffused innovations with seemingly high degrees of relative advantage, without real consideration that in many cases adoption may not be advantageous for certain adopters. As pro-innovation bias occurs when research is funded, sponsored or undertaken by governments, manufacturers and/or individuals who promote innovations, they often emphasise the "unquestionable benefits" to potential adopters and their proponents (Rogers, 2003:111).

Rogers (2003:118) also identifies a "source bias," which is the "tendency to side with these 'change agents' that promote innovations rather than with the individuals who are potential adopters." He recognises that due to the sponsorship of many diffusion investigations, often the individual is blamed rather than the system which caused them, and vice versa. He provides the analogy that “if the shoe doesn’t fit, there’s something wrong with your foot” (Rogers, 2003:119). With this bias, later adopters and innovation-accepting laggards are often blamed or seen as “irrational” for late- or non-adoption, when in fact it may not be in their best interests to adopt. The system, however, does not consider that in fact the problem may lay with their own lack of knowledge of the specific consequences to adoption by these groups (Rogers, 2003:121).

More importantly, Rogers pays particular attention to issues of socio-economic inequalities, especially with the developing world. He acknowledges that a “strong stamp of made in America” was present on many diffusion studies that focused on investigations in Asia, Africa and Latin America. One such example is the diffusion of western gender determination medical technology to rural India and China. Although generally considered a beneficial innovation, its diffusion to communities and societies and very different social and cultural attitudes without considering its full impact may lead to unintended and disastrous consequences. Although initially seen as theoretically and methodologically compatible and cross-culturally valid, in the 1970s, many western and local scholars began to question the cultural appropriateness of the application of western social science research to very different socio-cultural conditions within developing nations. These studies, perhaps unconsciously, supported the ideas of economic growth (urbanisation and industrialisation), expensive labour-saving technologies (often imported from western industrialised nations), and centralised planning (by economists and bankers to speed development). However, key to this is the idea that the roots of underdevelopment lay with the developing country, avoiding acknowledgement that external relations, such as trade with the developed world, may be to blame. Having the potential to bring about greater material and social advancement, diffusion holds the possibilities to disadvantage and subordinate certain groups (Rogers, 2003:121).

Other scholars, however, are not so lenient with their criticisms of Rogers’ diffusion. The harshest of these comes from Blaut (1987:30) who sees Rogers as the “Arch-diffusionist” and diffusionism as having been strongly, yet not thoroughly, criticised. He accuses Rogers of “demographic taxonomy,” by sorting peasant mentalities into pro-innovation cosmopolites and non-innovative laggards, polarizing the world into “inside” and “outside.” He determines that modern diffusion has been “reinvigorated” with the assumptions that “progress” for the developing world means the diffusion and acceptance of “modernised” ideas, traits and socio-political behaviour of developed countries within multinational capitalism. He criticises diffusionism as “elitist,” by considering invention to be “rare,” with innovations (such as ideas, intellect, moral products) flowing from a rational, progressive, cosmopolitan, modernised, civilised, Europeanised and Westernised centre to backward ‘periphery’ regions inhabited by “natural races.” Blaut criticises the assertion that diffusion primarily takes place voluntarily between individuals though interpersonal communications, rather than between communities and cultures. He even links diffusionism with imperialism and colonialism, whereby there is a “grand transaction” of goods, materials or people provided in return for “enlightenment” and “civilization” (Blaut, 1987:31-32).

McMaster and Wastell (2005:385-397) support Blaut’s criticisms of diffusionism as a justification for “Euro-centric superiority” and “colonialism” whereby an “elite few gains power and influence over a subject community.” They argue that diffusion is an attempt at ideological and “self-serving moral dichotomy” towards adoption as desirable and progressive, while portraying non-adoption failure as resistance to progress. They accuse diffusionism of employing “pseudo-scientific arguments” as moral justification to “appease uncomfortable questions,” whilst holding simple formulations that promise to make accurate predictions based on a small number of variables, thus obscuring the political realities and complexities of the real world. These facts, however, are considered by diffusion scholars to be derived from unique sources where “immutable objects waiting either to be uncovered or invented by superhuman discoverers and inventors” which once “discovered” mysteriously and freely spread throughout society, reinforcing their claims that diffusion is all but a “myth.” They rather harshly accuse diffusion scholars of colluding “in the production of pseudo-scientific knowledge to validate aspects of diffusionist mythology […] without any self-critical awareness of the paradigm in which they operate.”

Without going into too much detail or being overly explanatory until one is awareness of the theoretical themes and conceptual components of the DOI (which will be discussed in the respective chapters), these arguments primarily set the scene for the theory’s application (to international CCS cooperation with China) and adaptation of the paradigm (to consider the potential for a truly hybrid model of diffusion) in the research.

Models of Innovation Diffusion: Centralised, Decentralised or Hybrid

Typically, within diffusion studies, there are two types of systems which assist us in identifying the possible approaches used by parties for the diffusion of innovations within a ‘client social system.’ The first is the concept of a ‘centralised diffusion system,’ whereby an “innovation originates from an expert source” and then “diffuses the innovation as a uniform package to potential adopters who accept or reject the innovation.” Such adopters are often seen as “relatively passive acceptors” with the “key decisions about which innovations to diffuse, how to diffuse them and to whom, made by technically-expert officials near the top of the diffusion system.” There is the opinion, however, that centralised systems use more one-way (linear) models of communication (Rogers, 2003:395-9).

Conversely, Schön (1971) determines that while in many scenarios this traditional model of diffusion may have relevance, in other circumstances, it is often overly simplistic and not reflective of all reality. He provided the alternative conceptual model of a “decentralised diffusion system,” whereby an innovation may “originate from numerous local sources and then evolve as they diffuse via horizontal networks” with “a certain degree of re-invention occurring as the innovation is modified by users to fit their particular conditions." Schön (1971) also argues that decentralised systems are therefore not centrally managed by officials and technical experts and that diffusion decisions are often shared with those who may or may not adopt. Decentralised systems are thought to involve more of a two-way "convergence model of communications," whereby "participants create and share information with one another in order to reach a mutual understanding" (Rogers and Kincaid, 1981).

One striking advantage of a decentralised system over a centralised system is that the innovations diffused are more closely in tune with the needs of the social system. For potential adopters seeking more relevant information from more trusted homophilous sources, this provides them more control over their own decisions and potential adoption experiences. With the assumption that members within a decentralised system have greater ability to make sound decisions on managing diffusion, this likelihood is sharply increased when they are highly educated and technically competent experts themselves. Although in the absence of a sufficient level of technical expertise, inadequate innovations with undesirable effects could also be diffused, perhaps with devastating consequences.

<table>
<tr><th>Centralised
Diffusion System
(Rogers, 2003:395-9)</th><th>Decentralised
Diffusion System
(Schön, 1971)</th><th>Hybrid Model
Of Diffusion
(Proposition)</th></tr>
<tr><td>Innovation originates from an expert source</td><td>Originate from numerous local sources and then evolves as diffused via horizontal networks</td><td rowspan="4">The application of the DOI theory (within the context of international CCS cooperation with China) and adaptation of the DOI paradigm (to consider the potential for a truly hybrid model of diffusion):

A truly hybrid model of diffusion would allow all parties to find a common language and to communicate around the technologies but would provide the potential of quickening technological development, demonstration, and deployment</td></tr>
<tr><td>One-way (linear) models of communication of diffusing a uniform package</td><td>More of a two-way convergence model of communications with a degree of reinvention occurring as the innovation is modified to fit particular conditions</td></tr>
<tr><td>Diffused to relatively passive acceptors</td><td>Participants create and share information with one another in order to reach a mutual understanding</td></tr>
<tr><td>Key decisions are made by technically-expert officials near the top of the diffusion system</td><td>Diffusion and decisions are often shared with those who may or may not adopt</td></tr>
</table>

Table 3.1. The characteristics of centralised, decentralised, and hybrid models of diffusion

Most relevant to this research is Rogers' acknowledgement that certain elements of centralised and decentralised diffusion systems might be able to be combined to form a 'hybrid diffusion system' that uniquely fits a particular situation (Rogers, 2003:395-9). Therefore, this investigation set out to explore Rogers' idea of a 'hybrid model of diffusion' and how the application of certain theoretical themes and conceptual components might have been applied (and could be utilised) to the acceleration of the diffusion of CCS within China and to other technologies' development more generally, leading to the potential for wide-spread deployment globally. However, before we delve into this idea more deeply, it's important to lay out what these theoretical themes and conceptual components are and how they relate to the research areas being explored.

DOI Theoretical Themes and Conceptual Components

Rogers (2003:18) describes diffusion as "a particular type of communication in which the message content that is exchanged is concerned with a new idea." He states that "in its most elementary form, the process involves an innovation, an individual or other unit of adoption that has knowledge of, or has experienced using, the innovation, another individual or other unit that does not yet have knowledge of, or experience with, the innovation, and a communication channel connecting the two units." With this providing the stepping stones for the expansion of the DOI paradigm, at this point it is important for me to define what 'an innovation' means in this context.

An Innovation (Hardware and Software)

For Rogers (2003:12) an innovation is an "idea, practice, or object that is 'perceived' as new by an individual or other unit of adoption." Although CCS is a relatively new idea to most people, both in China and globally, some of the concepts and processes have been used before, however, not until relatively recently as a full chain of technologies and for the purposes of mitigating climate change.

As a technological innovation, CCS contains both 'hardware' and 'software' aspects, which Rogers (2003:139-40) sees as identifiable tools or objects and less visible informational components. This conceptual understanding combines both the technologies that constitute its physical objects, and the practices, policies and knowledge behind its practical application, which form its software components. CCS can be described more as a technology cluster, which Rogers (2003:153,249-50) sees as consisting of a number of distinguishable but interrelated technologies, which are often packaged and diffused at the same time. CCS can also mean different things to different people, from the very obvious components of CO_2 capture, CO_2 transportation and CO_2 storage, to the less known areas of CO_2 utilisation, policies regulations and monitoring, to all the minute sub-specialities that comprise the entire CCS chain. Rogers (2003:14-15) warns, however, that an important conceptual and methodological issue is how to determine the boundaries around a technological innovation and to identify where one innovation stops and another one begins. This, he states, is defined by the perception of the potential adopters and is something which has been investigated very little. With this in mind, in order to define the boundaries of CCS, I was careful in my research to allow research subjects to tell me what they perceive CCS to be and for this to define collectively what CCS is to the Chinese CCS community as a whole.

While CCS is clearly the ‘innovation’ within this research, the subject-matter themes under investigation are: the ‘International CCS Community’ (as the more knowledgeable and experienced party), the ‘Chinese CCS Community’ (as the less knowledgeable and experienced parties), and ‘Sino-International CCS Cooperation and Collaboration’ (the communication channels that link both sides). In addition to Roger’s original theoretical themes, I’ve also included an additional theoretical theme (the ‘Innovation-Decision process’), which allows me to look at the efforts towards removing the uncertainties around the innovation during the Chinese innovation–development process. With the ultimate goal of applying the DOI theory within the context of international CCS cooperation with China and adapting the DOI paradigm to consider the potential for a truly hybrid model of diffusion, this approach is particularly unique in the diffusion literature and the implications this has for China’s adoption of the technologies is potentially great (Table 3.2).

Figure 3.2. Adapting the DOI paradigm to consider the potential for a hybrid model of diffusion in the context of Sino-International CCS cooperation

Research Areas/Themes	Research Questions	Conceptual Components	Centralised Diffusion System	Decentralised Diffusion System	Hybrid Model Of Diffusion
The International CCS Community as the 'More Knowledgeable and Experienced Parties'	1. How is the International CCS Community structured, how does it function, and how does it communicate to influence the CCS-related policy processes? 2. Do the messages regarding CCS originate from expert sources (a centralised system) or numerous local sources (a decentralised system) via horizontal networks?	**Sources of Information** **Diffusion Networks** **Change Agents** **Paraprofessional Aides**	Innovation originates from an expert source	Originate from numerous local sources and then evolves as diffused via horizontal networks	**The Application of the DOI theory (within the context of International CCS Cooperation with China) and Adaptation of the DOI Paradigm (to consider the potential for a truly hybrid model of diffusion):** A truly hybrid model of diffusion would allow all parties to find a common language and to communicate around the technologies but would provide the potential of quickening technological development, demonstration, and deployment
Sino-International CCS Cooperation and Collaboration as the 'Communication Channels'	3. By what means or through what methods do international parties cooperate, collaborate and communicate with Chinese parties to share information about and their experiences of CCS? 4. Are the communications channels primarily one-way/linear where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system) or two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system)?	**Communication Campaigns** **Communication Channels** **Exemplary and Experimental Demonstrations** **Perceived Characteristics**	One-way (linear) models of communication of diffusing a uniform package	More of a two-way convergence model of communications with a degree of reinvention occurring as the innovation is modified to fit particular conditions	
The Chinese CCS Community as the 'Less Knowledgeable and Experienced Parties'	5. What are the motivations and behaviours of the Chinese parties in engaging in CCS-related activities and what does this tell us about the current and future domestic development of the technologies? 6. Are Chinese stakeholders relatively passive acceptors of CCS (a centralised system) or do they actively participate in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system)?	**Social System** **Innovation-Development Process** **Instrumental Action and Motivations**	Diffused to relatively passive acceptors	Participants create and share information with one another in order to reach a mutual understanding	
Removing CCS Uncertainties and Accelerating Technologies' Deployment through the 'Innovation-Decision Process'	7. How can international entities employ various types of communications channels to diffuse different kinds of CCS-related information that may influence Chinese decision-making processes? 8. Are key decisions made by technically-expert officials near the top of the diffusion system (a centralised system) or if such decisions about diffusion should be made shared with those who may or may not wish to adopt (a decentralised system)?	**Innovation-Decision Process** **Hierarchy of Communication Effects** **Rate of Adoption** **Hybrid Model of Diffusion**	Key decisions are made by technically-expert officials near the top of the diffusion system	Diffusion and decisions are often shared with those who may or may not adopt	

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Chapter Four: Methodological & Analytical Approaches

During this research, I employed a number of methodological and analytical approaches, ranging from communications surveys to gather quantitative data, semi-structured interviews to gather more qualitative information, and case studies analysis to provide wider political and geographical information to supplement my findings.

While undertaking my initial CCS-related literature review, I began to collect relevant information relating to CCS programmes and projects that had an element of cooperation between Chinese and international parties. Without knowing much about the background of these initiatives, a number of things stood out to me; firstly, that they were all primarily led by foreign government departments or bodies; secondly, that these were primarily from western, industrialised, and relatively rich (fossil-fuel dependent) nations; and lastly, that the arrangements were primarily based on soft governance functions (MoU or cooperative agreements) and activities (policy seminars, technical workshops, and/or capacity building) that involved very short-term and/or tentative commitments with little real material obligation or provision (i.e., technology transfer or funding).

From these initial observations (and in light of the seriousness of climate change, the urgency of western parties to deploy CCS, and the very real potential to demonstrate CCS in China, as well as the overall desire to accelerate the technologies' development), I began to question why this half-hearted approach to cooperate with China might be the case, and to explore what could be done to speed things up. This led me to investigate the International CCS Community and to question their motivations for engaging with China, while also exploring what international parties might be getting from these relationships and efforts. Crucial to this, from a theoretical perspective, I would also need to identify whether these parties were indeed the expert sources of information or if they considered this relationship with China to be one of equals in the development of CCS. Although these initiatives would be examined in greater detail at a later stage, at this point, I needed a way in, so I looked towards these soft governance functions and activities as my initial entry point.

Step One – Scoping Exercise of CCS-related Soft Governance Functions and Activities

Through an online investigation and communications with event organisers and past participants, I sourced the official agendas and participant lists for 21 CCS-related conferences, seminars, workshops and capacity building/ training events, spanning back to 2005. These events were significant, as they had either taken place in China or internationally with a focus on China and/or included a large number of Chinese attendees. While recognising that the actual number of events well exceeded 21, some organisers felt the disclosure of the attendee's personal information was either professionally private or commercially sensitive so were reluctant to do so. Following a preliminary analysis of speakers and participants from the information attained, there appeared to be a high degree of repetition, meaning those already sourced would be sufficient to take the steps needed to communicate with potential research participants and identify the Chinese CCS community. The data from these sources were then compiled into a single database of 840 conference speakers and attendees in order to allow for the distribution of communications surveys and for arranging follow-up face-to-face interviews.

Step Two – Communications Survey and Face-to-Face Interview Script Design

With the full realisation that my ultimate goal was to apply and develop Rogers' theoretical themes and conceptual components to my selected research areas, I began a deconstruction of the DOI theory in order to design an online 'communications survey' and a follow-up 'Face-to-Face Interview Script.' It was my intention through this online survey to recognize those with the right backgrounds and level of experiences and to gather the most beneficial information and to maximise the potential from my limited time and resources. In order to enhance the professionalism and increase the potential for responses, I also personally translated both the survey and interview script, providing a bi-lingual English/Chinese version, which was then proof-read by native speakers of both languages and checked for translation accuracy. With both the theoretical and language issues addressed, I then tested the survey with both Chinese and non-Chinese academics, CCS professionals and doctoral students who had either a background in CCS, in research methods, or both. All feedback was accepted, and any necessary adjustments were made.

Step Three – Adherence to "Code of Conduct" and "Research Ethics Processes"

To observe good research practice and institutional protocol, I was keen to ensure that this investigation endeavoured to honestly and lawfully abide by the University of Nottingham's "Code of Research Conduct" and followed the norms and guidelines of the "Research Ethics Processes" provided by the then School of Contemporary Chinese Studies. The first step in doing so was to make sure that all intended materials and methodologies were reviewed by the school's Research Ethics Officer and Ethics Research Committee, so as to comply with all internal and external systems, requirements and checklists.

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NCCCS
Nottingham Centre for Carbon Capture and Storage

碳捕获与储存（CCS）的扩散：与中国进行国际合作及社会学习
The Diffusion of Carbon Capture and Storage (CCS): International Cooperation and Social Learning with the People's Republic of China

研究简介和声明 Research Introduction & Plain Language Statement

8%

调查介绍: 我的名字是卡尔•詹姆斯•马克林顿 (Karl James McAlinden). 我是英国诺丁汉大学当代中国学学院及地质能量研究中心（GERC）（原诺丁汉碳捕获与储存中心 NCCCS）的博士生. 在英国地质调查所（British Geological Survey）的指导下，我正在撰写我的博士毕业论文，着眼于国际合作在中国碳捕获与储存（CCS）应用中的性质与影响，旨在寻找进行有效合作的机会. 这份调查问卷旨在搜集跟毕业论文有关的数据.

声明:

- 所有的问题都是非强制的，每位应答者都是出于自由意志参加的.
- 这份调查问卷是匿名问卷且在任何时候都不会泄露应答者的身份.
- 这份调查问卷是遵循诺丁汉大学包括道德风险评估备忘录在内的调查规范.
- 调查问卷的内容将会作为一部分被用于本科生的毕业论文因此会有可能出版.

中国当代学院已根据研究道德检查程序对这项研究项目进行检查。这一程序是在学校关于研究行为和研究道德的行为标准的指导下进行的。如果您现在或将来有任何疑问，请联系本人或我的导师。如果您对我在问卷中的研究行为或研究道德有任何质疑，请联系我的导师或者英国诺丁汉大学的道德委员会。

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中国当代学院研究道德官: Andreas.Fulda@nottingham.ac.uk
大学研究道德管理员: Claire.OCallaghan@nottingham.ac.uk

Research Introduction : My name is Karl James McAlinden and I am a PhD candidate at the University of Nottingham's School of Contemporary Chinese Studies and the GeoEnergy Research Centre (GERC) (formally the Nottingham Centre for Carbon Capture and Storage NCCCS). Under the supervision of the British Geological Survey (BGS), I am writing my dissertation on the nature and influence of international cooperation on China's adoption of carbon capture and storage (CCS) with a hope to identify possible opportunities for effective cooperation. This questionnaire has been designed in order to collect data relevant to this topic.

Plain Language Statement:

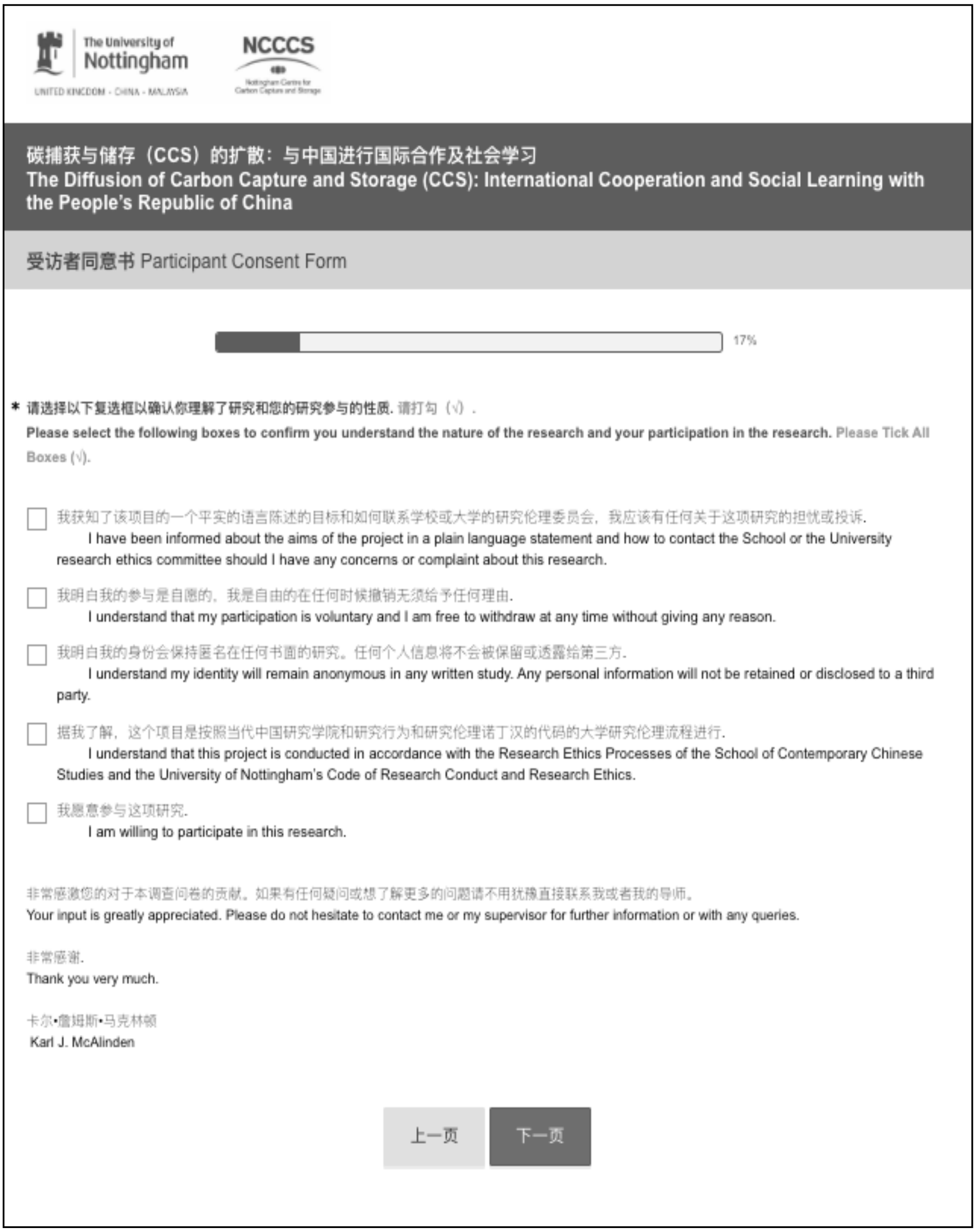
- The following information request is optional and every respondent takes part in this questionnaire out of free will.
- This questionnaire is anonymous and no identities will be included at any stage.
- This questionnaire follows the University of Nottingham's Research Code of Conduct, including the Ethics Risk Assessment Checklist.
- The content of this questionnaire will be used as part of a doctoral dissertation and might therefore be published.

This research project has been reviewed according to the ethical review processes in place in the School of Contemporary Chinese Studies. These processes are governed by the University's Code of Research Conduct and Research Ethics. Should you have any questions now or in the future, please contact me or my supervisor. Should you have concerns related to research ethics, please contact my supervisor or the University's Ethics Committee.

Researcher: Karl James MCALINDEN (llxkjm@nottingham.ac.uk)
Supervisors: Dr Cong CAO (Cong.Cao@nottingham.ac.uk); Dr Zhengxu WANG (zhengxu.wang@nottingham.ac.uk)
School of Contemporary Chinese Studies Research Ethics Officer: Dr Andreas FULDA (Andreas.Fulda@nottingham.ac.uk)
University Research Ethics Committee Administrator: Claire O'CALLAGHAN (Claire.OCallaghan@nottingham.ac.uk)

Figure 4.1. Image of research introduction and online 'Plain Language Statement'

From the outset, participants were informed of the aims, objectives, expected outcomes and likely dissemination strategies of this research and were also given the opportunity to opt out or withdraw their contribution at any time (Figure 4.1.). As promised, all identifiable information collected, as well as the analysis, was kept confidential (only shared with supervisors and project partners), while treated with the utmost respect and stored securely so as to protect against issues of data protection. Copies of the bilingual ''Survey Questions and Follow-up Interview Script," the "Plain Language Statement" and the "Participant Consent Form" (Figure 4.2.) were also kept for future reference.



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The Diffusion of Carbon Capture and Storage (CCS): International Cooperation and Social Learning with the People's Republic of China

受访者同意书 Participant Consent Form

17%

* 请选择以下复选框以确认你理解了研究和您的研究参与的性质. 请打勾（√）.
Please select the following boxes to confirm you understand the nature of the research and your participation in the research. Please Tick All Boxes (√).

☐ 我获知了该项目的一个平实的语言陈述的目标和如何联系学校或大学的研究伦理委员会，我应该有任何关于这项研究的担忧或投诉.
I have been informed about the aims of the project in a plain language statement and how to contact the School or the University research ethics committee should I have any concerns or complaint about this research.

☐ 我明白我的参与是自愿的，我是自由的在任何时候撤销无须给予任何理由.
I understand that my participation is voluntary and I am free to withdraw at any time without giving any reason.

☐ 我明白我的身份会保持匿名在任何书面的研究。任何个人信息将不会被保留或透露给第三方.
I understand my identity will remain anonymous in any written study. Any personal information will not be retained or disclosed to a third party.

☐ 据我了解，这个项目是按照当代中国研究学院和研究行为和研究伦理诺丁汉的代码的大学研究伦理流程进行.
I understand that this project is conducted in accordance with the Research Ethics Processes of the School of Contemporary Chinese Studies and the University of Nottingham's Code of Research Conduct and Research Ethics.

☐ 我愿意参与这项研究.
I am willing to participate in this research.

非常感激您的对于本调查问卷的贡献。如果有任何疑问或想了解更多的问题请不用犹豫直接联系我或者我的导师。
Your input is greatly appreciated. Please do not hesitate to contact me or my supervisor for further information or with any queries.

非常感谢.
Thank you very much.

卡尔•詹姆斯•马克林顿
Karl J. McAlinden

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Figure 4.2. Image of online 'Participant Consent Form'

Step Four – 'Going Live' by Launching the Online Communications Survey

Using the online scoping exercise database, I sourced the names, positions and institutions of 319 (with an additional 204 not found) event attendees whose contact details were available. Many contact details had been provided within the agenda and participant lists collected, however many had not and were located either through online searching or via common professional connections. While it was much easier to source personal and contact information from those in academia and research institutes, attendee information from those within industry and the private sector more generally were much more difficult to locate. Additionally, as many events had taken place between 2005 and 2014, it is only natural that people had moved on professionally and thus their contact information had become outdated. This seemed to be the case for 45 respondents whose survey invitation email bounced back as either 'Email Failure' or 'Undelivered,' leaving 274 assumedly received emails. It also needs to be acknowledged that while many of the attendees were students during that time period, their university email accounts not only ceased to work but they had less of an established professional online presence to allow for such contact information to be sourced.

With preparations for "going live" completed, the survey was then launched on 9 March 2015, one month before I was due to begin my interviews in China. While a considerable number of responses were received within the first few days, a reminder email was sent two weeks later to those who had not yet responded. With the dates of communications with each potential participant recorded (as not to overbear them with requests), a final reminder was then sent in late April (the midpoint of the fieldwork exercise). This reminder informed potential participants that the survey would close in the coming weeks and that this would be their last time to take part, should they be willing. This strategy worked well, as each time reminders were sent naturally the response rate grew. Those that did respond were asked politely to forward the invitation to those they knew working on CCS with me in copy, so that I could follow up afterwards.

As a control mechanism, the survey was designed in a way that those who had little experience of fully engaging with CCS in China would be unable to continue throughout the entire survey, possibly leading to disqualification. During this exercise, I attained partial data sets from 71 key respondents and complete quantitative data sets from 48 key CCS-related individuals, which were then used to guide qualitative face-to-face interviews. While these figures could be considered too low to deduce any significant quantitative findings, they have offered some very valuable supplementary evidence to support my qualitative findings, which I will detail in the next chapter and reference throughout the thesis. However, my main motivations for undertaking this exercise were primarily to open up communications with potential interviewees in China; to disqualify those potential interviewees that may not be the best allocation of time and resources; and to collect preliminary research data and save precious time during face-to-face interviews. This approach worked well, and I had 15 confirmed interviews for my first two weeks in Beijing.

Step Five – China-based Fieldwork: 9 Weeks, 10 Cities, 40 Interviews, and 46 Audio Hours

Arriving in Beijing on 4 April 2015 and leaving nine weeks later on 8 June 2015, I had set the primary objective of this fieldwork exercise as interviewing Chinese CCS stakeholders, collecting data for the completion of my thesis, and familiarising myself with the status of CCS within China, as well as engaging with the Chinese CCS community when possible. Altogether, I visited ten cities (Beijing, Changchun, Dalian, Guangzhou, Hangzhou, Ningbo, Qingdao, Shanghai, Wuhan, and Zhenjiang) (Figure 4.3.), as well as attending the "Workshop on Carbon Capture, Utilisation and Storage (CCUS): Opportunities for Enhanced Oil Recovery (EOR)" hosted by the NDRC and the GCCSI. This workshop was a valuable opportunity to learn first-hand about the current developments and progress of CCS within China and to meet key individuals who otherwise might have been difficult to access. I also took the opportunity to formally and informally present my research project to the Chinese Academy of Science Institute of Policy & Management (CAS-IPM) and the NDRC's Department of Climate Change (DCC), as well as the faculty at UoN Ningbo.

Figure 4.3. Map[1] of cities visited during fieldwork

Having set dates and times for 15 Beijing-based interviews before my arrival, I successfully carrying out 40 formal face-to-face interviews with individuals and small groups throughout the country. With the intention to gather further information based on the data collected throughout the survey, these interviews allowed me to learn more about

[1] Source: https://www.chinahighlights.com/map/china-city-map.htm

the Chinese stakeholders' interactions with international parties, their attitudes towards CCS, and their experiences of adopting the technologies. Although the majority of interviewees had received survey invitations in early March, a number were referred through others within the Chinese CCS Community. Also, realising that not everyone may have the time or patience to undertake the online survey, I sent out a short email to all non-respondents informing them that I was currently in China and would like to speak with them, should they have the time and willingness to meet. This approach worked well.

Step Six – Semi-Structured Interviews (Chinese CCS Innovation-Decision Processes)

While many interviewees had already undertaken the 'Communications Survey' prior to the time I had emailed to request an interview, those that hadn't were prompted to do so before the interview date itself. Although primarily requested in order to gather basic personal and contact information and as a basis to inform our initial interview discussions, this was also intended to improve the completeness of my data set. Failing that, during the interview itself, I collected this information to the best of my ability, without hindering the natural flow of our conversation. The 40 interviewed participants primarily came from Chinese government departments and agencies, state-owned enterprises (SOEs) and private industry, and Chinese Academy of Science's institutions and universities. Due to time and financial constraints, as well as scheduling challenges and logistics, it was not possible to interview an additional 15-20 individuals, who had shown an interest.

Step Seven – Transcription and Translation

Upon returning to the UK, I transcribed the almost 46 hours of bilingual interview audio, while being assisted by a Chinese student within the university to ensure that my transcription and translation of the approximately 18 hours of Chinese language recording was both accurate and true. Despite using a time-saving audio playback software tool, this was an arduous step in the process, which took much more time than I had anticipated.

Grouping these respondents into four primary stakeholder groups, I have used their self-identification and for purposes of anonymity referenced them as follows throughout this thesis: (G) = government, (R) = researcher, (A) = academic, and (I) = industry. These initials are then followed by the interviewee's unique identification number. For example: (G01) = governmental party, interviewee number one. For reference, researchers are those that are only involved in research and academics also have teaching responsibilities.

Step Eight - Analytical Approach and Theoretical Framework

Using the qualitative data analysis software NVivo, I performed my coding during two distinct stages (firstly from the international and secondly the domestic perspectives). This allowed me to focus on the specific research areas more intensively and to structure my findings based on my research areas and questions, while exploring the theoretical themes and concepts applicable to those particular areas.

From an international perspective, my objective was to identify who was influencing China's CCS-related decision-making process, to understand their possible motivations for doing so, and the tools and mechanisms they might use in this process (i.e., change agents, diffusion networks, paraprofessional aides, communications campaigns and channels, as well as demonstrations). This would allow me to assess whether the messages regarding CCS were originating from expert sources (a centralised system) or numerous local sources (a decentralised system) via horizontal network. At the same time, I examined if communications channels were primarily one-way/linear, where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system), or two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system).

From a domestic Chinese perspective, my objective was to better understand the motivations of the Chinese participants and the challenges they face in their adoption of CCS. Taking on board Markusson *et al.* (2012) thinking around "double exposure" (whereby CCS technologies are ready yet still need further development), I used both the theoretical themes and conceptual components from the 'innovation-development process' and 'innovation-decision process' as a guide for my initial qualitative and quantitative analysis. This would allow me to assess if Chinese stakeholders were relatively passive acceptors of CCS (a centralised system) or active participants in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system). At the same time, I looked at whether CCS-related decisions were made by technically-expert officials near the top of the diffusion system (a centralised system) or are such decisions about diffusion shared with those who may or may not wish to adopt (a decentralised system). Ultimately, my goal was to assess whether there is a truly hybrid model of diffusion that would allow all parties to find a common language and to communicate around the technologies, which may provide the potential of quickening CCS's technological development, demonstration, and deployment.

Step Nine – Case Studies – Uncommon Amalgamation

Following Rogers (2003:125-6), who promotes an "uncommon amalgamation," I merged my coded survey and interview data with secondary and supplementary literature to write case studies on the international entities (see Annex). The purpose of this was to uncover the intricacies behind the emergence and development, and those parties behind its development, their motivations and how they "see" the technological innovation and the implications this may have on the diffusion and adoption processes of CCS in China. For me, this provided greater clarity around some of the uncertain/unclear responses from Chinese interviewees, while also filling in the gaps for my own knowledge and understanding. Rogers states that while most diffusion studies neglect to include the innovation-development process of technological innovations, those that do look retrospectively. He reminds us of considerable value in looking at this process prospectively. Crucially, Rogers also pointed out that while such studies almost entirely rely on research publications to reconstruct a partial view of the innovation-development process, thus giving the impression that everything was well planned and organised, this often ignores the intricacies that went into the innovation's development. He advises that future research should investigate how research priorities and agendas are set, how needs and problems are communicated to (and by) R&D workers, what role lead users may have, and what are the key linkages and interrelationships among the various organisations in the development of a technological innovation within the innovation-development process.

Robert K. Yin's "Case Study Research Design and Methods" (2014) was seen as a pioneering study for the use of case studies as a separate and all-encompassing method with its own research design. First published in 1984, the most recent (fifth) edition recognises the advances in the area of case study research and provides a comprehensive guide for the design and application of case study research, which stands up to any questions around the methodology's validity and reliability. Yin (2014:16) defines case study as "an empirical inquiry that investigates a contemporary phenomenon (the 'case') in depth and within its real-world context," which can help explain the outcomes by matching empirically-observed events with theoretically predicted events. As noted by Hollweck (2015), within his book, Yin emphasises "rigour, validity, and reliability," with the need for high-quality case study research to focus on "readability, credibility, and concern with confirmability [of] all matter" (Yin, 2014:192). He also makes reference to the need for data triangulation and the logic model of using three types of information as an analytical tool that can be used with both qualitative and quantitative case study data. Given the many real-world gaps within my data collection, Yin's case study methodological and analytical approaches are highly relevant and critical to this research. Using a combination of my survey data, interview transcripts, and secondary and supplementary literature, the annexed case studies allowed me to write more rigorous, valid, and reliable analytical chapters of this thesis, which although dense at times has greatly improved the quality of this research.

Figure 4.4. Adapting the DOI paradigm to consider the potential for a hybrid model of diffusion in the context of Sino-International CCS cooperation

Research Areas/Themes	Research Questions	Conceptual Components	Centralised Diffusion System	Decentralised Diffusion System	Hybrid Model Of Diffusion
The International CCS Community as the 'More Knowledgeable and Experienced Parties'	9. How is the International CCS Community structured, how does it function, and how does it communicate to influence the CCS-related policy processes? 10. Do the messages regarding CCS originate from expert sources (a centralised system) or numerous local sources (a decentralised system) via horizontal networks?	**Sources of Information** **Diffusion Networks** **Change Agents** **Paraprofessional Aides**	Innovation originates from an expert source	Originate from numerous local sources and then evolves as diffused via horizontal networks	**The Application of the DOI theory (within the context of International CCS Cooperation with China) and Adaptation of the DOI Paradigm (to consider the potential for a truly hybrid model of diffusion):** A truly hybrid model of diffusion would allow all parties to find a common language and to communicate around the technologies but would provide the potential of quickening technological development, demonstration, and deployment
Sino-International CCS Cooperation and Collaboration as the 'Communication Channels'	11. By what means or through what methods do international parties cooperate, collaborate and communicate with Chinese parties to share information about and their experiences of CCS? 12. Are the communications channels primarily one-way/linear where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system) or two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system)?	**Communication Campaigns** **Communication Channels** **Exemplary and Experimental Demonstrations** **Perceived Characteristics**	One-way (linear) models of communication of diffusing a uniform package	More of a two-way convergence model of communications with a degree of reinvention occurring as the innovation is modified to fit particular conditions	
The Chinese CCS Community as the 'Less Knowledgeable and Experienced Parties'	13. What are the motivations and behaviours of the Chinese parties in engaging in CCS-related activities and what does this tell us about the current and future domestic development of the technologies? 14. Are Chinese stakeholders relatively passive acceptors of CCS (a centralised system) or do they actively participate in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system)?	**Social System** **Innovation-Development Process** **Instrumental Action and Motivations**	Diffused to relatively passive acceptors	Participants create and share information with one another in order to reach a mutual understanding	
Removing CCS Uncertainties and Accelerating Technologies' Deployment through the 'Innovation-Decision Process'	15. How can international entities employ various types of communications channels to diffuse different kinds of CCS-related information that may influence Chinese decision-making processes? 16. Are key decisions made by technically-expert officials near the top of the diffusion system (a centralised system) or if such decisions about diffusion should be made shared with those who may or may not wish to adopt (a decentralised system)?	**Innovation-Decision Process** **Hierarchy of Communication Effects** **Rate of Adoption** **Hybrid Model of Diffusion**	Key decisions are made by technically-expert officials near the top of the diffusion system	Diffusion and decisions are often shared with those who may or may not adopt	

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Chapter Five: Research Results – Communications Survey Data

As mentioned earlier, the Communications Survey was sent ahead of potential interviews with the intention of gathering preliminary data that could be used to probe for additional information during the semi-structured interviews.

Personal and Professional Information

Of the 71 responses to the Communications Survey, an overwhelming 82 percent (58) of participants identified as male, compared to only 18 percent (13) of participants identifying as female (Figure 5.1.). This group appeared to be well educated (96 percent having advanced degrees) and experienced (82 percent coming from mid-senior management levels), while also being financially comfortable or affluent and able to converse effectively in English (Figures 5.2. to 5.5.). However, the group was not entirely homogeneous, as a number of participants held only Bachelors' degrees (3 percent), with some in the early stages of their careers (18 percent at student/entry levels) and a few having little monthly income (1 percent), or an inability to communicate effectively in the English language (10 percent). This, however, would only add to the richness of the qualitative responses on their CCS adoption experiences.

Figure 5.1. Gender

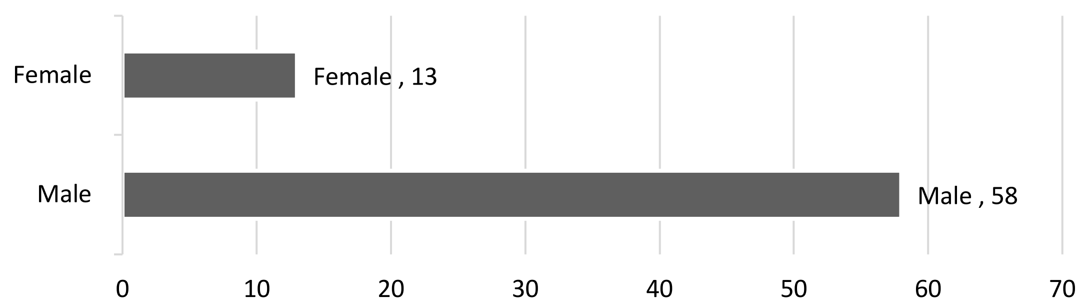


Figure 5.2. Education Level

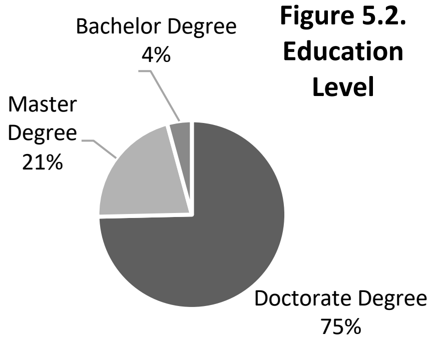
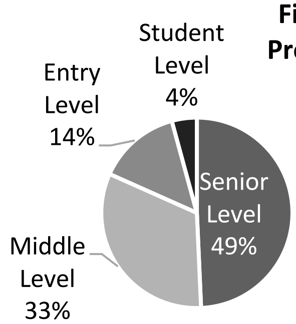


Figure 5.3. Professional Level



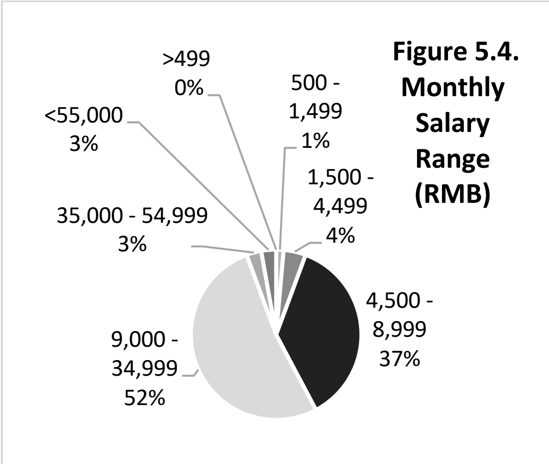


Figure 5.4. Monthly Salary Range (RMB)

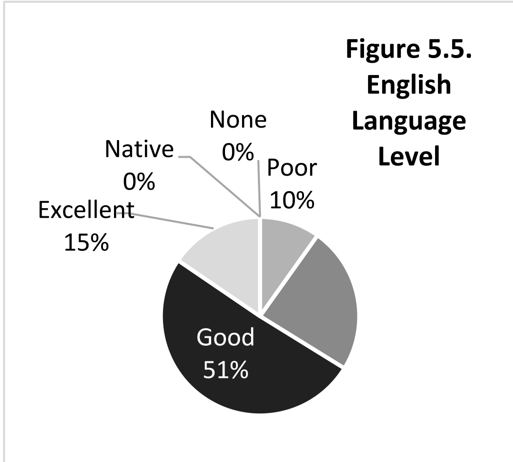


Figure 5.5. English Language Level

While keeping an open mind into who might respond, I sought to find an equal balance between those within key stakeholder groups that may work on different aspects of CCS technologies and the related policy areas, and those that might have engaged with international parties. For this reason, I asked those surveyed to identify which industries or sectors they worked in (Figure 5.6.). However, given what I know now, it was not entirely possible to find an equal distribution of participants from all industries and sectors, as these results largely reflected the developmental status of CCS within China at the time.

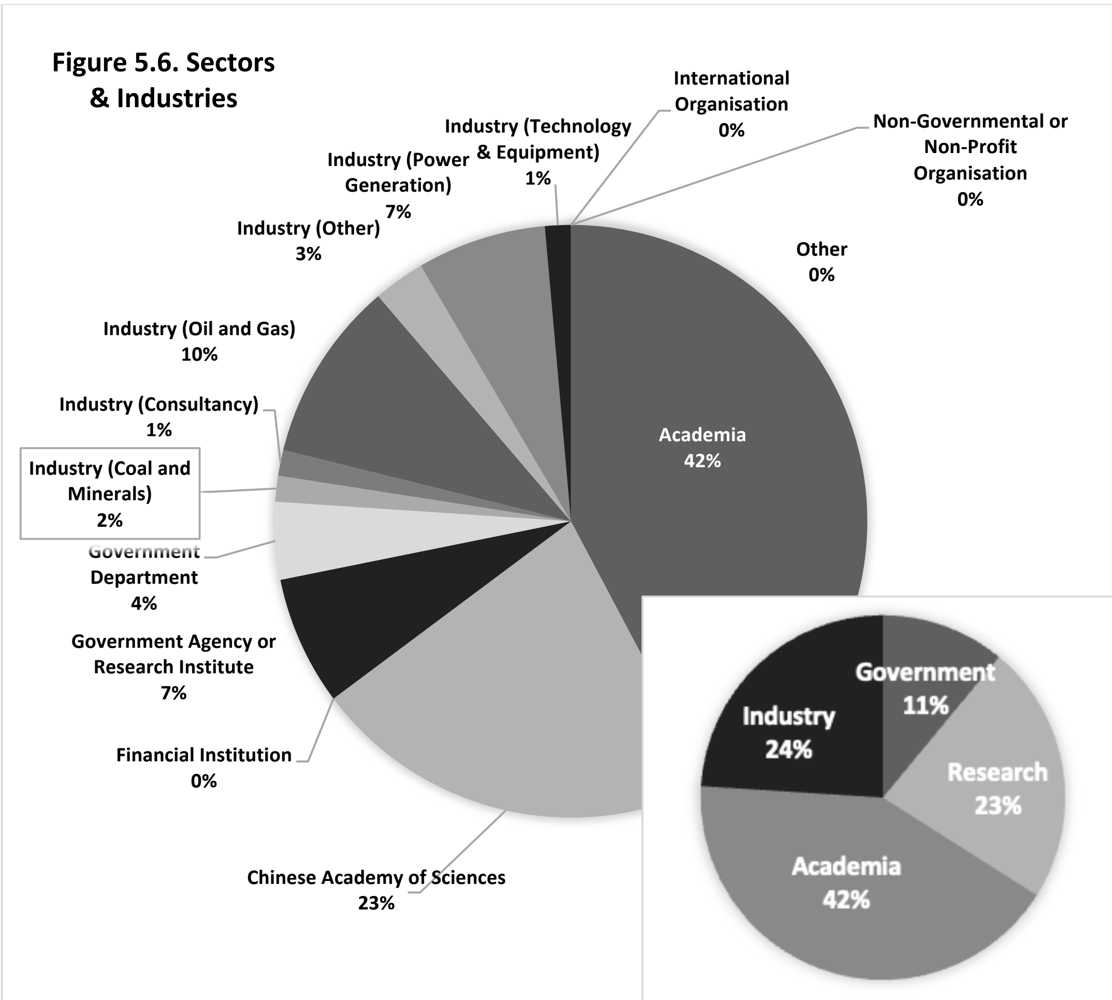


Figure 5.6. Sectors & Industries

Throughout the period 2005-2015, most activity had focused on government-led activity with a strong contribution from the Chinese Academy of Sciences (CAS), the Government's premier scientific and technical research and advisory organisation. With this increase in government-sponsored research activity, academia also played a larger part in this process, with various industries (many state-owned enterprises) also showing an early interest (oil and gas, power generation, coal and minerals, technology and equipment, and consultancies). Upon reflection, it's also not surprising that there were few Chinese participants from internationally-focused Chinese organisations, financial institutions, or non-governmental organisations, as CCS had maybe not become a priority area of their work just yet. Below you will find the names of some of the institutions that participated in either the Communications Survey and/or semi-structured interviews (Figure 5.7.).

Figure 5.7. Participating organisations by stakeholder group

Government (G)

- National Development & Reform Commission (NDRC)
- Ministry of Science & Technology (ACCA21)
- Administrative Centre for China's Agenda 21 (ACCA21)
- State Bureau of Oceanic Administration (SOA)
- Institute of Hydrogeology and Environmental Geology (IHEG)
- Tianjin Geothermal Exploration and Development Designing Institute (TGEDDI)

Research (R)

- CAS Guangzhou Institute of Energy Conversion (CAS-GIEC)
- CAS Institute of Engineering Thermophysics (CAS-IET)
- CAS Institute of Geology and Geophysics (CAS-IGG)
- CAS Institute of Policy & Management (CAS-IPM)
- CAS Institute of Process Engineering (CAS-IPE)
- CAS Institute of Rock and Soil Mechanics (CAS-IRSM)
- Shanghai Advanced Research Institute (SARI)
- South China Sea Institute of Oceanology (SCSIO)

Academia (A)

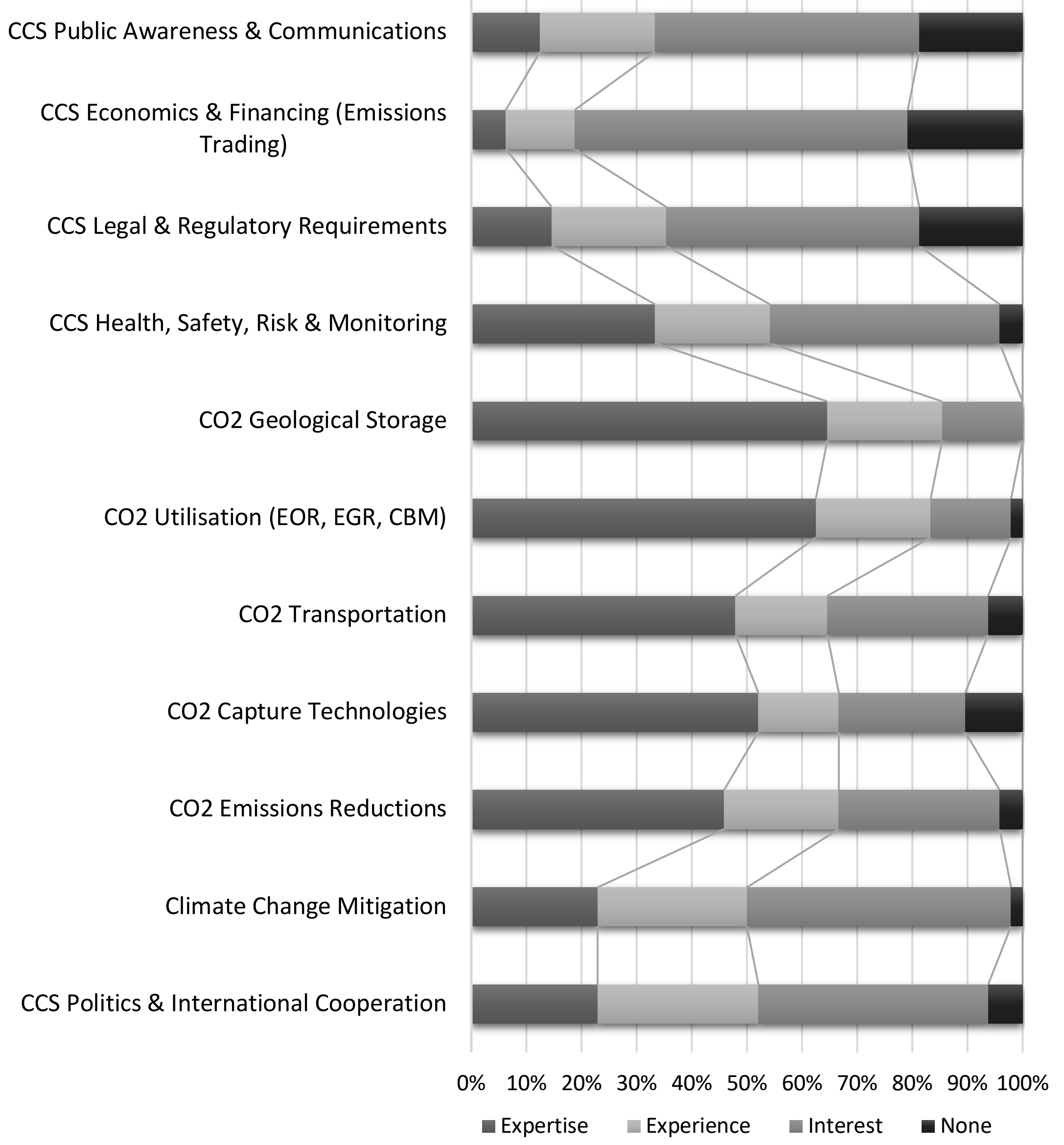
- Beijing Forestry University (BFU)
- Beijing Normal University (BNU)
- China University of Geosciences (CUG)
- China University of Mining & Technology (CUMT)
- China University of Petroleum in Beijing (CUP)
- China University of Petroleum in Huadong (CUP)
- Dalian University of Technology (DUT)
- East China University of Science & Technology (ECUST)
- Huazhong University of Science & Technology in Wuhan (HUST)
- Jilin University (JLU)
- Northwestern University (NWU)
- Tsinghua BP Centre for Research & Education (THCEC)
- Tsinghua University
- University of Science & Technology Beijing (USTB)
- Zhejiang University (ZJU)

Industry (I)

- Asian Coalition for Climate and Energy (ACCE)
- China Electricity Council (CEC)
- China Huaneng Group Clean Energy Research Institute (CERI)
- China National Petroleum Corporation (CNPC)
- China Wuhuan Engineering Co. Ltd.
- Jiangsu Hanlong Environmental Protection Sci. & Technology Co., Ltd.
- North China Electric Power Design Institute Engineering Co Ltd
- PetroChina (CNPC)
- Shanxi Yanchang Group
- Shengli Engineering & Consulting Co Ltd
- Shenhua Group (Shenhua Ordos CCS)
- Shenhua Guohu (Beijing) Power Research Institute Co Ltd
- Sinopec Petroleum Engineering Corporation
- Yuanda Engineering

It was important to better understand the participants' level of CCS expertise, experience, and interest in different areas, particularly around various aspects (or components) of the technologies, and what this might teach me about the motivations of these parties and/or the focus of the stakeholder groups. Acknowledging that a strong majority of respondents hold advanced degrees and many self-selected themselves as either senior or middle-level professions (Figures 5.2. and 5.3.), the survey results also showed that respondents came with expertise in mainly scientific and technical subjects with a focus on capture technologies, CO_2 utilisation, and geological storage, with less experience (although an interest) in the policy, regulatory, financing and communications aspects of CCS (Figure 5.8.). However, yet again, this could be reflective of the status of CCS technological and policy development in China at that time, which led me to question where these respondents came from and where I should direct my initial focus.

Figure 5.8. CCS Expertise, Experience & Interest



With the personal data collected showing the 71 respondents spread across China, it became clear (Figure 5.9.) that much of the CCS-related activity was happening in (or at least being coordinated from) Beijing, so that is where I based myself for fieldwork. With a significant number of responses coming from Dalian, Guangzhou, Shanghai, and Wuhan, I was also keen to visit these places but was conscious of my limited time and resources. With this in mind, I began communicating and coordinating with potential interviewees and prepared myself for my two months of fieldwork in China.

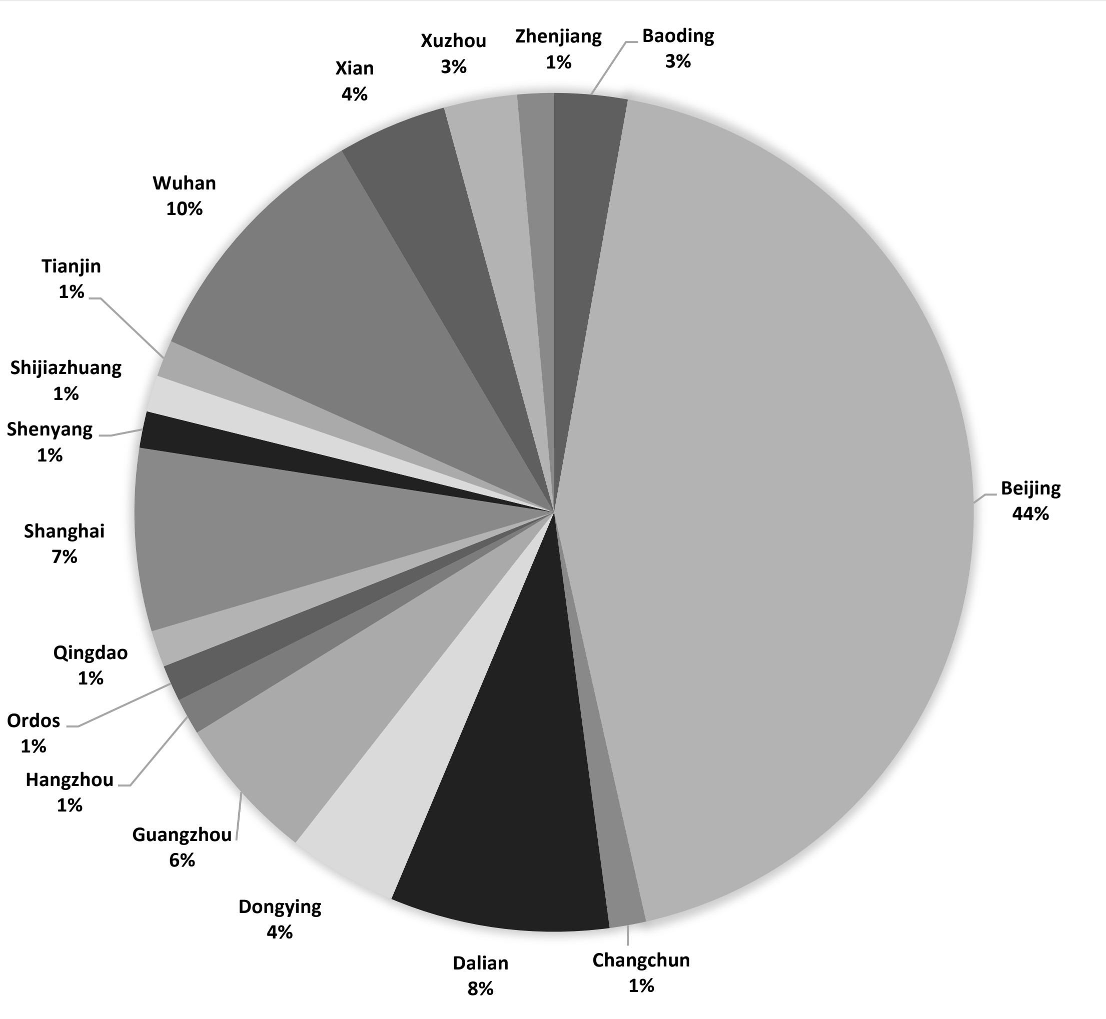


Figure 5.9. Geographical location of respondents

Having collected basic personal and professional information on each respondent, I spent an important part of my data collection effort focused on organisational behaviour.

Organisational Behaviour (I)

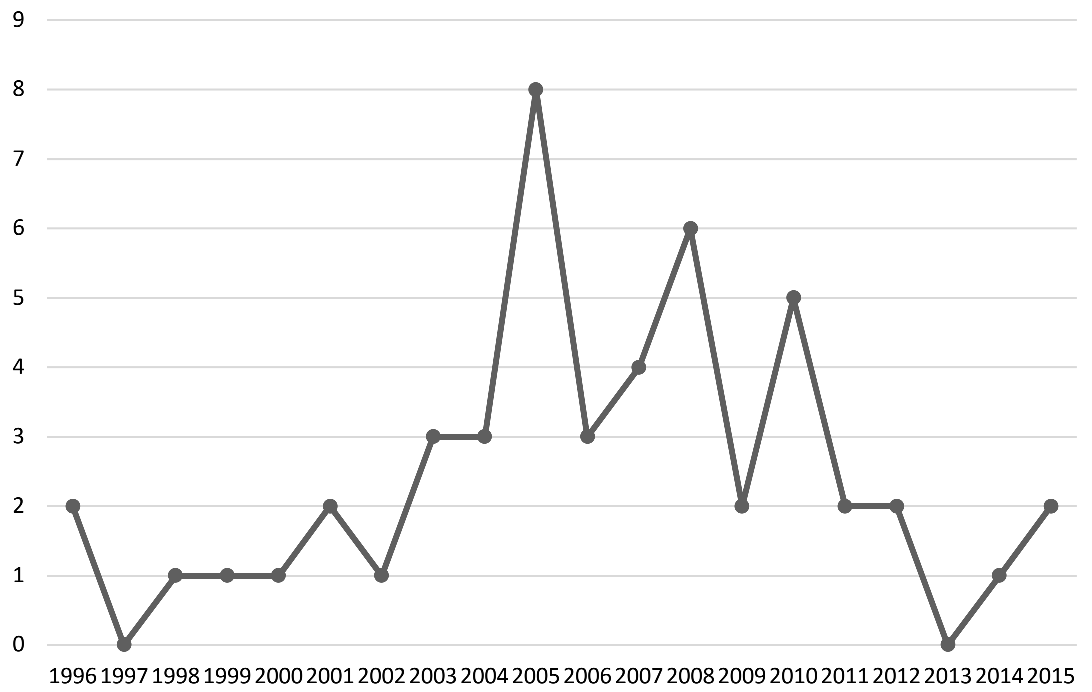
Questions (Q.1.1. to Q.1.7.) were designed to understand the context within which these individuals were working and if they were supported in their CCS-related work within their own organisations. They also provided important opportunities for arranging interviews with key decision makers within the organisations or others within that had championed (or indeed opposed) the technologies openly.

Organisational Behaviour (II)

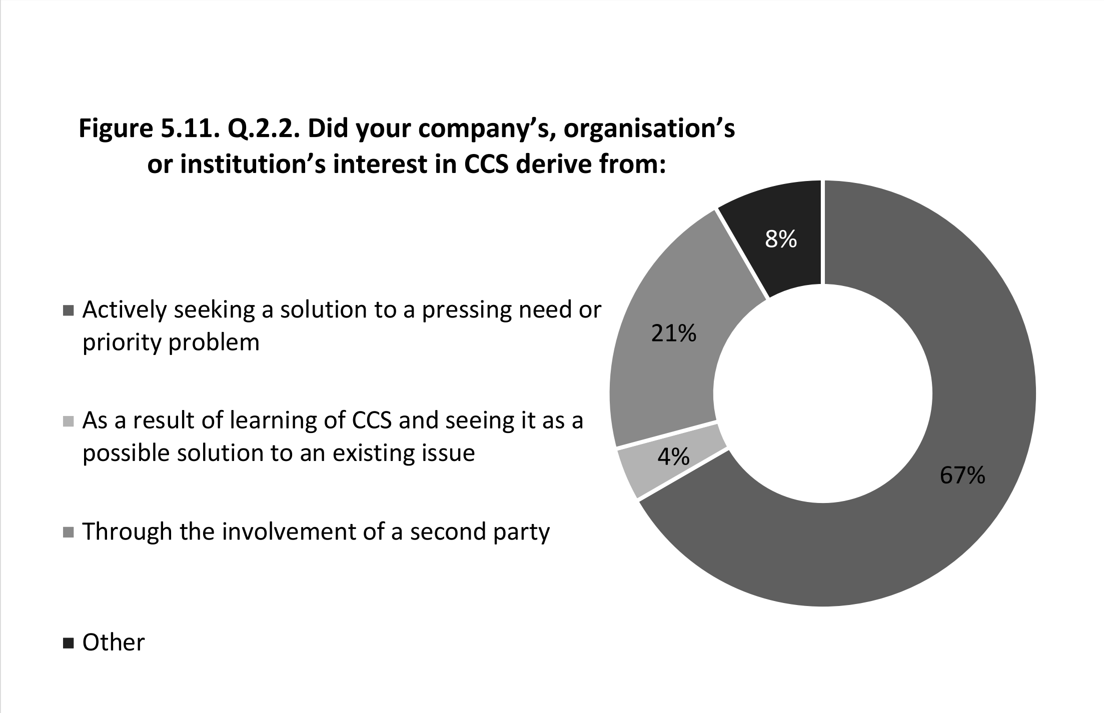
I wanted to explore Rogers' theory of the 'organisational adoption process' and his ideas behind 'initiation' (agenda setting and matching) and 'implementation' (re-defining/restructuring, clarifying and routinizing) of an innovation within an institution, with the goal of understanding each organisation's experience of adopting the technologies through the eyes of those working in these areas. Therefore, it was important to understand when these organisations first became interested in CCS technologies.

Starting with the date of the organisations' initial engagement with CCS, I asked Q.2.1. "When did your company, organisation or institution first become interested in CCS-related work?" This went back as far as 1996 for some but really only peaked at 2005, 2008, and 2010 (Figure 5.10.).

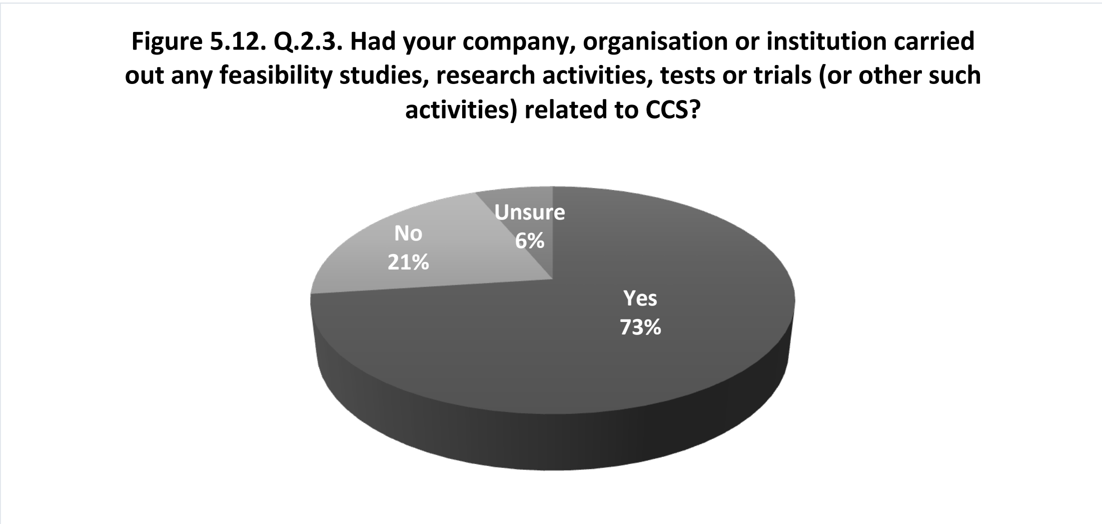
Figure 5.10. Q.2.1. When did your company, organisation or institution first become interested in CCS-related work?



Considering the agenda setting aspect, when asked in Q.2.2. from where their organisation's interest in CCS derived and if they were "actively seeking a solution to a problem," "passively learning of CCS from a second party," or if there was another reason, 67 percent said it was in response to "actively seeking a solution to a pressing need or priority problem," while 21 percent responded saying "through the involvement of a second party" (Figure 5.11.). I will explore this more fully in subsequent chapters.

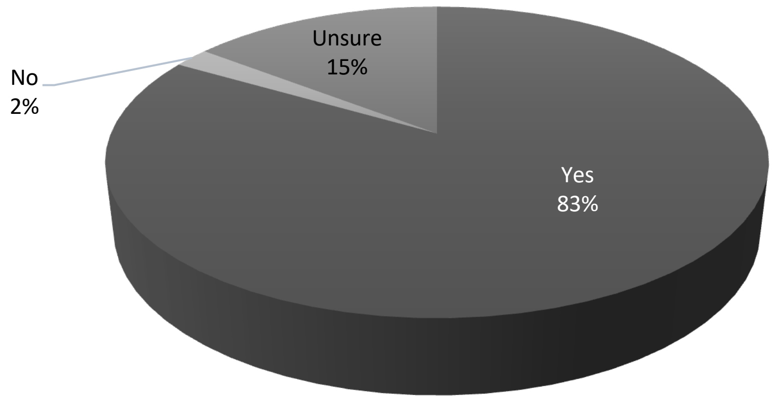


Keen to learn if these organisations had carried out any type of feasibility studies, research activities, tests or trials (or other such activities) related to CCS (Q.2.3.), I was also interested in learning whether they had made any contributions to CCS development nationally (Q.2.4.). In responding to Q.2.3. "Has your company, organisation or institution carried out any feasibility studies, research activities, tests or trials (or other such activities) related to CCS?", 73 percent had said "yes" and 21 percent said "no," while only 6 percent said "unsure" (Figure 5.12.).



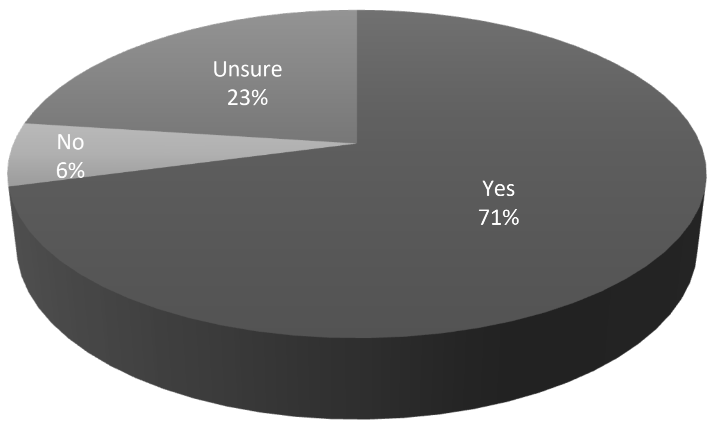
I had also asked Q.2.4. "Has your company, organisation or institution engaged in any CCS-related work which may lead to the advancement in the progress of CCS development and deployment nationally?" Again, 83 percent had said "yes," while 15 percent were "unsure," and two percent said "no" (Figure 5.13.).

Figure 5.13. Q.2.4. Has your company, organisation or institution engaged in any CCS-related work which may lead to the advancement in the progress of CCS development and deployment nationally?



With the possibility of significant modifications, adjustments, redesigning, and/or alterations to the technologies (Q.2.5.), if any significant changes were made, I wanted to know the reason for this (such as customization, personalisation, or simplification) (Q.2.6.). When asked Q.2.5. "Has your company's, organisation's, or institution's CCS related work led to any modifications, adjustments, redesigning or alterations of CCS components? 71 percent said "yes," while 23 percent said they were "unsure," and six percent responded "no" (Figure 5.14). I will reserve the qualitative responses to those questions for the subsequent analytical chapters, where they will have more relevance and meaning.

Figure 5.14. Q.2.5. Has your company's, organisation's or institution's CCS related work led to any modifications, adjustments, redesigning or alterations of CCS components?



Those that responded "yes" were then asked what the reasons were for such modifications (Q.2.6.) and the majority of respondents said 'customisations to meet local needs.' Others said 'alteration to be used for other purposes' (EOR, EGR, EBCM, or EWR) or 'changed for commercialisation and gaining profit' (Figure 5.16.).

Figure 5.16. Q.2.6. If yes, what were the reasons for such modification?

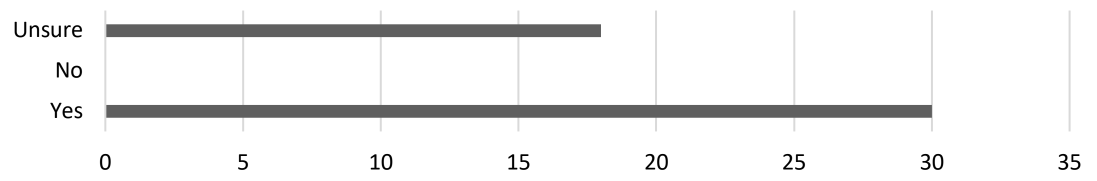
I had also asked if they had ways to share their findings and inquired whether or not these organisations have any formal or informal means of communicating, disseminating or distributing these and other findings and achievements to individuals, other companies, organisations, institutions within the wider CCS community (Q.2.7.). This allowed me to better understand the idea of the Chinese reinvention of CCS to suit their particular circumstances and whether or not they were sharing these developments domestically and/or internationally. This information is covered in the communications sections below.

I was also keen to explore if these organisations had experienced any changes or restructuring (such as new procedures or processes, the hiring of CCS specific staff or the creation of a new organisational unit), as a result of their CCS-related activities (Q.2.8.). Hoping to understand whether or not these activities were now more frequent and widespread within their organisations (Q.2.9.), it was also important to ask if they had experienced any difficulties related to their CCS work (Q.2.10), whether this work was embedded or institutionalised (Q.2.11.), and whether or not they anticipated that their CCS-related activities would cease at any point in the future (Q.2.12.).

Organisational Behaviour (III)

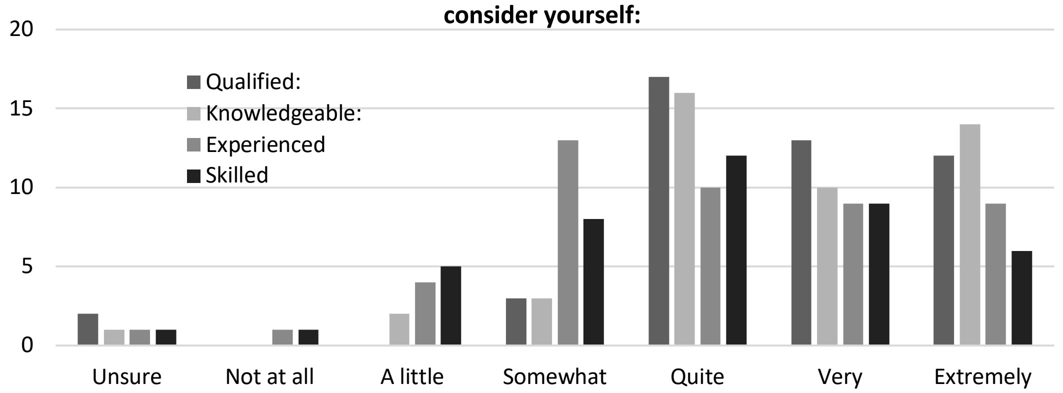
Considering the degree of centralization within an organisation, I wanted to again probe whether or not the respondent was the primary decision maker (Q.3.1.), and to what degree they felt they and their colleagues possessed the right qualifications, knowledge, experience, and skills needed to work on CCS (Q.3.3.) and to make effective decisions. When asked Q.3.2. “Do you personally have a role in making any CCS-related decisions?” 62.5 percent responded “yes,” while 37.5 percent responded “unsure” (Figure 5.17.).

Figure 5.17. Q.3.2. Do you personally have a role in making any CCS-related decisions?



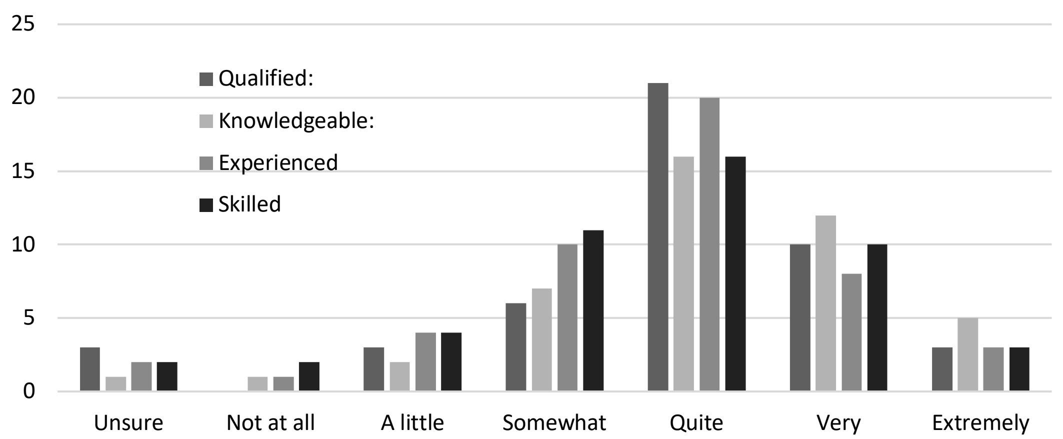
When asked Q.3.3. "When engaging in CCS-related work, to what extent do you consider yourself: qualified, knowledgeable, experienced, and skilled?" Most respondents believed themselves to be qualified, knowledgeable, and skilled but to a lesser extent experienced (Figure 5.18.). This is largely consistent with the stage of CCS experience in China.

Figure 5.18. Q.3.3. When engaging in CCS-related work, to what extent do you consider yourself:



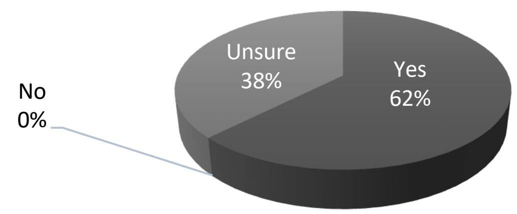
I had also asked Q.3.4. "When engaging in CCS-related work, to what extent do you consider your colleagues: qualified, knowledgeable, experienced, and skilled?" and found that respondents had less confidence in their colleagues (Figure 5.19.).

Figure 5.19. Q.3.4. When engaging in CCS-related work, to what extent do you consider your colleagues:



It was also important to ask if they felt they had the right managerial systems and administrative/structural support needed to continue their work, or if they faced unnecessary institutional bureaucratic barriers in doing so (Q.3.4.), particularly in relation to the financial resources they have committed towards this area (Q.3.5.). This was vital to understand the potential difficulties and challenges they faced as they worked around CCS technologies. Given the concerns over funding and the impact this has on the future of CCS, Q.3.6. asked "Is there a possibility of further monetary or non-financial resources (which have not yet already been committed) to be obtained?" Bearing in mind that this was funding from their own institution, 62 percent said "yes" and 38 percent said "unsure," while no one responded "no" (Figure 5.20).

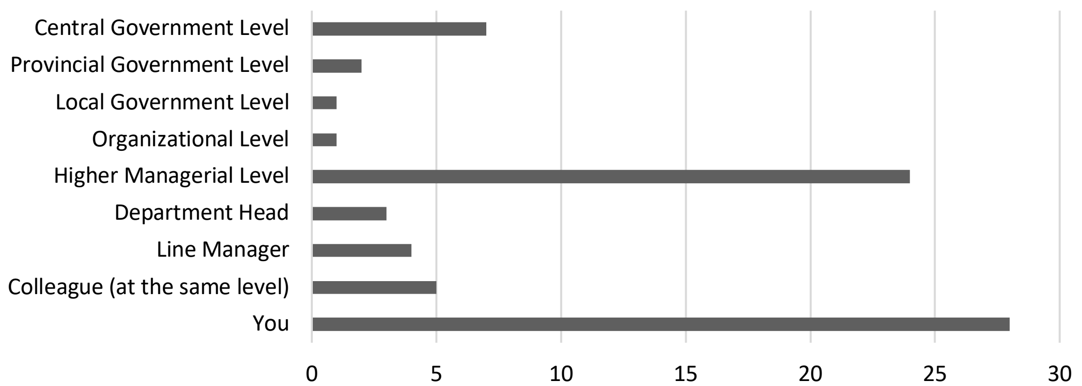
Figure 5.20. Q.3.6. Is there a possibility of further monetary or non-financial resources (which have not yet already been committed) to be obtained?



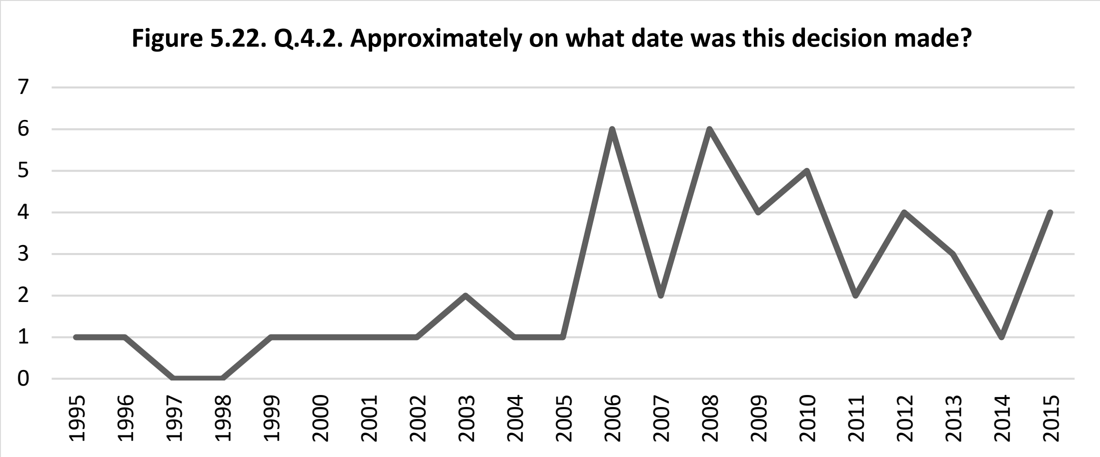
Types of Decision Making

Drawing similarities to 'Organisational Behaviour (I),' I sought to understand who the real decision makers might be (i.e., central, provincial, local-levels of government and/or managerial levels within the organisation and colleagues). When asked Q.4.1. "Who (or at what level) decided that you personally would engage in CCS-related activities?" "Central Government," "Higher Managerial Level," and "You" came out on top (Figure 5.21.). This was perhaps due to the higher number from academia/CAS.

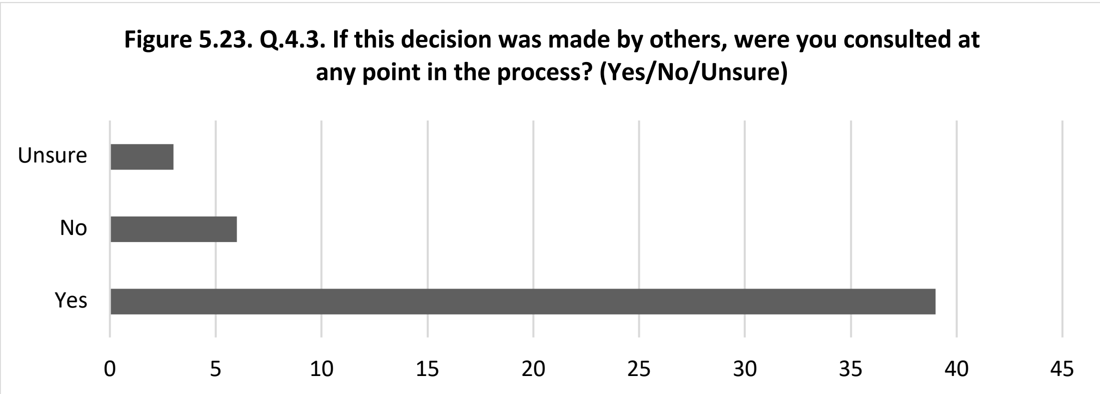
Figure 5.21. Q.4.1. Who (or at what level) decided that you personally would engage in CCS-related activities?



While asking if the respondent had a role in decision making, I then I followed up by asking if anything was significant about the timing of this. When asked Q.4.2. “Approximately on what date was this decision [that they should be involved in CCS activities] made?” Again, we see that 2006, 2008, 2010, and 2012, are key decision-making dates (Figure 5.22), which we should consider as we move through subsequent chapters.



Additionally, Q.4.3. asked “If this decision was made by others, were you consulted at any point in the process?”, 81 percent responded “Yes” and 13 percent responded “no,” with only 6 percent responding “Unsure” (Figure 5.23.), demonstrating high levels.



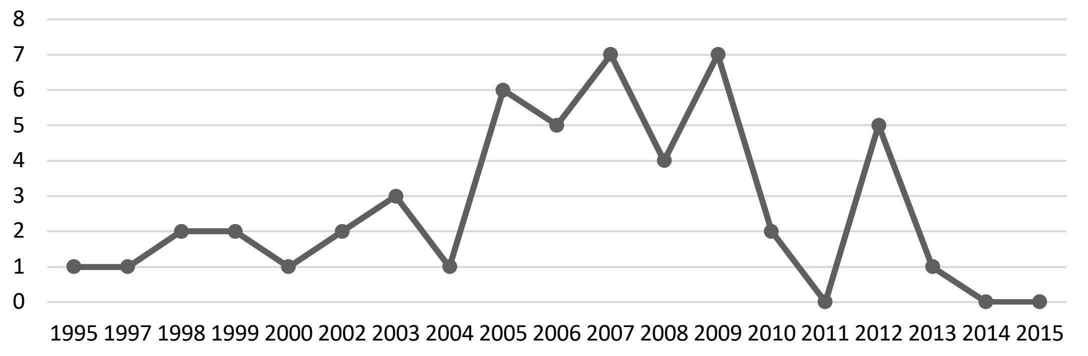
These questions helped to frame the next section, which led my discussions on the individual’s innovation-decision processes on whether or not they should try, test, adopt, and continue to use the innovation under investigation.

Innovation-Decision – Knowledge

Briefly mentioned earlier but explained in greater detail later, Rogers describes innovation-decision as “the process through which an individual (or other decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision” (Rogers, 2003:20-21,168).

With typically five distinct stages (knowledge, persuasion, decision, implementation and confirmation), I asked participants when they first heard of CCS (Q.5.1.), from what medium or source (Q.5.2.), how "new" the concept was (Q.5.3.), and their level of necessity at that time (Q.5.4.), in other words the 'knowledge' stage.

Figure 5.24. Q.5.1. When was the first time you personally heard of CCS?



When asked in Q.5.2. "From which medium or source had you first heard of CCS," 38 percent learnt from interpersonal connections (colleagues, personal friends, professional associates, and supervisors), 34 percent from engagement activities (conferences, seminars, meetings, workshops, and trainings), and 28 percent learnt from mass media channels (academic journals, newspapers, and websites) (Figure 5.25.).

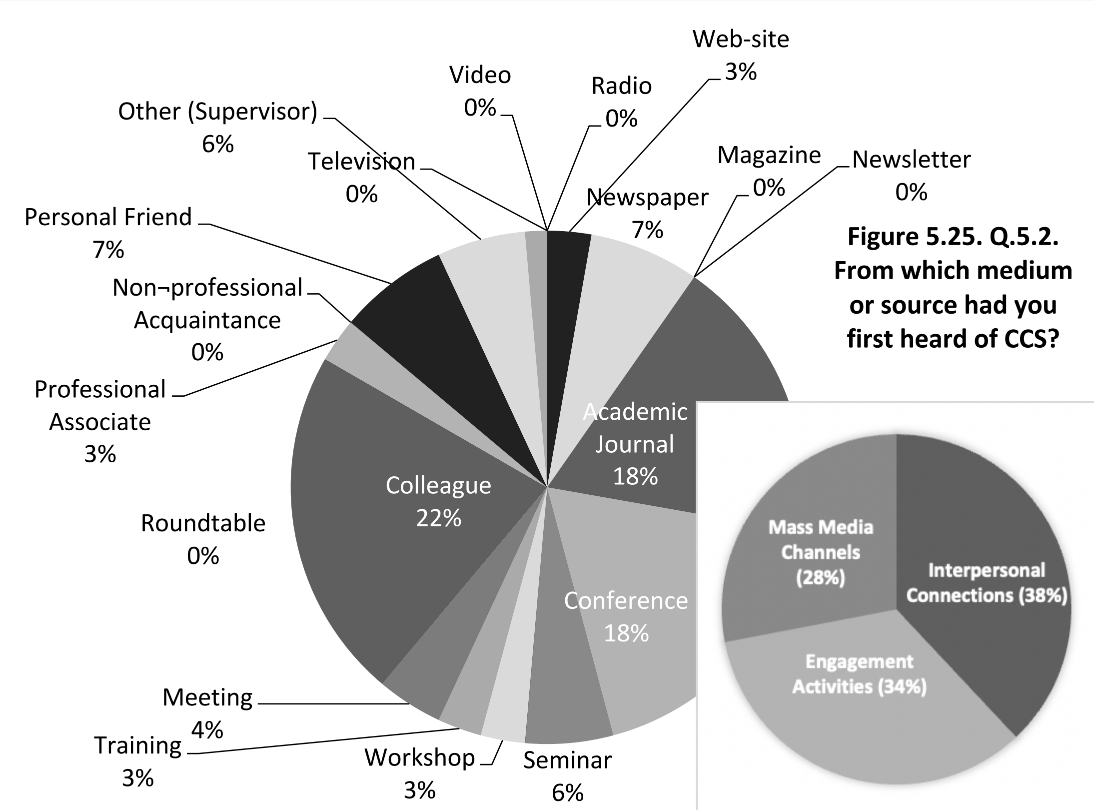
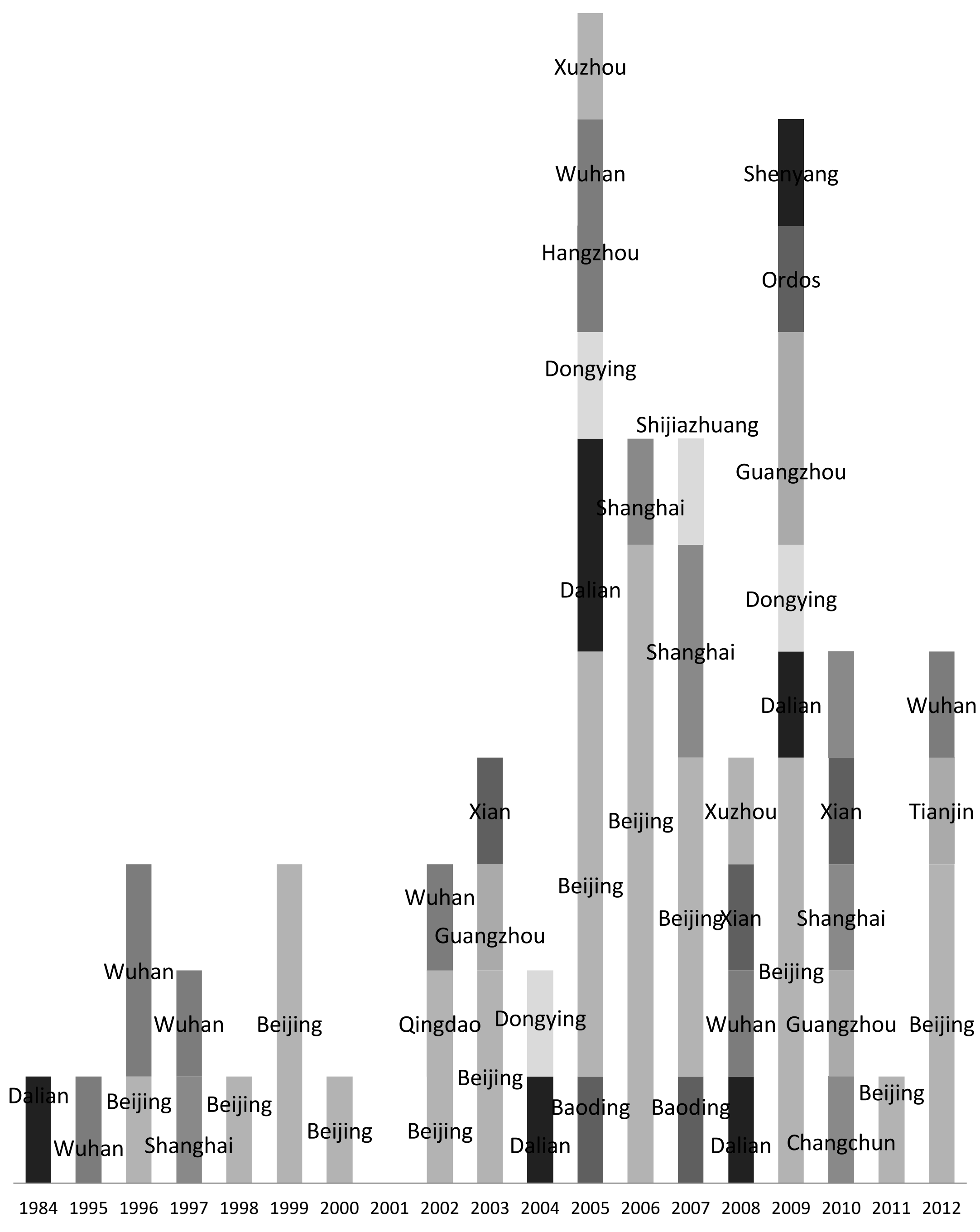


Figure 5.25. Q.5.2. From which medium or source had you first heard of CCS?

When looking at 'knowledge' by sector (Figure 5.26.), industry's knowledge appeared to be growing until 2009, only to fall. Academia's knowledge took sharp peaks and deep troughs, and research and government knowledge appeared to be bubbling along. For knowledge by location, Dalian, Wuhan and Shanghai were the earliest, with Beijing and other cities joining at later dates, which is not unexpected. Figure 5.27. represents the number of respondents that said they gained first knowledge of CCS as a concept.

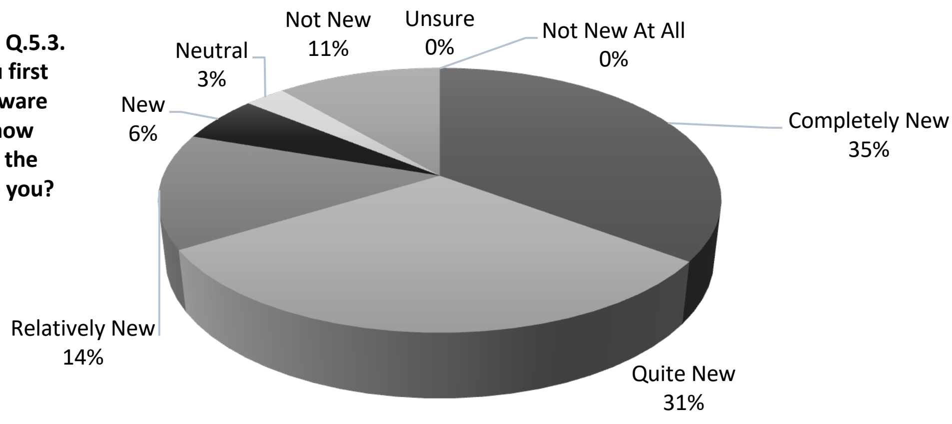
Figure 5.27. Location of Knowledge by Year



Innovation-Decision – Newness & Necessity

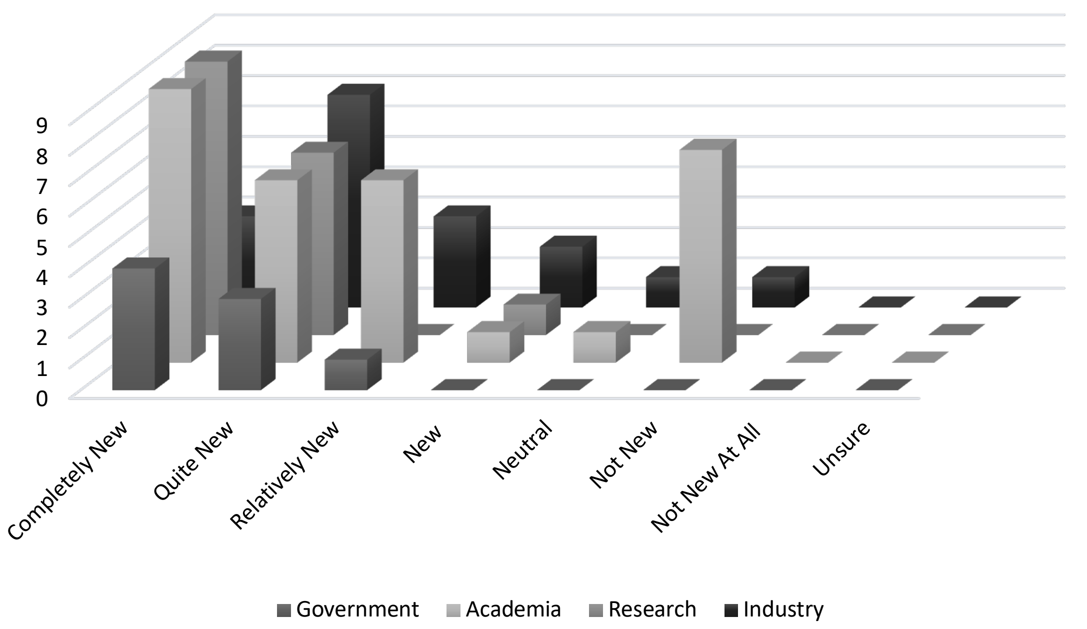
When asked Q.5.3. "When you first became aware of CCS, how new was the concept of CCS to you?" 86 percent of respondents said it was new to some degree, while only 11 percent said it wasn't new, and 3 percent said neutral (Figure 5.28.).

Figure 5.28. Q.5.3. When you first became aware of CCS, how new was the concept to you?



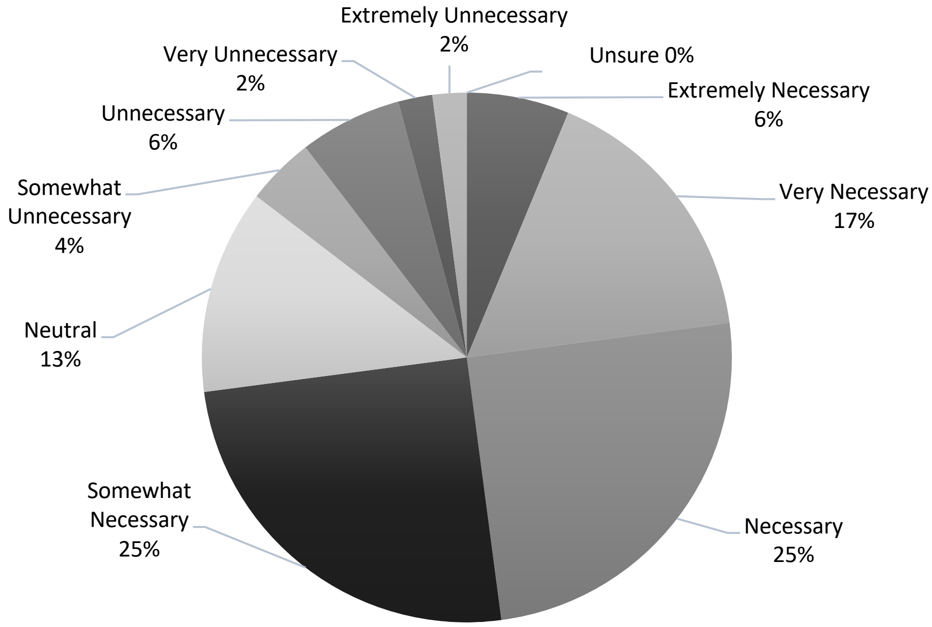
Broken down by sector, it appears that CCS was completely new to many within academia and research, while academia also had the largest number that was already familiar with the concept (Figure 5.29.).

Figure 5.29. Conceptual Newness by Sector



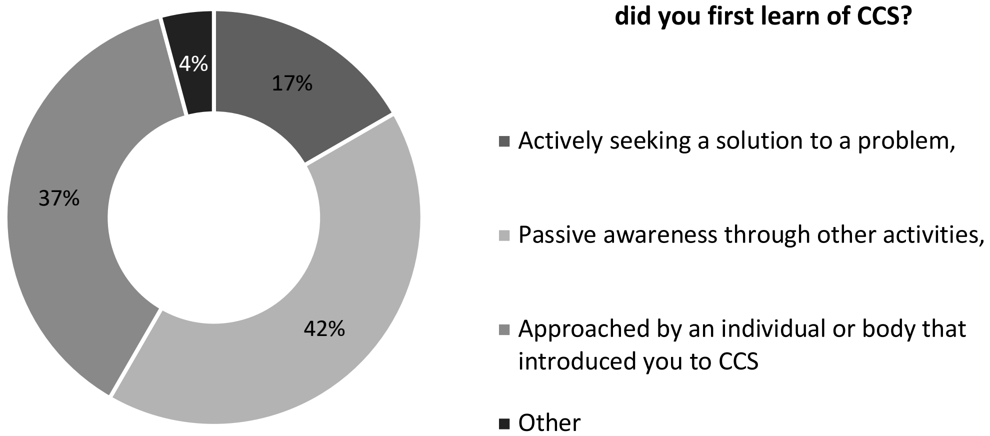
Asked Q.5.4. "Please rate your level of necessity for CCS at that time," 73 percent saw CCS as necessary and 13 percent saw it as unnecessary, while 14 percent saw it as neutral (Figure 5.30.). Clearly almost two thirds saw the technologies as very much relevant.

Figure 5.30. Q.5.4. Please rate your level of necessity for CCS at that time.



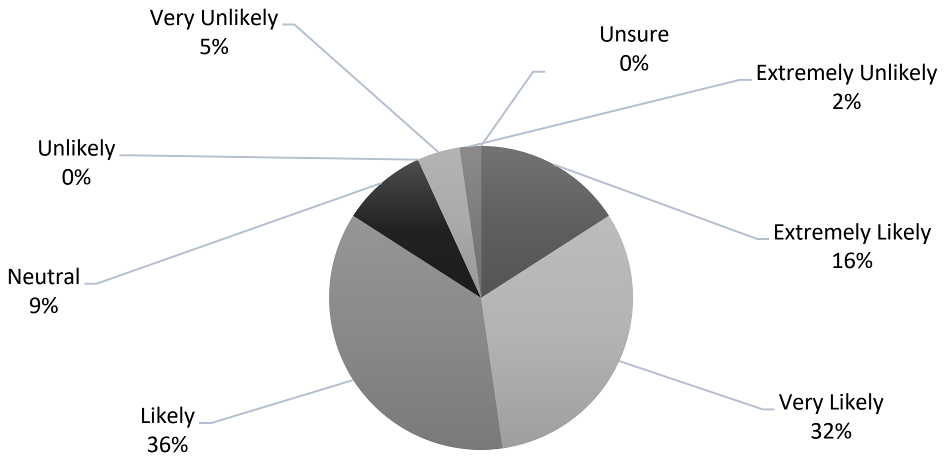
Having probed their level of necessity for the technologies at the time 'knowledge,' I explored if this contact came about by 'actively seeking solutions to a problem(s),' by 'passive awareness through other activities,' or if they were 'approached by an individual or body.' When asked in Q.5.5. "Under what circumstances did you first learn of CCS," only 17 percent said they actively sought a solution to a problem, while 79 percent was approached by others or learnt about it passively through other activities (Figure 5.31).

Figure 5.31. Q.5.5. Under what circumstances did you first learn of CCS?



When asked Q.5.6. "If you were actively seeking to resolve a problem, in your opinion, what is the likelihood that CCS will succeed in resolving these problems?" 84 percent said it was likely to some degree, while only 7 percent said it was unlikely, and 9 percent said neutral (Figure 5.32.). These important findings will be discussed in subsequent chapters.

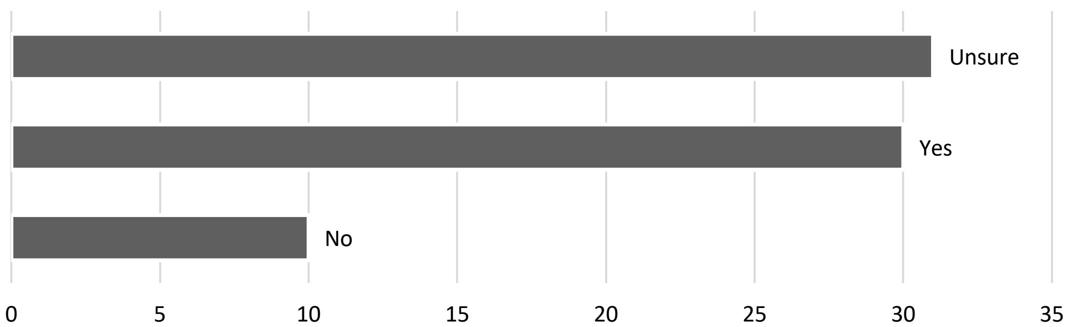
Figure 5.32. Question 5.6. If you were actively seeking to resolve a problem, in your opinion, what is the likelihood that CCS will succeed in resolving these problems?



Innovation-Decision – Alternatives, Opinions, & Attitudes

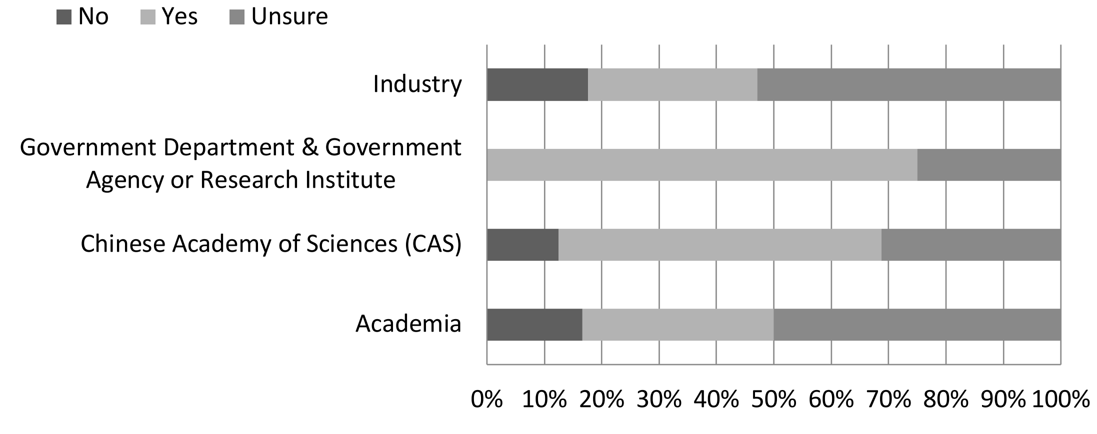
After examining ‘knowledge,’ ‘newness,’ and ‘necessity,’ it was time to assess the respondents’ opinion around possible superior alternatives to CCS (Q.5.7) and if they had developed opinions or attitudes towards CCS (Q.5.8.). Similarly, it was also important to gauge their level of positivity or negativity towards the technologies at that time and the likelihood that they would continue to engage in the future (Q.5,.9.), and whether (Q5.10.) or not their opinion was influenced by examples, trials, or demonstrations by other parties (Q.5.11). When asked Q.5.7. “In your opinion, are there superior alternatives to CCS in achieving your objectives?” 14 percent said there aren’t superior alternatives and 42 percent said there are, but 44 percent of respondents were unsure (Figure 5.33). This shows a high degree of uncertainty, which will be discussed more fully in later chapters.

Figure 5.33. Q.5.7. In your opinion, are there superior alternatives to CCS in achieving your objectives?



Looking at these by sector, the Government appeared to be the most convinced that there are superior alternatives, while the others all appear to have similar views (Figure 5.34.).

Figure 5.34.. Superior Alternatives by Sector



When asked to recall the dates respondents first formed a (positive or negative) opinion or attitude towards CCS (Q.5.8.), these also came in peaks and troughs, with 2006, 2008, and 2010, seen as key years to form opinions (Figure 5.35.). Q.5.9. asked whether these opinions were positive or negative and the response was overwhelmingly positive with only some neutral and somewhat negative opinions (Figure 5.36.).

Figure 5.35. Q.5.8. Please recall the date you first formed a (positive or negative) opinion or attitude towards CCS.

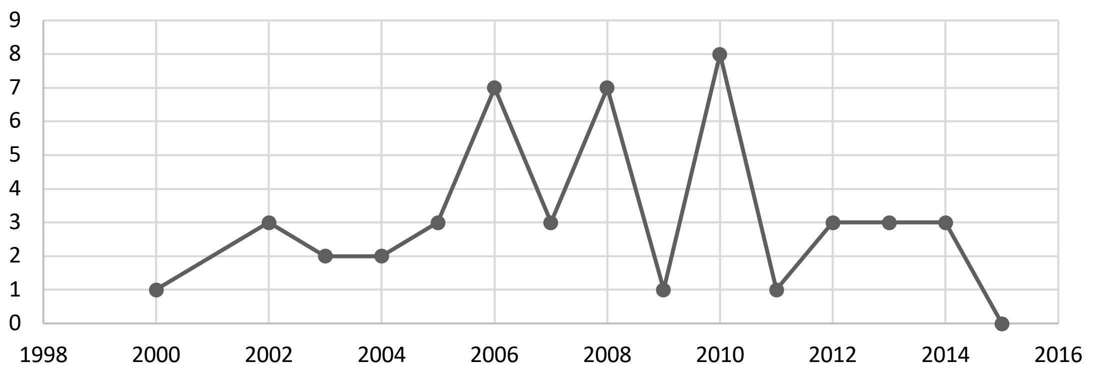
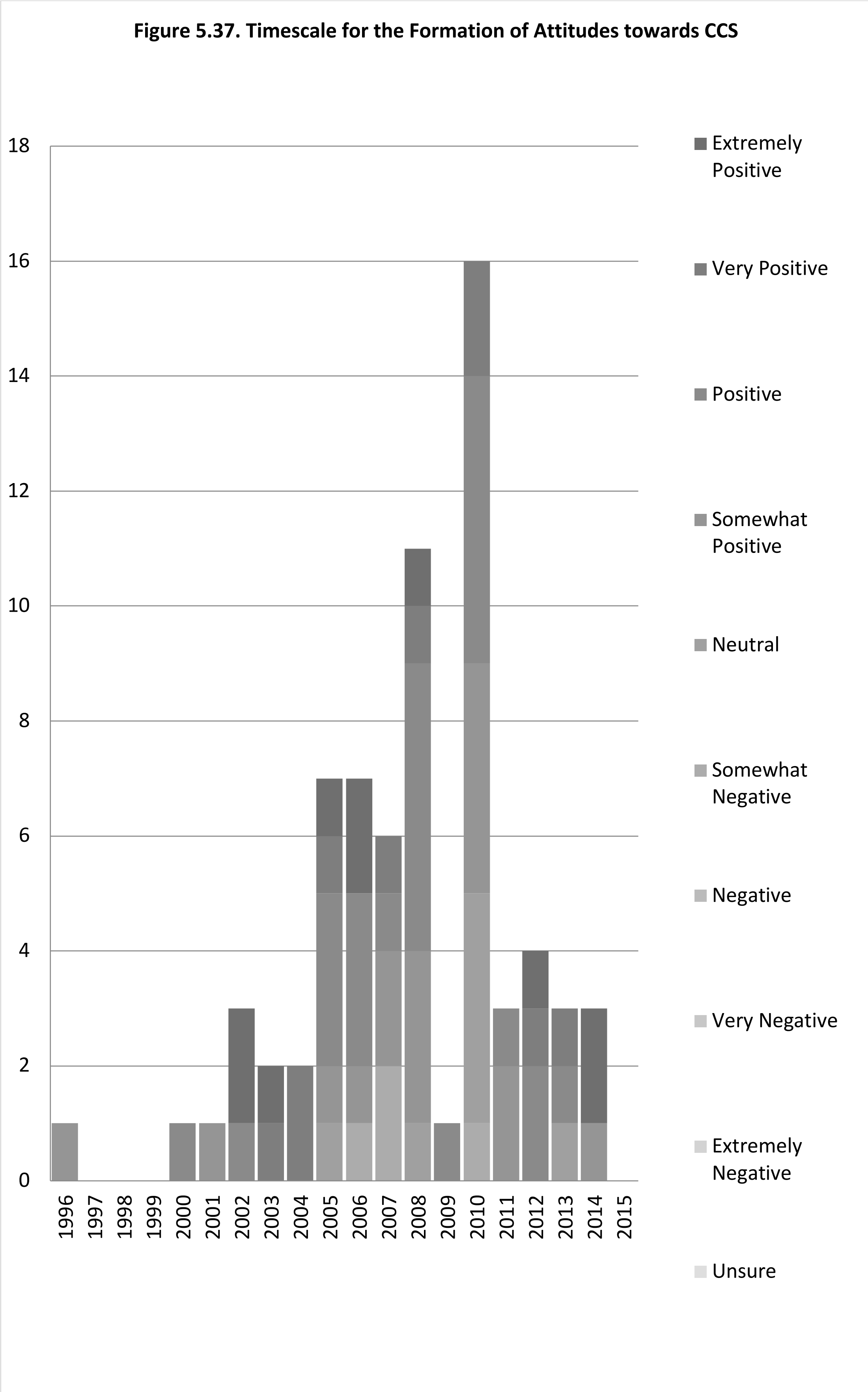


Figure 5.36. Q.5.9. When you first formed an opinion or attitude towards CCS, was this:

From Figure 5.37., we can see the timescale of opinion formation and the opinion made.



Innovation-Decision – Decision, Implementation, & Confirmation

Looking at the 'decision,' 'implementation,' and 'confirmation' stages of the innovation-decision process, I first asked in Q.5.10. "On what date did you decide to engage in CCS-related activities?" Looking at Figure 5.38., it appears that there are similar peaks that we identified in previous questions (2006, 2008, 2010), again making these interesting years. Significantly, 86 percent said their decision to engage in CCS-related activities had been influenced by examples, trials, or demonstrations given by other parties (Figure 5.39.).

Figure 5.38. Q.5.10. On what date did you decide to engage in CCS-related activities?

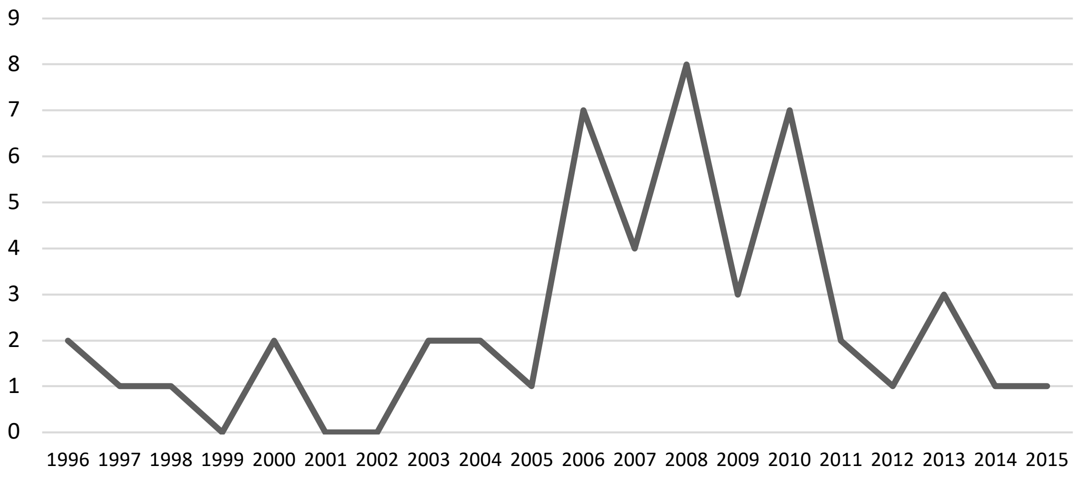


Figure 5.39. Q.5.11. Was your decision to engage in these activities influenced by examples, trials or demonstrations given by any other individual(s) or institutions?

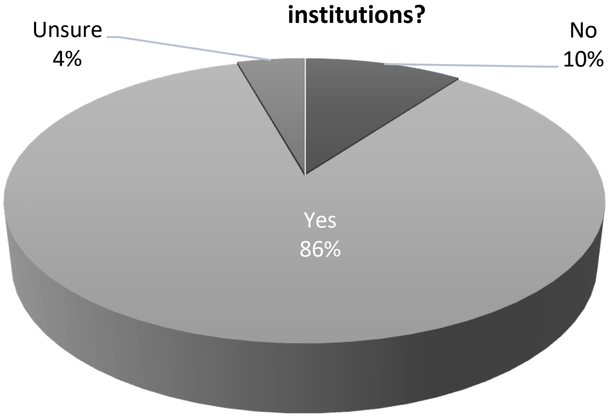


Figure 5.40. shows that this to be slightly less in industry, there appears to be no real distinction between sectors. As expected, Figure 5.41. suggests that just over 50 percent of these saw demonstrations as positive but surprisingly, only 20 percent saw them as negative, with more seeing them as neutral. By sector, this appeared to vary considerably, with academia the most positive, industry the most neutral/unsure, and the government the most positive/neutral (Figure 5.42).

Figure 5.40. Influenced of examples, trials, or demonstrations by sector

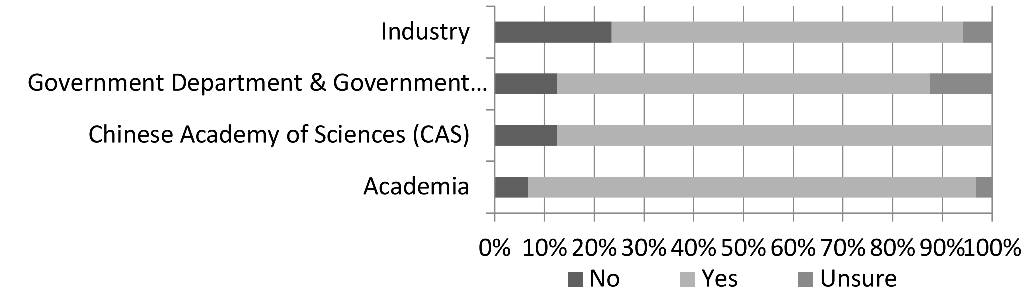


Figure 5.41. Positive & Negative Influnences of Trials & Demonstrations

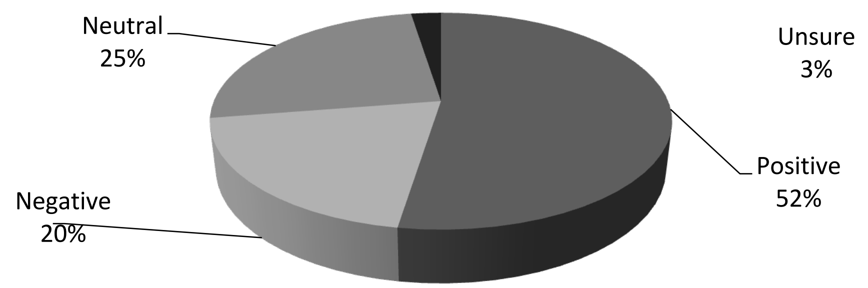


Figure 5.42. Positivity & Negativity by Sectors

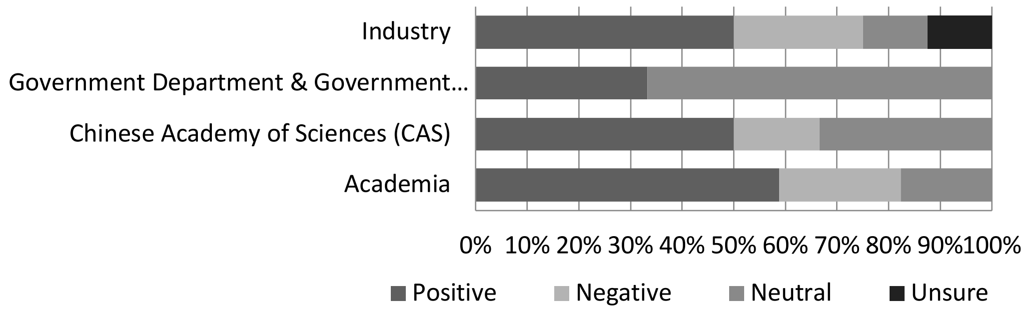
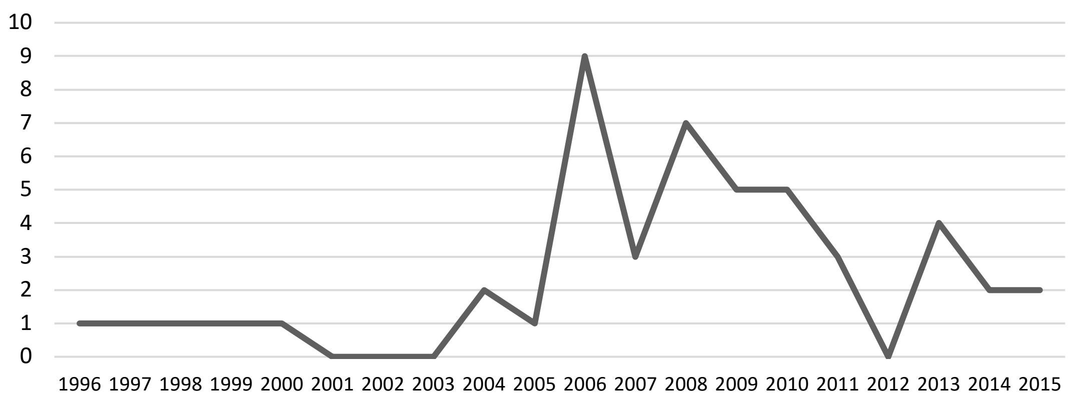
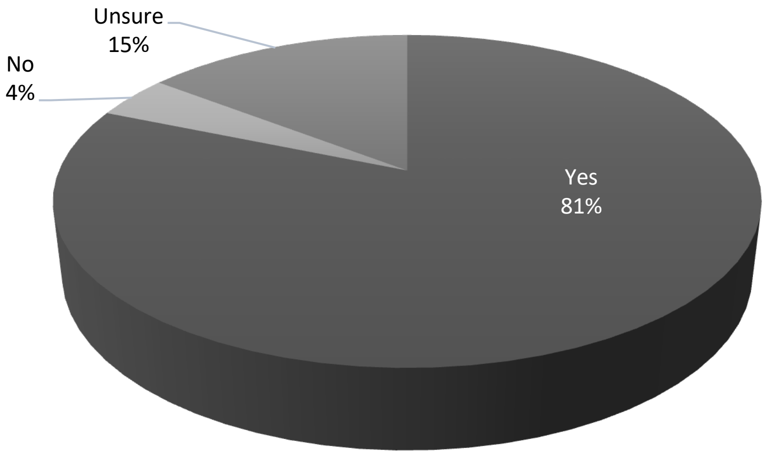


Figure 5.43. Q.5.12. Following your initial decision to enter into activities related to CCS, on what date did this decision turn into action?



When asked Q.5.12. “Following your initial decision to enter into activities related to CCS, on what date did this decision turn into action?”, there were similar peaks of 2006, 2008, 2010, and 2013 (Figure 5.43.). When asked Q.5.13. “Following a period of time engaged in CCS-related activities, do you believe your decision to begin these activities to be the right decision?” Overall, 81 percent believed it to be the right decision, while 15 percent were “unsure,” and four percent said “no.” (Figure 5.44.).

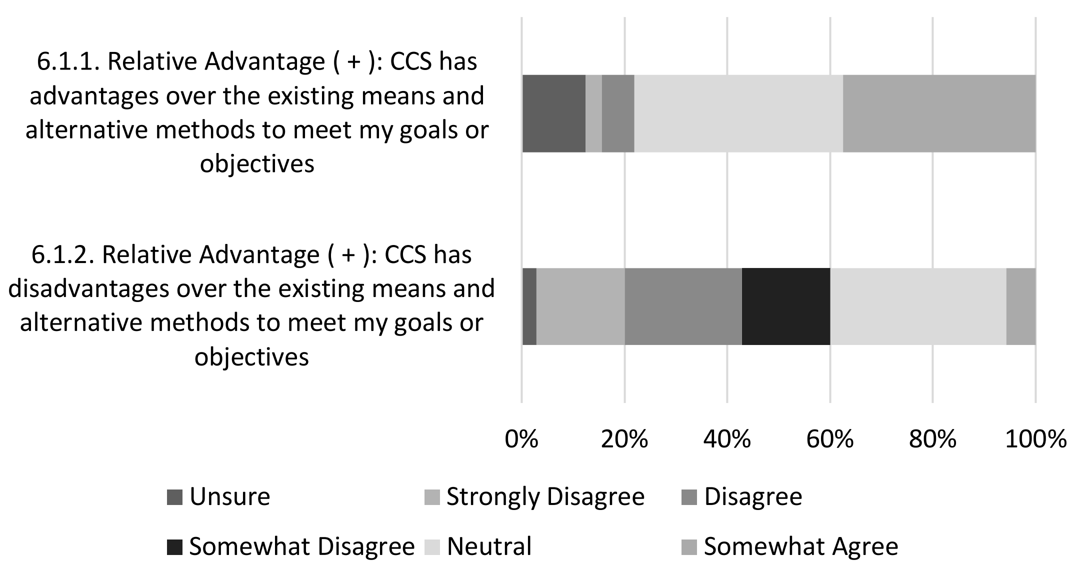
Figure 5.44. Q.5.13. Following a period of time engaged in CCS-related activities, do you believe your decision to begin these activities to be the right decision?



Perceived Attributes

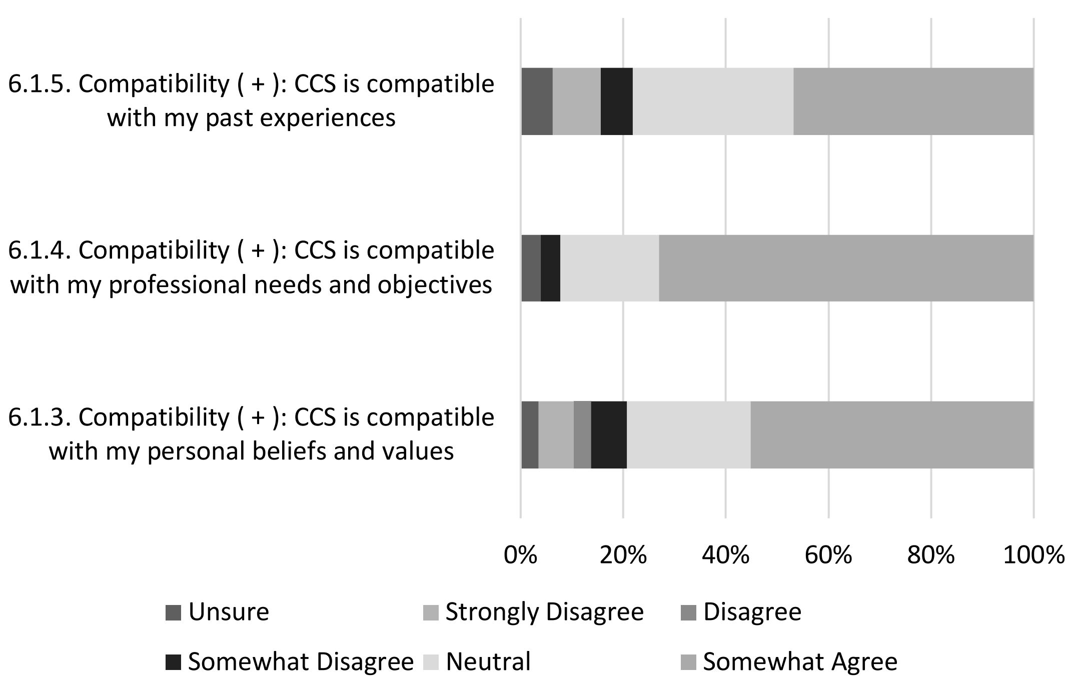
‘Part Six’ of the Communications Survey focused on the Chinese respondents’ understanding of CCS (the composition of technical hardware and its associated informational software components). In order to identify the meaning and purpose they placed around the technologies’ functions, as well as seeking to uncover what problem(s) they sought to resolve, my intention here was to recognize that all motivations might not be the same for everyone involved (Q.6.0.1. to Q.6.0.2.). Having this in mind, I followed this line of questioning by asking what the respondents’ own personal and professional objectives, interests, and motivations for involvement with CCS might be (Q.6.0.3.). Much of this came down to how they perceived the technologies to be in terms of: **‘relative advantage’** compared to alternative methods/means to achieving goals/objectives (Q.6.1.1. to Q.6.1.2.), **‘compatibly’** with personal beliefs and values, and professional needs and objectives, as well as past experiences (Q.6.1.3. to Q.6.1.5.); **‘complexity’** to understand and difficulty to put into effective use (Q.6.1.6. to Q.6.1.7.); **‘trial-ability’** by attempting tests on a partial or probationary period and the possibilities/experience of this (Q.6.2.1. to Q.6.3.2.); and**, ‘observability,’** which focused on whether or not the respondent had observed tests, trials, and/or demonstrations, and the impact these may have had on the respondents’ perceptions of the technologies (Q.6.3.1. to Q.6.3.2.).

Figure 5.45. Perceived Characteristics of an Innovation (Relative Advantage)



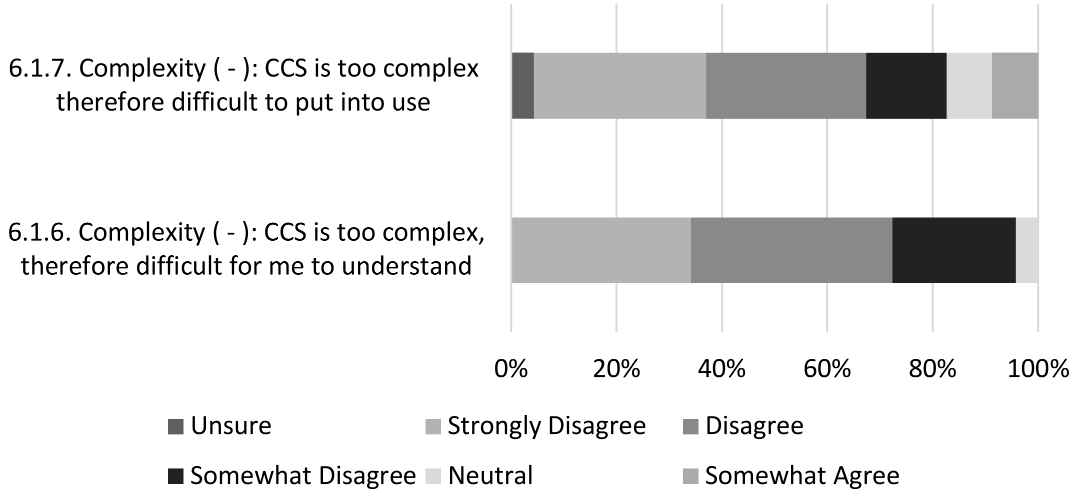
From Q.6.1.1. we see that slightly more respondents were 'neutral' than 'somewhat agree,' although this was significantly more than disagreed combined. Q.6.1.2. gave similar results, showing that overall, CCS was considered more advantageous (Figure 5.45).

Figure 5.46. Perceived Characteristics of an Innovation (Compatibility)



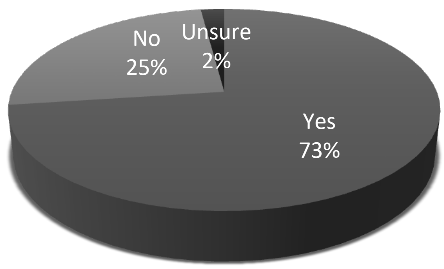
The responses from Q.6.1.3, to Q6.1.5. show that CCS is largely compatible with the respondents' personal beliefs and values, professional needs and objectives, and past experiences (Figure 5.46). This is unsurprising considering the respondents' characteristics.

Figure 5.47. Perceived Characteristics of an Innovation (Compatibility)



The responses to Q.6.1.6 and Q6.1.7. showed that CCS was not at all considered too complex for respondents to understand but was considered slightly more difficult to put into use (Figure 5.47.). This is perhaps a result of their limited practical experience.

Figure 5.48. Q.6.2.1. Trial-ability (+): Have you made attempts to test or trial some aspects CCS, perhaps on a partial or…



Asked in Q.6.2.1., if respondents had made any attempts to test or trial some aspects of CCS (perhaps on a probationary basis), 73 percent said 'Yes,' while 27 percent said 'No' or 'Unsure' (Figure 5.48.).

Figure 5.49. **. Q.6.2.2. If yes, has this been a positive or negative experience for you?**

The 73 percent was then asked in Q.6.2.2. if the experience had been positive or negative and their responses appeared to be overwhelmingly positive (Figure 5.49.).

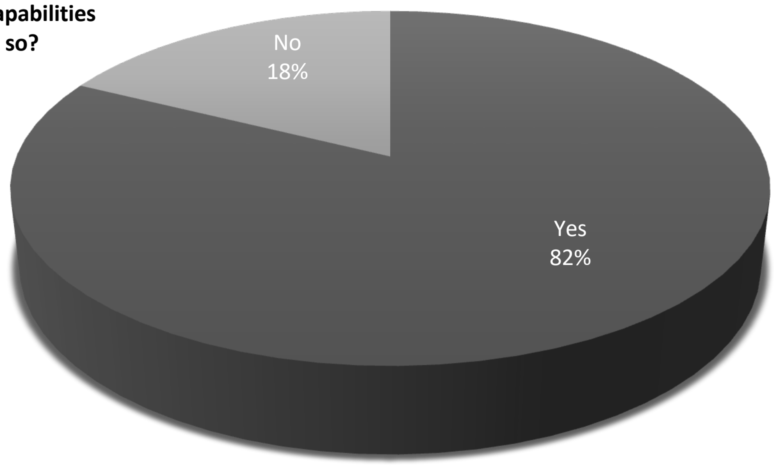
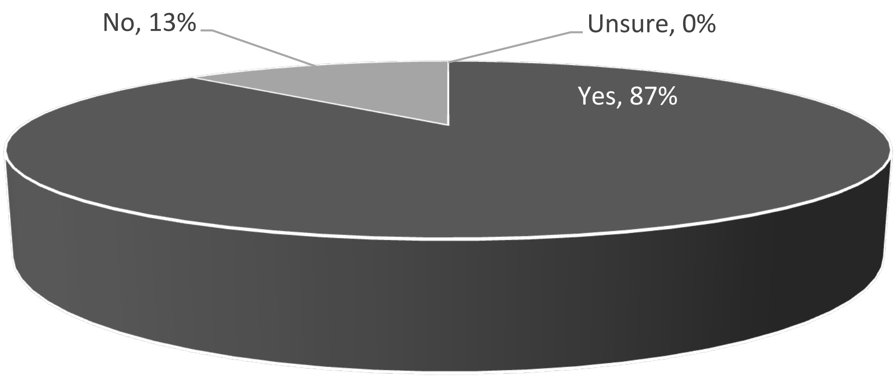


Figure 5.50. Q.6.2.3. Trial-ability (+): If not, do you have the capabilities to do so?

The 25 percent that said "no" was then asked in Q.6.2.3. if they had the capabilities to do so. 82 percent said yes, while 18 percent said no (Figure 5.50.).

Figure 5.51. Q.6.3.1. Observability (+): Have you observed demonstrations, tests or trials of CCS that have been carried out by other individuals or organizations?



Asked in Q.6.3.1., if respondents had observed demonstrations, tests, or trials of CCS that have been carried out by others, 87 percent said yes, 13 percent said no (Figure 5.51.). Asked in Q.6.3.2. if these left a positive or negative effect, the response again was overwhelmingly positive (Figure 5.52.).

Figure 5.52. **Q.6.3.2. Observability (+): If yes, have these tests or trials had a positive or negative impact on your attitude towards CCS?**

With this primarily focusing on the perceptions before or during potential adoption decisions, the next stage was to look at the effect and consequences of having actually adopted the technologies for a period of time.

Effects & Consequences

'Part Seven' focused on the positive effects and the negative consequences of adopting CCS on individuals, organisations, and others, for their industry/sector, and even at the national scale) (Q.7.1. and Q.7.5.), and whether these were anticipated or not (Q.7.2., Q.7.4. and Q.7.6.). Asking whether they had been informed or warned about these from others (Q.7.3. and Q.7.7.), and whether or not they feel these where avoidable (Q.7.8.), the purpose of this was to focus on the very real-world outcomes of those that had decided to adopt (i.e., to continue engaging in CCS-related activities).

When asked Q.7.1. to Q.7.3., "Has your involvement in CCS-related activities resulted in any positive effects for you, you organisation, others, your industry/sector, for China, and were these anticipated (or not), we see that the majority of responses in each category were "yes" (Figure 5.53.). Similarly, when asked Q.7.5 to Q.7.7., "has your involvement in CCS-related activities resulted in any negative consequences for you, you organisation, others, your industry/sector, for China, and were these anticipated (or not), we see that the majority of responses in each category were "no" (Figure 5.54.).

Figure 5.53. Positive Effects

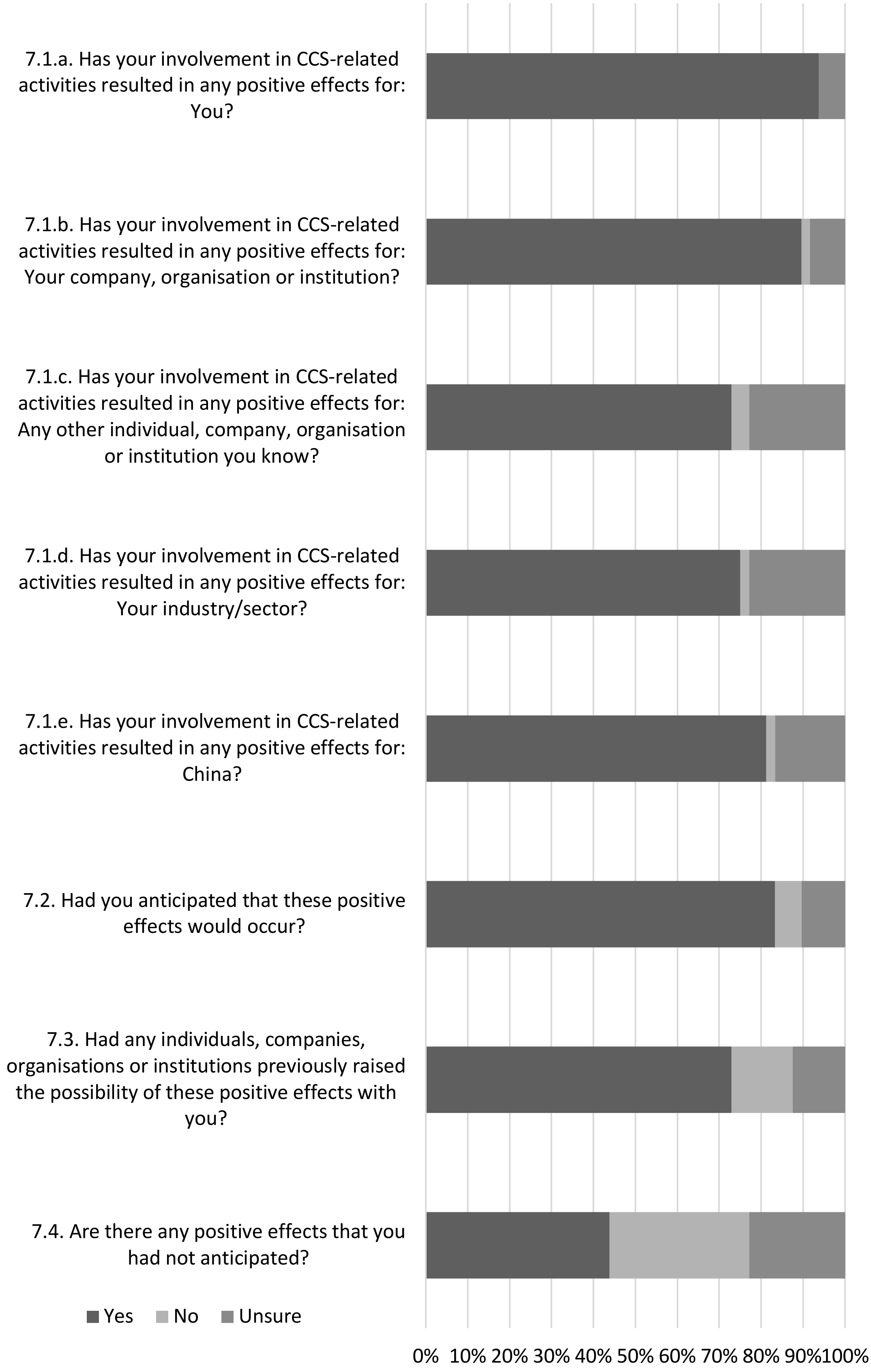
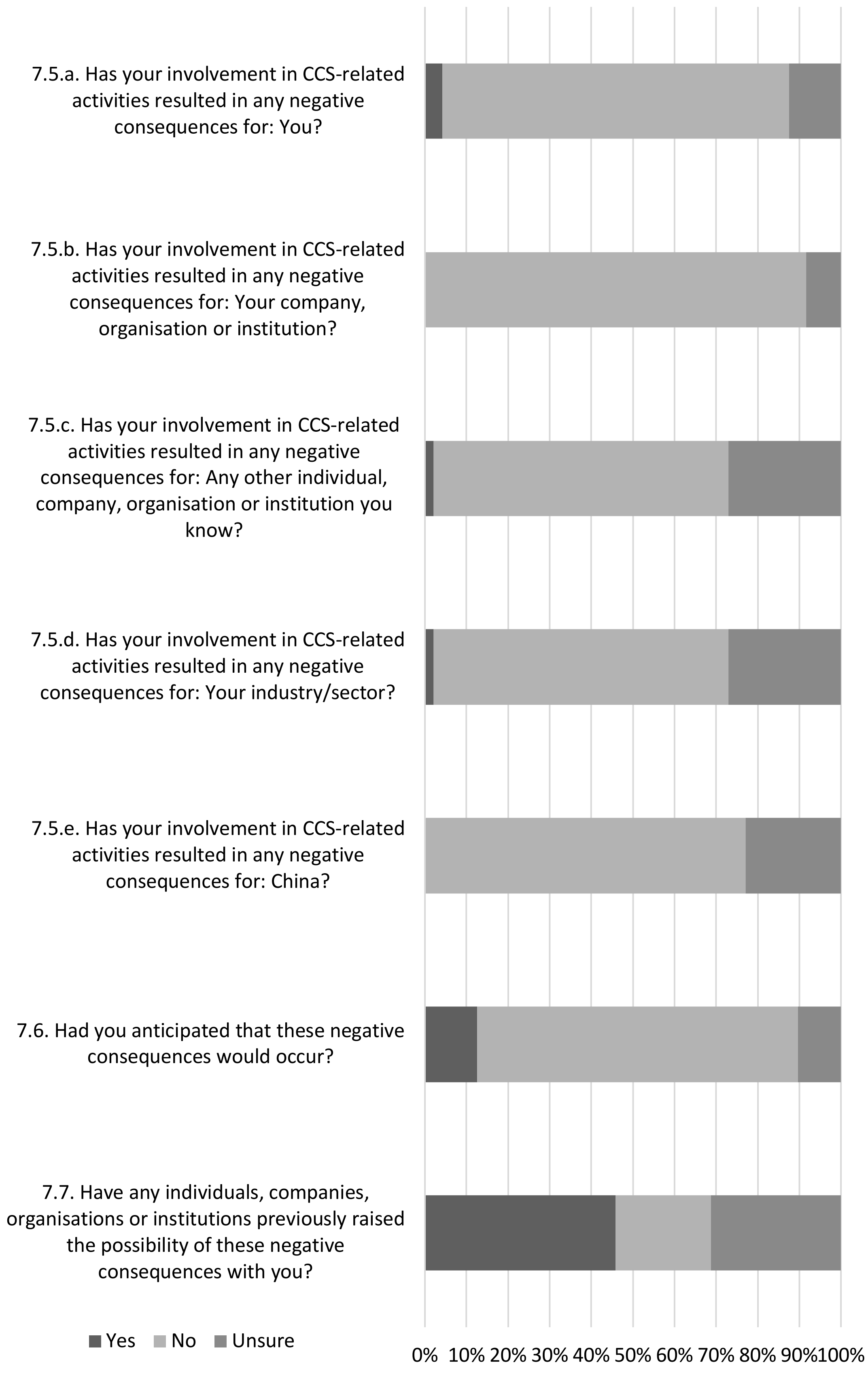


Figure 5.54. Negative Consequences

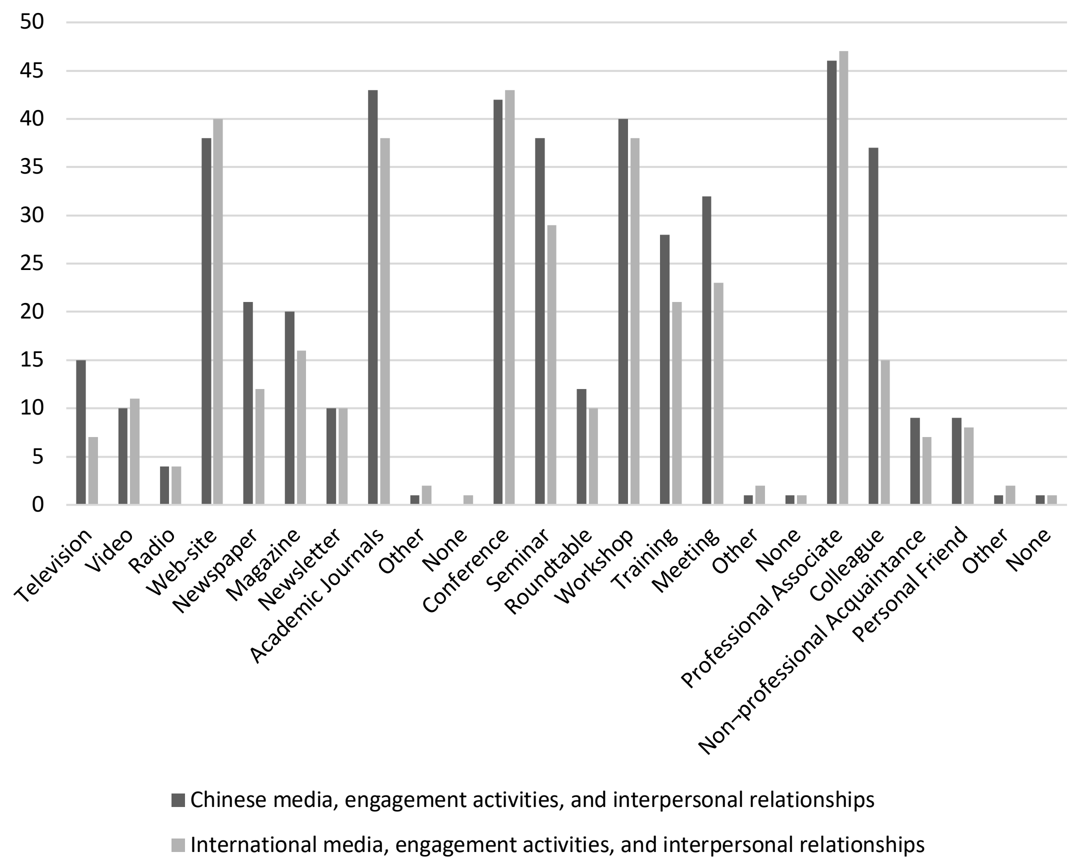


Although repeatedly probing for information about who these parties communicated with through the face-to-face interviews, the last section of survey questioning focused on the respondents' overall communications behaviour.

Communication Behaviours

With communication being the "process in which participants create and share information with one another in order to reach a mutual understanding" (Rogers and Kincaid, 1981), 'Part Eight' of the Communications Survey was designed to look at the communication behaviours of the respondents, and to better understand the channels they might receive and transmit information. Specifically, I wanted to look at whether the respondents were using primarily one-way, linear channels of communication in which one party seeks to persuasively transfer a message (diffuse a technology) to another in order to achieve certain effects (i.e., the adoption of CCS), or if they were a process of convergence (or divergence) as two or more individuals exchange information in order to move toward each other (or apart) in the meanings that they give to certain events. For this, I presented the respondents with a series of possible communications channels (media channels, engagement activities, and interpersonal relationships) and asked which they would use to receive CCS-related information and whether these would be primarily with Chinese parties, international parties, or both (Q.8.1. and Q.8.6.).

Figure 5.55. Communications Survey Data



From these results (Figure 5.55.), we learn that respondents said they primarily receive CCS-related information from international and Chinese websites, academic journals, conferences, seminars, workshops, trainings, meetings, and professional associates, as well as Chinese colleagues. From Figures 5.56. and 5.57., we can see that there is little real difference from the ways they consume CCS-related information from both sides.

Figure 5.56. International Channels

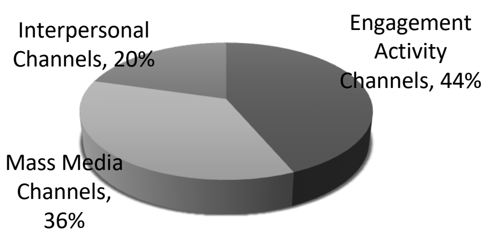
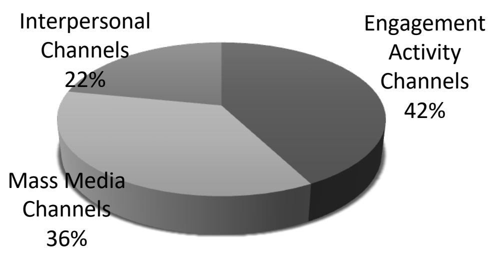


Figure 5.57. Chinese Channels



Summary and Conclusion

Those who responded to the Communications Survey were mainly men, well-educated, experienced, and affluent, with the ability to communicate in English. The majority came from academia, then industry, research, and government, with no responses from financial institutions and NGOs (perhaps due to CCS not being a key issue yet). Their expertise and experience are more on the scientific and technical aspects of CCS and less related to policy, regulatory, financing and communications aspects. Most respondents believed themselves to be qualified, knowledgeable, and skilled, but they had less confidence in the abilities of their colleagues. A little less than two thirds didn't see resources as a barrier to their work but about one third seemed unsure. Geographically, most of the participants are based in Beijing but there are also pockets of activity in Dalian, Guangzhou, Shanghai, and Wuhan.

The earliest year when respondents personally heard of CCS was 1995 but the majority of interviewees said 2005, 2007, 2009, and 2012. At the institutional level, the earliest was 1996 with a gradual increase and spikes of activity in 2006, 2008, and 2010. The majority had first heard of CCS through interpersonal connections (most commonly through colleagues) but also through engagement activities (conferences) and media channels (academic journals). From their communication behaviours, we can see that there is little real difference in the way my respondents receive CCS-related information from both Chinese and international sources.

In diffusion studies the newness of an innovation is important and almost 90 percent of the Chinese respondents said CCS was new to some degree. The majority of the respondents stated that their interest in CCS at those times came from 'actively seeking a solution to a pressing need priority problem' and fewer said they were 'influenced through the involvement of a second party.' They had either been approached and introduced to CCS by others or learnt about it passively through other activities.

The need for the innovation would also determine the success of diffusion as three quarters see it as necessary to some degree. Quite a large number felt that there were superior alternatives to CCS but an almost equal number was unsure, with the Government being the most assured that there are existing alternatives. In saying that, most respondents had a 'somewhat' to 'extremely' positive opinion of CCS, with attitudes towards the technologies developing most strongly since 2005, peaking in 2008 and then 2010 before declining sharply. A huge majority said their decision to engage in CCS-related activities had been influenced by trials or demonstrations given by other parties, mainly international partners. Around half see these as being positive but there was a recognition that there needed to be more experience and trust will be needed with the technologies and many interviewees spoke of engaging in desktop studies, experiments, pilots, and demonstrations. Almost three quarters stated they had undertaken feasibility studies, research activities, tests or trials, with most saying that these experiences were positive. A very substantial number claimed their work had led to the advancement of CCS at the national level and many called for the Government to take a more active role towards assisting in the scaling up of Chinese projects, perhaps through financially supporting a large-scale commercial demonstration in China with supporting policies. The sharing of data and lessons as well as international cooperation was seen as necessary.

A huge number stated that they had modified, adjusted, redesigned or altered CCS, mostly often making customisations to meet local needs so that the technologies could be used for other purposes or changed for commercialisation and gaining profit. After some time engaging with the technologies, the vast majority (around four out of five) believed they had made the right decision but many remained realistic about the future prospects for CCS and the challenges ahead. Much of its adoption success will depend on its perceived characteristics but unfortunately the respondents didn't see CCS as having much of a relative advantage over its alternatives. Fortunately, however, the respondents did see CCS as largely compatible with their personal beliefs and values, professional needs and objectives, and past experiences and they didn't consider the technologies too complex to understand but they did consider CCS slightly more difficult to put into use. When asked if they have a role in making CCS-related decisions within their organisations, the majority said yes and considered themselves to be a key decision maker, while most said they will be consulted in relation to any CCS decisions within their organisations.

To conclude, it is clear that the Chinese respondents were knowledgeable and experienced in fields related to CCS but they still had much to learn beyond the individual scientific and technical aspects and how to bring the whole suite of technologies to scaled-up demonstration and deployment. The majority of Chinese respondents were already seeking a solution to some problem, so their knowledge of CCS would be seen as selective exposure. This is consistent with Hassinger's (1959) argument for 'selective perception,' whereby potential adopters would seldom expose themselves to messages about an innovation unless they first feel a need for the innovation. We should also acknowledge that there were also others who were not actively seeking any solution to a problem and CCS was presented to them either proactively by others (i.e., at conferences) or passively through activities (i.e., reading). From this we can determine that the majority of Chinese respondents were active participants in creating and sharing information with one another about CCS (as seen in a decentralised system), while at the same time some Chinese respondents were relatively passive acceptors of CCS related information (as in a centralised diffusion system), which presents early signs of a hybrid model of diffusion.

The passively receiving, while at the same time pro-actively creating and sharing, information was also recognised through the learning from international demonstrations and the initiation of Chinese domestic projects. A huge number stated that they had modified, adjusted, redesigned or altered CCS, most often making customisations to meet local needs but also so that the technologies could be used for other purposes or changed for commercialisation and to gain profit. We heard from the Chinese respondents about the necessity for the one-way/linear models of communication whereby international partners would share their data and lessons, which could also be described as diffusing CCS as the uniform western conceptual 'package (as in a centralised diffusion system). This was alongside the need for more two-way/convergence models of communications, whereby both international and domestic partners would share information to enable a degree of reinvention to occur as the innovation is modified to fit Chinese conditions or commercial opportunities (as seen in a decentralised system). Again, this presents early signs of a hybrid model of diffusion.

We learnt from this data that the vast number of respondents were supportive of CCS, saw the technologies as largely compatible with their needs, and not overly complex, but they did see superior alternatives to achieving their objectives and were realistic about the challenges ahead.

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Chapter Six: International CCS Community as the 'More Knowledgeable and Experienced Parties' – Motivated expert sources diffusing CCS through localised sources along horizontal networks

Through the literature review and case studies (Annex), we learnt of the vested interests in the existing structures and systems around fossil fuels and the growing international pressure and public demand for increased climate action. In turn, this often leads to governments' desire for technical certainty and policy clarity, which has resulted in the need for increased global governance and cooperation on an international scale. Recognising that many aspects of this research area have already been explored, Stephens (2011) states that what we know less about is how the international community around CCS is structured, how it functions, and how it communicates, as well as how it might influence policy processes. This chapter seeks to fill that knowledge gap, while focusing on the influence of the International CCS Community on China.

Theoretical Framework

From a theoretical perspective I argue that the International CCS Community is composed of experts who are motivated to diffuse CCS through localised sources along horizontal networks, demonstrating the existence of a hybrid model of diffusion. Borrowing Rogers' theoretical theme of the 'more knowledgeable and experienced parties,' that are often also the original primary 'sources of information,' I explore the concepts of 'diffusion networks' and 'change agents,' as well as 'paraprofessional aides,' all of which can be used to assist in diffusion activities (See Figure 6.1).

Research Questions	Conceptual Components	Centralised Diffusion	Decentralised Diffusion	Hybrid Model of Diffusion
1. How is the International CCS Community structured, how does it function, and how does it communicate to influence the CCS-related policy processes?	**Sources of Information**	Innovation originates from an expert source	Originate from numerous local sources and then evolves as diffused via horizontal networks	**Motivated expert sources diffusing CCS through localised sources along horizontal networks**
	Diffusion Networks			
2. Do the messages regarding CCS originate from expert sources (a centralised system) or numerous local sources (a decentralised system) via horizontal networks?	**Change Agents**			
	Para-professional Aides			

Figure 6.1. International CCS Community as the 'More Knowledgeable and Experienced Parties'

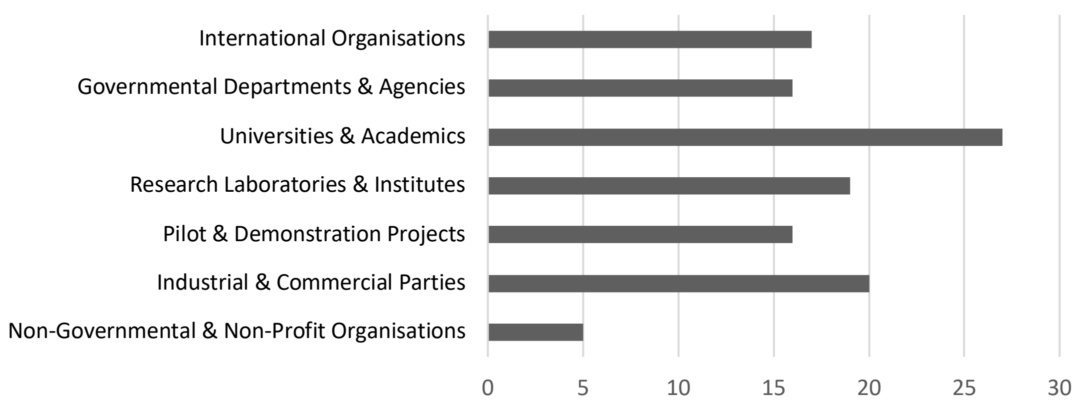
More Knowledgeable and Experienced Parties

Through a quantitative and qualitative analysis of my survey and interview data, I identified 120 international entities that had interacted with my respondents, thus offering them the opportunity to influence Chinese decision-making processes. Further research into these entities allowed me to provisionally organise and categorise them under countries and stakeholder groups (Figure 6.2. and Figure 6.3.).

Figure 6.2. 120 international entities that had been identified by the respondents

From an initial overview, 17 entities were international organisations and 103 appeared to originate from 16 (mainly industrialised) economies. At a national level, many entities were academic institutions and research laboratories, as well as industrial and commercial bodies, with a substantial number of government bodies but only a number of non-governmental organisations. Further analysis was needed to understand the connections.

Figure 6.3. International CCS Community Categories



Following Rogers (2003:125-6) advice to create an "uncommon amalgamation," which combines both primary audience-based research data and secondary-sourced materials in diffusion studies, I merged my primary-sourced coded survey and interview data with secondary and supplementary literature to write case studies on theses international entities (see Annex). Rogers sees this as a way to uncover the intricacies behind the emergence and development of an innovation, as well as those parties behind its development and their motivations. For me, this provided greater clarity around some of the uncertain/unclear responses from Chinese interviewees, while also filling in the gaps for my own knowledge and understanding.

Using this combination of my survey data, interview transcripts, stakeholder mapping, and case studies allowed me to identify the main 'sources of information,' the 'diffusion networks,' and the 'change agents,' as well as the 'paraprofessional aides.'

Sources of Information

Rogers (2003:204) defines the sources of information as "an individual or an institution that originates a message" and he goes on to state that "it is often difficult for individuals to distinguish between the source of a message and the channel that carries the message." When faced with a multitude of parties throughout the entire innovation diffusion process, it is important to identify those who actively seek to diffuse an innovation and those who are assisting with the diffusion activities.

Reflecting on Rogers' (2003:204) warning that it is often difficult to distinguish between the source of a message and the channel that carries it, this was certainly the case for the International CCS Community and their efforts to diffuse knowledge about CCS in China. What was clear to me was that the sources of CCS-related messages were not merely single individuals or institutions but nation states via coalitions of countries with vested interests in presenting CCS technologies as the most viable solution for sustaining fossil fuel consumption while appearing to simultaneously address climate change. Again, recognising the challenges in differentiating between sources and channels, I found that the primary messages around CCS emerged simultaneously from two broad technical and political regimes, namely the Intergovernmental Panel on Climate Change (IPCC), as the scientific advisory body to the United Nations Framework Convention on Climate Change (UNFCCC), and the International Energy Agency (IEA), as the Group of Eight's (G8) *de facto* energy advisor.

With its scientific authority and assumed objectivity, the IPCC periodically assesses the landscape of technologies that may mitigate GHG emissions. The IPCC 'Special Report on CCS' (2005) gradually provided confidence in the technologies' mitigation potential and its networks of scientists and researchers had the potential to influence national agendas and funding decisions. Crucially, as noted by de Coninck *et al.* (2011:368-376), many developing countries were involved in the IPCC's processes which contributed to gradual normative shifts towards a greater acceptance of CCS in the global south. I have also seen clear evidence of this within my research, where Chinese experts were involved in the China-specific elements of the IPCC's work, which subsequently led them to advocate for the technologies and demonstration projects domestically (A03;I37;I05;R24;R23). Unfortunately, although seen as the most legitimate, efficient, and cost-effective forum for CCS to emerge (de Coninck, 2011:375), the international climate negotiations at the time were too politically polarised and it appeared difficult for the technologies to gain widespread support within the UNFCCC.

Using the IPCC's technical reservations and environmental uncertainties to their advantage, collectives of non-OECD countries called for greater assurances. Continuously calling for additional reviews of implications of the technologies' deployment, these politically and economically-motivated developing countries were able to block successive attempts by fossil fuel advocates to link CCS with the Clean Development Mechanism (CDM). This led to scholars, such as Zakkour *et al.* (2014:6948-9), seeing CCS advancement within the UNFCCC as a failure. Others, such as the IEA, seemed to remain optimistic for the prospect of CCS within the multilateral system but coalitions of developed countries had already started to launch initiatives that included selected developing countries, emphasising the mutual benefits of other forms of cooperation, which de Coninck (2011:368-76) sees as a "weakening of multilateral climate diplomacy."

Recognising that CCS as a concept was facing political challenge within the UNFCCC and that the IPCC would not be an absolute advocate for the technologies, the OECD-orbited IEA seemed to be already in a position to lead on providing recommendations that could be elevated to political levels during key moments of the G8. Using the IEA's technical modelling, analysis, and scenarios, as a means of getting out messages, Hansson (2012:77-8) argued that these both necessitate and rationalised the use of CCS, whereas Meadowcroft (2009:273-4) would also see these as storylines that continue to deeply-embed societal practices and maintain the fossil fuel systems that would inhibit more radical change. Recognising its internationally-respected reputation, the IEA's narratives, statistics, and predictions have been routinely cited and its analysis has formed the basis of many developing countries' domestic climate strategies and policies.

Acknowledging that the G8 summits were key opportunities to elevate the IEA's messages to political levels while strengthening its recommendations through setting targets for international demonstrations, the IEA constructed more policy-focused road maps that also set out long-term plans and key milestones, as well as immediate actions, in order to increase coordination and maximise the effectiveness towards deployment. Seeing positive signs that some OECD countries were responding to this approach, the IEA was also cognisant that there would need to be significant engagement with non-OECD developing countries and associated support to aid their efforts. In the absence of real financing, there were opportunities to influence policies and regulations through creating peer-to-peer networks and by facilitating forums, most notably through the IEAGHG.

Though this investigation, we also know that China was not immune to the IEA's ambitions for domestic demonstrations and IEA actively sought to influence the country's policies, not only though involving Chinese parties in the development of Chinese CCS road maps and associated workshops and through assisting them in China-specific feasibility studies but through the regular provision of positive information and reassuring messages.

It is also important to remember that it was the UK that had raised the political profile of CCS as a mitigation option and it was the G8 through its summits and communiques that had committed to work towards accelerating the development and commercialisation of CCS. Charging the IEA to provide its recommendations, which conveniently mirrored its own goals, the G8 also created the CSLF and later the GCCSI as international mechanisms for monitoring countries' progress. Cognisant of the necessity to engage with non-OECD countries, the G8 Energy Ministers' Meetings were key opportunities to seek developing countries' commitments, particularly the large emitters, towards the G8s goals, which were essentially IEA's recommendations for demonstrations. Surprisingly, the G8 itself didn't seem to have a significant influence on the respondents of this study, probably because it primarily pursued its goals through its intermediaries, the CSLF and the GCCSI. Many of these intermediaries appeared to take the role of diffusion networks, although we should also acknowledge that the G8 itself could be considered so too.

Diffusion Networks

Rogers (2003:373-7,383-4) sees diffusion networks as holding the prospect of more effective interactions and increased persuasive credibility. As such, the more homophilous partners have a greater capacity to form and change opinions and to effect overt behavioural change, with the possibility to accelerate diffusion. Appearing to gain little personally from others' adoption, the communications between these homophilous parties can be considered more credible, frequent, easy and effective. Recognising the challenges of advancing CCS through the UNFCCC processes and with the necessity to engage effectively with developing countries through the G8, diffusion networks could be considered as a means to build trust between the more experienced parties and their lower-level clients (those who are not key decision makers). From the parties identified by the Chinese interviewees, the following entities could be defined as diffusion networks.

The first example of a CCS-specific diffusion network came in the form of the CSLF, which was widely regarded as a hegemonic attempt by the US to share its limited domestic learnings, while benefiting from the international activities of others. Despite having some limited engagement with the larger developing country emitters, it was still criticised by Bäckstrand (2008:92-93) for being a "mini-lateral island" and by de Coninck *et al.* (2011:373-375) for only serving to promote the availability of CCS as a technological option in order to avoid climate commitments while legitimising the use of fossil fuels. Although criticised for being reluctant to see CCS actually being deployed, the CSLF did establish a 'Capacity Building Task Force (CBTF).' As one of the larger developing country emitters that the CSLF had engaged, the Chinese respondents from this study seen the CSLF as an abundance of ambitious and positive information related to CCS, although much of this information was not entirely new and their real motivations were the prospects of building foreign commercial contacts and gaining international funding.

Accused by Lesage (2009:271-4) of using its institutional power to envelop western-dominated organisations to undertake its own energy-related work and by de Coninck (2011:369,375-6) of exerting their influence over the multilateral development banks (MDBs) serving the national interests of hegemonic countries, the G8 members had called on MDBs during the Gleneagles Summit (2005) to increase their engagement on CCS, which led to the World Bank (WB) outlining US$3bn within its 2007 "Action Plan." A few months later, the developing countries that had been invited to the Aomori Summit had ensured that the need for financial support, capacity building, and information sharing was included in the joint Energy Ministers' statement. However, despite the possibility of some of the WB's US$6.1bn 'Climate Investment Funds (CIFs)' going on CCS projects in emerging and developing countries, there was opposition from some against supporting coal-related projects. Recognising the role of the MDBs in supporting CCS as a critical transformative technology and for demonstration in the developing world, the UK channelled GBP£25m and GBP£35m through the WB and ADB, respectively, to support CCS-related projects, regional analyses, and capacity building activities in Africa, Indonesia, Mexico, and China, via the WB CCS Capacity Building Trust Fund (CCSTF). We have seen through the responses within this investigation that the WB was not only a source of techno-economic analysis and legal and regulatory assessment for China but supported Chinese parties in the development of a Chinese CCS road map and smaller CCS-related feasibility studies.

Also responding to the G8's call, the ADB had been steadily increasing its financial investments in low-carbon technologies and building the capacity of its developing country members, while striving to provide assurances to investors by combating technical gaps and potential policy holes (Seligsohn, 2010:8). Despite providing short-term loans for the construction of small-scale projects, according to Lai *et al.* (2012:643), there was a longer-term over-reliance (particularly within the Chinese system) on international (and state) funding for constructing CCS projects, with commercial partners unwilling to be burdened with the high operating costs. There was also a hesitancy by potential investors to undertake expensive feasibility assessments, time-consuming storage capacity characterizations, and/or costly front-end engineering and design (FEED) studies. As such, the ADB established its CCS Trust Fund (CCSTF), which was initially funded by an AU$21.5m contribution from the GCCSI and a further US$35m from the UK, which we will discuss further later. We know through this investigation that China received funding from the ADB, establishing research teams to resolve technical issues, and to develop a "CCS Road Map for China."

Also criticised by Bäckstrand (2008:67,91-94,97,99) for being a US attempt at unilateralism, the Asia-Pacific Partnership on Clean Development and Climate (APP) played a very similar role to the CSLF in bringing together mainly industrialised, energy-consuming, and/or GHG-producing countries to exchange information and share experiences, again allowing the US to extend it international reach. As a non-binding compact, it involved only like-minded countries, had no mitigation targets, and included barrage on voluntary technology agreements, which led it to be seen as an attempt to circumvent what was considered the more "Eurocentric" Kyoto Protocol, despite its proclamations to be complementary to the UNFCCC. Its membership included the non-European G8 members (Australia, Canada, Japan, and the US) plus those who were invited to the G8's 'Aomori Meeting' (South Korea, India, and China), similar to the CSLF, the APP developed its own partnerships governance with its members, which included a partnership statement to establish its vision and a suite of founding documents. These were intended to set the parameters for their multilateral and bilateral partnerships that sought to develop sustainable solutions to shared challenges through bottom-up practical action. APP held the third (and final) Ministerial Meeting in China during October 2009. My respondents see these as important occasions to develop and sustain bilateral partnerships, with the MoU between Australia and China for increased CCS-related cooperation seen as important.

Seen as another example of multilateral cooperation based on mutual developed-developing country respect, the Asia-Pacific Economic Cooperation (APEC) emphasised the need to ensure essential energy services for developing countries, and was praised for having an inclusive atmosphere that cultivated a spirit of cooperation. Meanwhile, it was also seen by many western industrialised nations (particularly the US and Australia) as a gateway to lucrative economic markets and an opportunity to promote low-carbon sectoral development and to diffuse clean-coal technologies, such as CCS. Unfortunately, it was also criticised for being a talking shop that only promoted soft targets with little enforcement and as another attempt to circumvent the soon-to-be-concluding Kyoto protocol. As such, while China had already been an active participant in the APEC Energy Ministers' Meetings, in 2014 the country hosted the APEC Leaders' Summit and used this as an opportunity to announce more ambitious climate commitments (alongside the US) and to outline their future bilateral engagement on CCS. For some, such as Marcu (2014:6), this was a total breakdown of the Kyoto Protocol-style separation in climate change negotiations between developed and developing countries. This high-level attention to CCS was noticed by my Chinese respondents, legitimising the technologies (and their work), with successive summits refocusing attention and attracting new members to their community. However, there were some concerns that this was merely diplomatic showcasing to improve bilateral relations and perhaps to appease international calls for climate action from these two large emitters. At a technical level, the US DoE and IEA-led Energy Working Group (EWG)'s Expert Group on Clean Fossil Energy (EGCFE) was carrying out a suite of capacity-building activities throughout the APEC region, a number of which focused on China.

Also created in response to the G8's call for demonstrations, the Global CCS Institute (GCCSI) was seen to cater for the same coalition of willing states that were involved in the other CCS-related initiatives. Established using Australian Government funding, to complement its domestic demonstration ambitions, de Coninck (2011:375) considers the GCCSI as a hegemonic exercise to serve the country's own national interests. Creating an atmosphere of optimism that CCS would soon be deployed at commercial scale, this hope was short lived for a number of reasons, not least the financial stress of the 2008 economic meltdown and the political disappointment from COP15. Losing its funding from the Australian Government, the GCCSI became a membership-driven NGO that is composed of carbon-intensive economies and fossil fuel producing/consuming industry partners, with offices in Australia, China, Japan, EU, and US. Working with other multilateral entities and international institutions, the GCCSI helped to forge strategic alliances and form public-private partnerships and investment alliances, while combining global expertise, coordinating activities, and sharing knowledge.

Importantly, it was the GCCSI's partnership-building role that prompted Stephens *et al.* (2012:144-5) and Hagemann (2011:5705-7) to argue that the establishment of the GCCSI led to the creation of an increasingly-interconnected International CCS Community. de Coninck (2011:372-7) saw this as counteracting the considerable fragmentation that existed within the CCS governance landscape, although she also viewed the GCCSI's advocacy role with suspicion, as its membership and its overly-positive narratives often lack real criticism of the technologies' potential. Despite being perhaps the most well-resourced CCS-related organisation, the GCCSI budgets didn't quite stretch towards facilitating demonstrations but the organisation did take a leading role in publicly tracking the progress of large-scale projects. Positioning itself as the global broker of CCS-related information and a central repository for global CCS-related data, it continues to coordinate subject-area networks and hosts seminars and workshops, however its non-OECD capacity building activities were usually undertaken in collaboration with the IEA, CSLF and/or WB.

China has not been immune from the GCCSI's advocacy efforts, as the Government signed an MoU to strengthen technical cooperation and advance demonstration and deployment in 2012, with the Huaneng Group becoming the Chinese power industry representative and the China Steel Corporation its non-power CCS applications representative. Although having a physical office in Beijing and a close GCCSI partnership on the "China CCS Road Map," the GCCSI has not had much progress in attracting international funding or investment for large-scale demonstrations and other notably CCS projects in China. My respondents benefited from the GCCSI's function of bridging international stakeholders, convening conferences, seminars and workshops, and its repository of CCS-related information, although they doubted the influence these softer governance activities on their attitude towards the technologies, feeling that funding would have a greater impact on CCS adoption.

Change Agents

Rogers (2003:173,366-370) defines a 'change agent' as "an individual who influences a client's innovation decisions in a direction deemed desirable by a change agency. A change agent usually seeks to secure the adoption of new ideas, but he or she may also attempt to slow the diffusion process and prevent the adoption of certain innovations with undesirable effects." The essence of a change agency is to "provide a communication link between a resource system with some kind of expertise and a client system" and it typically performs a sequence of seven roles or functions in their pursuit to diffuse an innovation (Figure 6.4.), which have different communication effects.

Figure 6.4. Change Agents Functions

The first of the change agent's roles is to 'develop a need for change,' whereby a change agent initially helps clients become aware of the need to alter their behaviour and points out new alternatives to existing problems, while often dramatising the importance of these problems and assuring clients that they are capable of confronting these problems. The second role is to 'establish an information exchange relationship' by developing a rapport with their clients by empathising with them and increasing their own perceived credibility, competence and trustworthiness. At this point, quite often the next stage is to 'diagnose problems' and to assist the clients to determine if the innovation can be a possible alternative or solution to their problem. Once this has been established, it is then the objective of the change agent to 'create intent within the client to change' by laying out possible avenues and motivating their interest in the innovation. If they manage to get this far, the next stage is to 'translate intent into action' by influencing a behavioural change within the client based on its recommendations, most often through indirect interpersonal contact and the activation of peer networks. With the penultimate stage being to 'stabilise adoption and prevent discontinuance' of the innovation often through reinforcing messages, the final stage is to 'achieve a terminal relationship' whereby the change agent creates a self-renewing and self-reliant behaviour and establishes the client as its own change agent.

Change Agents within the International CCS Community

From what we have learned, there are a number of western industrialised countries who already have strong domestic efforts and national aspirations for CCS. In an attempt to raise the profile of the technologies and kick-start activity internationally, we saw the UK Presidency raise CCS within the G8, Australia pushed for CCS inclusion in the CDM and created the GCCSI, and the US established the CSLF. We also saw their collective efforts to launch regional activities through the APP and APEC and mobilise funds through the MDBs.

Although these are not individual people, as Rogers (2003:173,366-370) would expect, the ambitions and efforts of these western industrialised countries to influence the decisions of mainly emerging and developing countries and to secure their adoption of CCS, has led me to categorise them as potential 'change agents' within the International CCS Community. Presenting CCS technologies as the most viable solution for sustaining fossil fuel consumption, while appearing to simultaneously address climate change, these countries are motivated to speed up the diffusion of CCS. However, some scholars, such as Vallentin (2006:11), Meadowcroft *et al.* (2009:6), and Drahos (2009:126-130) all accuse this coalition of countries of seeking to hasten CCS demonstration, while also delaying its deployment. This is also consistent with Rogers' view that change agents can also attempt to slow the diffusion process and prevent the adoption of certain innovations to suit their own needs or circumstances.

Rogers (2003:173,366-370) sees the change agents' purpose as influencing innovation decisions in a direction deemed desirable by their 'change agency,' while also providing a communication link between a resource system with some kind of expertise and a client system. Assuming the change agencies, in this case, are western-industrialised nations, then the change agents in this study are their government ministries and agencies, namely the US Department of Energy (DoE), the Canadian International Development Agency (CIDA), the European Commission (EC), the UK Department of Energy & Climate Change (DECC), and the Italian Ministry of Environment, Land, and Sea (IMELS), as well as the Australian Department of Resources, Energy & Tourism (DRET). These Government entities have had substantial interactions with China, which has undoubtedly had a significant impact on Chinese decision making. Others (Norway, France, Germany, Netherlands, Denmark, and Japan) have shown some signs of change agent activity but not enough to warrant being considered one fully at this time, within this research at least. Looking at the wider behaviours of these entities within the case studies, I will now identify instances of when they have undertaken change agent roles. Before I do that, it is important to better understand their possible motivations in a little more detail.

One of the key differences between a motivated 'change agent' and its 'client' is their expertise and experience of the innovation, in this case CCS. Without a doubt, those identified in this study already had significant domestic expertise and experience, with individual national interests for cooperating with China. For example, Stephens (2009:33) tells us that despite significant progress in promoting, funding, and coordinating national/regional-level CCS activities, the US DoE was failing to meet its domestic demonstration, deployment, and market penetration targets. Drahos (2009:125), sees the US entering into a bilateral partnership with China to benefit commercially from opportunities from accelerated development and deployment of technologies, while avoiding duplicative costs. Similarly, CCS had already been featuring prominently within

Canadian climate change strategies and the federal and provincial governments had already allocated billions of Canadian dollars towards for large-scale fully-integrated demonstration programmes and projects, with Mitrović *et al.* (2011: 5685-91) seeing the Weyburn-Midale and SaskPower Boundary Dam as the earliest and first/largest global fully-integrated/commercial-scale projects. Needing to curb its provincial petroleum industries' emissions and hoping to revitalise its CBM industries, Canada had spotted opportunities to transfer its technologies to new markets and set out to collaborate with Chinese partners to test its CO_2-ECBM technologies in China.

The EC's cooperation with China appeared to focus around emissions reductions and gradually saw plans for CCS development and Chinese demonstration emerge as a key bilateral priority, which included pledges of small amounts of funding. Quite openly, the EC stated that this was an opportunity for "a concrete and politically visible demonstration plant on a scale large enough to catalyse change at the national level and to transform external perceptions of China" (EC, 2009), which alongside emission reductions can be assumed their primary motivation. As an EU member state, at the time, the UK was also facing domestic difficulties with its demonstration ambitions and DECC saw strategic opportunities for joint learning under similar conditions through cooperation with China, as well as lucrative potential market for CCS technologies. This was a similar situation for the IMELS, as despite having significant CCS experience at home, Enel's plans for large-scale demonstrations were suspended due to strong domestic opposition, leaving the largest national energy provider to pursue opportunities for investment in other countries, with its contacts and cooperation with China becoming useful. Lastly, Australia's fossil-fuel dependency and emissions-reductions necessity meant the DRET was always going to invest in domestic CCS-related R&D, pilots and demonstrations. Well known as the world's largest net exporter of coal, supplying China as the greatest consumer, Australia would have many strategic and economic interests, none less so than sustaining their trading relationship through the advancement of clean coal technologies.

Now that we've touched on these entities' experience in CCS and their interests in China, we can look at how they have developed the countries' need to change.

Developing a need for change

According to Rogers (2003:173), 'developing a need to change' is when a change agency initially helps a client to become aware of the need to alter their behaviour and points out new alternatives to existing problems, sometimes dramatising the importance of these problems and assuring clients that they are capable of confronting these problems. It's difficult to tell when exactly the change agents might have developed a need to change but that doesn't stop us exploring the possibilities. At the multilateral level, we've already seen how these change agents can use both sources of information (IEA and IPCC) and diffusion networks (CSLF, APEC, WB, ADB, APP, APEC, GCCSI) to develop a need to change but nation states can also amplify these efforts and undertake bilateral activities too.

For the US DoE, an obvious example of this could be the 'US-China Strategic and Economic Dialogue' (2009) when the new US President Obama called for the two largest emitters to work towards mutual interests of clean and secure energy future with low-carbon economies that protect their people from climate change, with joint R&D for new technologies, such as CCS, a central aspect. Regarding Canada's cooperation on CO_2-ECBM, it appeared that the US success in this field may have resulted in China's organisation of the "Prospects for Enhanced Recovery of Methane from Deep Beds of Unmineable Coal" (1991) promotional event, but it was also the opportunity to jointly develop and submit a successful proposal to CIDA's "Canadian Climate Change Fund' that led to the 'China CBM Technology Development Agreement" (1999) with China's Ministry of Commerce (MOFCOM).

The EU-China Summits appeared to be key periodic opportunities to set bilateral priorities, with the "Joint EU-China Partnership on Climate Change" including CCS development and demonstration in China within its "Joint Declaration on Climate Change" (2005) with opportunities for CCS funding through the EC's Framework Programme (FP). Similarly, including CCS within the scope of its 'Strategic Prosperity Fund (SPF),' the UK hoped that funding a number of small-scale studies would motivate the Chinese Government to develop a national CCS strategy. In May 2008, China's MOST and the IMELS signed the "Cooperation on Clean Coal Technologies, including CCS Technology and Ultra-Supercritical Thermal Power Technologies," as a mechanism for constructive dialogue and a means to transfer technologies (Ping, 2014:8116-8122). Lastly, Australia's DRET and China's National Energy Administration (NEA) established the 'Australia-China JCG,' which would make US$12m available for a joint feasibility study for China's first commercial-scale integrated demonstration project, at Huaneng's Gaobeidian in Beijing.

We can see from the above that these change agent entities set about developing a need to change through formalising their relationships with China, often by setting out areas of mutual interests through jointly agreed memorandums. These often include short-term opportunities for small amounts of international funding but quite often had expectations of longer-term strategic impacts on Chinese policies or markets. However, this was only the beginning of these relationships and there needed to be a way to continue to communicate and influence bilaterally.

Establishing an information exchange relationship

Rogers (2003:173,366-370) states that change agents often provide a communication link between a resource system with some kind of expertise and a client system, often to establish an information exchange relationship while developing a rapport with their clients by empathising with them and increasing their own perceived credibility, competence and trustworthiness. As many of the change agents identified here had already formalised their relationships and set out areas of mutual interest at a high-level, each one had also set about establishing information exchange mechanisms that provided opportunities to have continuous bilateral communications at multiple levels, providing opportunities to build trust with and influence Chinese parties. While we will discuss these mechanisms in much more detail in the next chapter, it might be worthwhile only touching on them briefly here.

Seen as a way to support their respective national commitments, the first-of-its-kind US-China CERC was innovatively designed to encourage a level-playing-field and equal-funding-type collaboration, while hoping to deliver the G8's demonstration ambitions (Asia Society, 2009a:6-8,13,45). Although governed by a high-level ministerial council, the CERC included non-state-actor-led consortia which intended to build on the partners' expertise and experience, in order to "accelerate the development and deployment of clean coal technologies, including CCS within both countries" (CERC, 2013:B1, CERC, 2014b:11-12). An important aspect of the CERC was its innovative but somewhat unsuccessful approach to IP protection. Based on the responses from my respondents, there is no question that the CERC was a successful mechanism to bring Chinese and US parties together (G02;G12), with many Chinese parties connecting with US partners (A07;A03;A11;R01;R14;A21;R06;A39;G02;R35;R16;A29;A28;A17) and others stating that its communication activities were seen as very valuable (A21;I18;I40). However, there were also criticisms that the partnership was quite "exclusive" (A07) and that US partners increasingly saw less value in participating in its activities (A11).

On a much smaller scale, the CIDA-CUCBM agreement had created the China-Canada CO_2-ECBM Project, which He (2011) sees as the most significant Sino-Canadian CCS-related initiative of its time. Similar to the CERC, the CO_2-ECBM Project was expected to be funded by equal contributions from both governments, with the goal of transferring Canadian technologies to China and to demonstrate the viability of injecting and storing CO_2 in deep unmineable coal. Also similar to the CERC, it too was broken down into 'work breakdown structures' and was regarded by Canadian partners as a successful transfer of Canadian technologies and the building the capabilities of their Chinese colleagues (Ye, 2007:6,34,40; Wu, 2015:8; Sloss, 2015:32-3; GCCSI, 2017). This was confirmed by my respondents (A03;R14;A07), who had participated in these activities and had seen them as a way to demonstrate the great commercial potential of CO_2 sequestration and utilisation in China.

Similarly, on the back of its "Joint Declaration on Climate Change," the EC had established its Bilateral Consultation Mechanism (BCM), which was intended to strengthen the EU-China climate-related relationship (Romano, 2010:3-4). To deliver on its "Demonstrating CCS in Emerging Economies and Developing Countries: Financing the EU-China NZEC Plant Project (2009)," it had also established the EU GeoCapacity, $STRACO_2$, COACH, and NZEC initiatives, all of which provided opportunities for different consortia partnerships to exchange different types of information along the CCS advancement processes, thus potentially influencing policy makers, industry leaders, and developing a CCS supply chain in China. However, as Vangkilde-Pedersen *et al.* (2011:6; 2009:48; 2009:2670) confirmed, Chinese Government regulations restricted the provision of data relating to its domestic infrastructure and subsurface geology, limiting the two-way sharing of information between partners.

Despite the limitations faced, De Matteis (2010:450-7,467,472-3) sees these joint dialogues, meetings, and feedback mechanisms as opportunities for the EC to shape China's domestic climate policy development processes, while also avoiding the stormy waters at the diplomatic and political levels. A number of my respondents reported having direct contact and interactions through a number of EU-China bilateral CCS-related projects (R04;G02;R01) and many (R01;R04;R06;R09;I18;A21;A39;R16;A19) stated that they these initiatives ignited their interest in CCS as a concept and provided opportunities to meet with EU parties as well as with other non-EU countries (A17;A32;A29). Some also reported that these initiatives allowed them to carry out desktop investigations, laboratory tests, and very small-scale pilot projects, which produced valuable data and significant results for China and its partners (R01;A39;A19;I18;A08).

Diagnosing problems

Rogers (2003:173,366-370) tells us that the 'diagnosing problems' role is when "change agents assist their potential client to determine if the innovation can be a possible alternative or solution to their problem." As noted by my respondents, the establishment of information exchange relationships was a very useful method to provide Chinese parties opportunities to carry out desktop investigations, laboratory tests, and small-scale pilot projects, which produced valuable data and research results, thus determining if the innovation can be a possible alternative or solution to their problem. Often taking place in the form of work packages, they would often focus on the viability of technologies and presenting possible policy options.

For example, the CERC 'Advanced Coal Technology Consortia' (ACTC) undertook experimentation, piloting, demonstration, and investigations into the optimisation of processes, in order to provide learnings for technological efficiencies, cost savings, and to create commercial conditions. The CO_2-ECBM Project's work breakdown structures helped Chinese parties to identify micro-piloting sites for the demonstration and evaluated various Canadian technologies. The EU GeoCapacity developed a CO_2 emissions point source inventory and assessed storage capacities, while providing the scientific rationale and proof for the legitimacy and cost efficiency of the concept of CO_2 geological storage and its contributions to climate change. STRACO_2 investigated opportunities for Chinese incentivisation schemes, financial mechanisms, international trade, and technology transfer, as well as socio-economic issues. COACH sought to provide design recommendations for large-scale demonstrations by identifying the most viable technologies, providing geological assessments and point-source mapping, as well as CO_2 transportation options. NZEC sought to identify viable CCS technologies, to design a Chinese demonstration, and supported its construction and operation, ultimately seeking to build confidence around the technologies in China. GDCCUSC partners co-authored reports on CO_2 point sources, storage, mitigation costs, commercialisation, and capacity building/public awareness, which concluded with a report outlining the demand, benefits, challenges, and likely timings for CCS demonstration in Guangdong. SICCS had three distinct work packages that shared technical information, research findings and project experiences on capture pilot tests, concluding that CCS could be transferred and installed within China without issue. Finally, the CAGS sought to develop storage-related technical skills through capacity building activities and the sharing of expertise, while advancing the science through research projects in China. From this, it is apparent that the international change agents' activities had a number of objectives in mind, such as developing the skills and enhancing the experience of their partners while providing research outcomes that identified design and policy options.

'Creating intent to change' and 'translating intent into action'

Rogers (2003:173,366-370) sees the 'creating the intent to change' role as "laying out the possible avenues and motivating clients' interest in the innovation" and the 'translating intent into action' role as "influencing a behavioural change within clients based on recommendations, most often through indirect interpersonal contact and the activation of peer networks." We have already seen evidence of creating intent within the other change agent roles (i.e., establishing high-level commitments, providing small amounts of funding, frequent bilateral activities, evidence-based experiments and projects that provide viable options), so the next stage of the diffusion processes appears to be the exchange of information and sharing of experiences with both project partners, policy makers and business leaders, as well as potential investors. Quite often, this took place through meetings, seminars, training, site visits, and other capacity building or communication activities.

As we focus on communication channels in a later chapter, I won't go into much detail here. However, it is worth noting that many capacity-building activities took place under bilateral projects. Noted by my Chinese respondents (R01;A39;A19;I18;A08), these seminars, workshops and training exercises were a very good way to push CCS forward, especially for those that had only just learnt about CCS. My respondents also reported that these activities allowed them to understand more about the technologies and how they can be beneficial to China, all in a very short period of time. They were also seen as useful methods of bringing people, such as students, academics and professionals around the technologies, allowing them to network with other Chinese parties and international experts. We see a perfect example of how these activities can lead to the creation of networks below.

With demonstrations in mind, between 2009-10, the UK provided funding for a techno-economic feasibility, the "Feasibility Study of Developing CCUS-Readiness in Guangdong Province (GDCCUSR)," leading to the "CCUS Development Roadmap Study for Guangdong." This outlined the benefits, challenges, and likely timings for CCS demonstration and deployment in Guangdong by 2030, while also recommending the need to create domestic platforms and share information, tools, skills, and expertise. Following this advice, the GDCCUSR Team set about establishing Chinese CCS-related bodies, organising meetings, facilitating on-site visits, and forging a network of stakeholders, in order to create a source of local expertise. The GDCCUSR Team also facilitated visits to Chinese demonstrations and overseas facilities abroad which provided opportunities to speak with engineers and management, while launching the "China Low-Carbon Energy Action Network (CLEAN)" as China's first formal CCS partnership as a multi-sectoral platform for domestic cooperation and becoming a hub for communications.

Crucially, as many of these initiatives continued to identify the technological and policy options and provided recommendations towards CCS advancement, large-scale demonstration projects in China were seen as the next logical step in the process.

'Stabilising adoption & preventing discontinuance' & 'achieving a terminal relationship'

Rogers (2003:173,366-370) describes 'stabilising adoption and preventing discontinuance' as "reinforcing messages" and 'achieving a terminal relationship' as when a change agent creates a "self-renewing and self-reliant behaviour" and establishes the client as its own change agent. We did see some change agents retreat or withdraw from their bilateral CCS activities but this was more a harsh reality that the partnerships were not working the way they were expected or that they had reached a point with which they were offering more than receiving in return. For example, the US had earlier experienced governance and funding issues with Chinese counterparts and many US partners withdrew from the CERC over intellectual property concerns, funding hesitations, and a lack of clear benefits for engaging with the Chinese partners, such as access to Chinese testing platforms and demonstration projects. However, this didn't seem to stop the US and China discussing a second phase of the CERC.

The CO_2-ECBM Project was seen by Canadian partners as successful in building the capabilities of Chinese colleagues and transferring Canadian technologies. However, despite supporting conceptual designs, the project didn't receive additional funding and the prospects for a larger commercial-scale pilot and demonstration projects were never fully realised. Similarly for Italy, although the initial SICCS technology transfer and prefeasibility activities had gone well and a new MoU was signed for further feasibility studies and the construction of a CCS demonstration construction, future plans were highly dependent on more structured public-private partnerships and the partnership and its ambitions didn't progress any further. There was some success when the JCG-funded 'Australia-China Post-Combustion Capture (PCC) Feasibility Study Project' led to China's first commercial-scale integrated demonstration project at Huaneng's Gaobeidian coal-fired power plant in Beijing. World leading at the time, the JCG continued to meet periodically, continually renewing their commitments to reducing emissions from fossil fuels to meet emission reduction targets, and to reiterate the vital role that CCS will play in meeting those targets. Hannan (2013:11) considered this as a good model of "reinforcing communication channels" between stakeholders on both sides.

The EU had taken a more strategic approach to engaging with China through a series of distinct but interrelated projects (GeoCapacity, STRACO$_2$, COACH, and NZEC) with the overall intention of providing the necessary information and creating the conditions for a large-scale demonstration in China. Unfortunately, the bilateral partnership seemed to suffer at a technical level due to Chinese Government regulations around the provision and sharing of data and the EC's financial support fell well short of the vast sums needed for the construction and operation of a large-scale demonstration in China and attempts to attract additional donors, public-private partnerships, or equity investors, were never fully realised. According to my interviewees (R01;A11;I18), there was a feeling by some that the "golden era" of EU-China CCS cooperation (approximately 2006–2013) was in decline but one positive to come out of this relationship was the creation of the NZEC Project Management Office within the Chinese MOST's Administrative Centre for China's Agenda 21 (ACCA21), which reportedly made a significant impact on China's adoption of CCS (G02;R04;R16).

Following the success of their initial joint feasibility activities, the UK and China established the 'UK-China (Guangdong) CCUS Centre' as a registered Chinese non-profit with a physical office in Guangzhou that would bring together technical experts and policy specialists from industry and academia to recommend the best commercial models and technology options for a Guangdong-based demonstration. Building on the GDCCUSC's work, expert recommendations for a large-scale demonstration project in South China was followed by a Chinese Government-endorsed announcement of the Provincial DRC plans for the first CCUS-ready demonstration project for Guangdong at the newly-constructed China Resources Power (CRP) Haifeng Power Plant. The UK put forward a small amount of funding for this, in the hope to attract other investors and signed an 'MOU for a Teaming Relationship' for a trilateral demonstration that would be led and coordinated by GDCCUSC, operated by CRP and China National Off-shore Oil Corporation (CNOOC), and with assistance from other industry, academic and non-profit partners.

While there is some evidence that the international change agents stabilised adoption and potentially prevented discontinuance, it was clear that there was a need to continually reinforce messages if large-scale commercial demonstration was to be realised and that for some achieving a terminal relationship as a long way away. However, we did see some positive signs of change agent creating self-renewing and self-reliant behaviours with the Chinese gradually establishing itself as its own change agent domestically.

Paraprofessional Aides

Rogers (2003:19-20,306,368,384-6) describes 'paraprofessional aides' as the more networked actors that are considered "less than fully professional change agents who intensively contact clients to influence their innovation-decisions." By being more homophilous to the lower status of members of the social system, he determines that while these parties might have less technical credibility, they do have the special advantage of safety credibility and can be perceived as near peers by clients. Therefore, they are often deemed more trustworthy and less likely to have selfish motives or manipulative intentions. Recognising that these parties can minimise the social distance between the change agents and the client system, he warns against the inauthentic professionalisation of these aides, whereby they take on the characteristics of the change agent and destroy the very heterophily-bridging function for which the change agent aides are employed.

To be clear, there is no strong evidence to suggest that the change agents identified within this study have formally employed paraprofessional aides to intensively contact Chinese parties to intentionally influence their innovation decisions. They have created opportunities for subsections of the International CCS Community to build near-peer relationships with Chinese parties with the potential to further CCS advancement within China. From what we have learned, many are already well-networked but the one clear distinction from Rogers' definition of a paraprofessional aide is that many of those identified do have more technical credibility than their change agents, which presumably only increases their safety credibility (confident that they can safety use the innovation) and improves their potential to be trusted, which influences decision-making processes. The subsections mentioned earlier can be categorised as, universities and academics, research laboratories/institutes, and industrial/commercial parties, as well as NGOs.

Universities and Academics

My Chinese interviewees referred a large number of international universities and academics, mainly from the US (Cornell, MIT, Texas A&M, Austin Texas, Illinois at UC, Kentucky, Oklahoma, Wyoming, Washington St. Louis, West Virginia), the UK (Heriot-Watt, Imperial College London, Cambridge, Edinburgh, Hull, Newcastle, Nottingham, Sheffield), and to a lesser extent Australia (Newcastle, Queensland, Western Australia) and Canada (Alberta, Saskatchewan), as well as Norway (NUST). Seen by some as a useful source of online information, particularly on the progress of CCS projects globally (A11), many were directly involved in one or more bilateral partnerships, such as the Tsinghua-MIT China Energy and Climate Project, CERC, GDCCUSC, and CAGS (I18;I05;A07;A03;R20;R23;A19). This allowed many international academics to be directly involved in Chinese needs assessments, technical feasibility studies, storage capacity studies, costings and financial analysis, policy and regulatory investigations, and technology road mapping, as well as informational platforms (G02;R22;I05;R06;A38;R01;R24;A03;R23;G27;A19). Academics were also seen as useful in providing information on international funding opportunities, in making introductions with commercial and industry partners (A17;A19), and providing opportunities to collaborate on joint pilot and demonstration projects (I05;A07;A28;A32). On a more academic level, some Chinese respondents even reported being supervised by non-Chinese academics (G02;A29;I18;A03), listening to quite frank speeches or lectures by foreign professors (A11), and participating in international conferences (A32;A11;A17).

Research Laboratories and Institutes

My Chinese interviewees referenced a large number of research laboratories and institutes. Many were from the US (Berkeley Lab, National Energy Technology Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, and West Virginia and Wyoming State Geological Surveys), Canada (Canadian Petroleum Technology Research Centre), the EU (British Geological Survey (BGS), Scottish CCS (SCCS), UK CCS Research Centre (UKCCSRC), French Bureau de Recherches Géologiques et Minières (BRGM), Institut Français du Pétrole (IFP), Geological Survey of Denmark and Greenland (GEUS), Norway (Stiftelsen for Industriell og Teknisk Forskning (SINTEF), Technology Centre Mongstad (TCM), Australia (Commonwealth Scientific and Industrial Research Organisation (CSIRO), Cooperative Research Centre for GHG Technologies (CO2CRC), and Japan (Geological Survey of Japan).

Similar to universities and academics, some Chinese parties (A07) see these as useful sources of online information on international CCS pilot and demonstration projects and a source of positive information on CCS technologies. For example, previously-written BGS CCS-related publications were translated by Chinese stakeholders and shared both internally and externally, so were collaborative papers between BGS staff and senior Chinese experts. Seen as a reliable source of technical information in the early days of Sino-international CCS cooperation, the BGS team continues to remain a source of guidance and expertise for Chinese stakeholders throughout their adoption experience. Perhaps not explicitly intended but BGS studies also had the potential to be persuasive in matching CCS with the Chinese perspective, not only for their Chinese collaborators but also the wider Chinese academic community and those within industrial and policy circles (R09;A19;R24;R06;A21;A39;R01).

Chinese interviews also reported that BRGM, IFP, GEUS, SINTEF, TCM, CSIRO and CO2CRC, similar to BGS, either as leading partners or participants in bilateral initiatives or projects, such as the CERC, GeoCapacity and COACH (R01;I18;I05;A07;R09;A03;A17;R20).

Interestingly, as well as providing invaluable learning-by-doing experiences that assisted the initial early activities for the first CCS pilot demonstration project at the Gaobeidian Plant in Beijing (I05;A39;A17), the TCM had also indirectly influenced the Chinese CCS adoption experience by acting as a model for the Chinese CCS community to organise itself into the 'Chinese CCS Alliance.' Inspired by the TCM platform for cross-sectoral collaborative research, cooperative knowledge building, and information sharing, the goal of this governmentally-coordinated but stakeholder-managed Chinese model aimed to promote the development of Chinese CCS and to speed the path towards Chinese CCS commercialisation (G02).

Industrial and Commercial Parties

My Chinese interviewees referenced only a few industrial and commercial parties, probably because CCS advancement in China was still very much at the R&D stage and only began to move towards demonstration and thinking about opportunities for commercialisation. Similar to discussions on the other subsections of the international CCS community, many of the international partners referred to by my Chinese respondents were involved in bilateral initiatives and collaborative projects. For examples, many (A07;A03;A11;I13;R01;R14;A21;R06;A39;G02;R35;R16;A29;A28;A17) referenced Alstom, Aramco Services, Dow Chemicals, Duke Energy, General Electric, ICF International, Total, Air Liquid, and Peabody Energy, many of which participated in the CERC, CSLF, CERC, COACH NZEC, as well as the GDCCUSC, actively sharing their international technological lessons learned with Chinese partners. A number of others (A17;A11) mentioned joint research centres between international and Chinese entities, such as Rio Tinto, Toshiba, and Mitsubishi Heavy Industry (MHI) and Tsinghua University.

Several others (R01;R04;R16) referenced a consultancy named Development Solutions (DS) facilitated the STRACO_2 Project, which brought together key stakeholders and experts from both sides to discuss the potential for CCS in China and the necessary policy and regulatory measures that needed to be considered. Senior CCS Solutions Ltd. also appears to have come into contact with Chinese parties through engagement in multilateral and bilateral CCS projects. Reported to have also been involved in the early stages of the development of the GDCCUSC, one individual had retained a relatively close relationship with Chinese parties and continues to offer technical advice and assist in the evaluation of Chinese CCS-related reports, feasibility studies and project plans. Mentioned by my Chinese interviewees (R24;R22), one significant challenge with this relationship, however, is that often such international expertise is somewhat limited, due to the often quite significant disparities between western and Chinese political circumstances and geologies.

Non-Governmental Organisations (NGOs)

My Chinese interviewees also referenced a number of international NGOs. Most prominently was the World Resources Institute (WRI). Publishing the "Guidelines for Carbon Dioxide Capture, Transport, and Storage" (2008), WRI had brought together the best practice from stakeholders in the US and released two subsequent guideline documents focusing on the EU and China in 2010. Introducing the concept of CCS, the authors had drawn from a wider resource of local expertise, soliciting views, opinions and advice. My Chinese respondents (A21;G02;R16) had reported being consulted and heavily involved in the research and writing of these China-specific guidelines, often through expert workshops, stakeholder debate and meetings and visits. Bringing together international experts in the policy, science and technology communities, this project established an international expert advisory group, which led to wider information-sharing, capacity building, field trips and visits by the Chinese members to international organisations and demonstrations. Such activities have led to long-standing professional and interpersonal relationships between employees at WRI and some of these stakeholders through weekly CCS communications (A21;R06).

The Energy Foundation describes itself as "pragmatic and nonpartisan, dedicated to finding practical solutions that work in the real world," with its primary role "as a grant maker, supporting groups to build the new energy economy" (Energy Foundation, 2016). In 2007, the Energy Foundation's China Electric Utilities Program (CEU) made funds available for projects that provide decision-makers with policy-relevant research on CCS. Commenting that without the support from the Energy Foundation they would not have been able to carry out any studies on the feasibility of CCS in China, a few of my respondents (R35;R06) have progressed to be the most knowledgeable and influential members of the Chinese CCS community, continuing to have great influence with industry, policymakers and the wider CCS community.

The US-based Clean Air Task Force (CATF) is another "non-profit organisation dedicated to reducing atmospheric pollution through research, advocacy, and private sector collaboration" and it provides objective facts and information about CCS on its website. My Chinese respondents (I40;R06) reported a Chinese-born individual within the CATF was instrumental in introducing the concept of CCS to Chinese parties, while also acting as a bridge between Chinese and US government departments and companies. At that time, in 2010, those CATF employees inspired and supported these Chinese individuals to seek out further information and knowledgeable individuals and to subsequently facilitate communications and cooperation between other Chinese and international parties.

NRDC is a US-based international environmental advocacy group that has been an overt supporter of CCS development and demonstration, reportedly due to the technological ability to bring opposing stakeholders with differing motivations and ideologies to the table for climate action. An NRDC white paper entitled "Identifying Near-Term Opportunities for CCS in China" (2009) had the multiple benefits of supporting Chinese parties to undertake joint feasibility research with knowledgeable international parties to access the suitable and possibilities of CCS in China for publication (R16;R06).

Finally, the UK-based Climate Group also has held CCS-related seminars and workshops in China (R04). In 2010, the Climate Group was supported by the British Embassy Beijing to publish a brief providing its key findings of an investigation into the prospects or CCS in China and recommendations for its future development. In its conclusion, it states that "the Climate Group supports the effective development of this technology worldwide to significantly achieve the reduction of global CO_2 emissions" (Climate Group, 2010).

It is also worth mentioning that a number of these NGOs, such as WRI, the Energy Foundation, NRDC, and the Climate Group, were also involved in bilateral initiatives and had permanent offices in China.

Summary, Analysis and Conclusion

During the literature review, we learnt from Meadowcroft and Langhelle (2009) as well as de Coninck and Bäckstrand (2011) about the growing interest around CCS and from Stephens and Liu (2012) about the emergence of the international CCS community and its capacity to influence policy. Offering different typologies of possible formations, Stephens and Liu (2011) and later Stephens (2012) discussed the different political lens through which to view and examine the nature of the international CCS community, while prompting us to further focus on its structure, its functions and how it communicates, as well as the influence it has on international policy processes.

Additionally, we learnt about the motivations of the international CCS community, with Torvangerm and Meadowcroft (2011) concluding that national governments seek to find the most timely and cost-effective pathway towards GHG emission reductions possible and are faced with great policy, technical, and financial uncertainties. Often accompanied by great cost and substantial risk, they crave the level of certainty needed to allow their domestic stakeholders to feel confident enough to move away from existing regimes and familiar structures in order to shift towards more climate-friendly technologies. Acknowledging the necessity for enhanced global governance, multilateral cooperation, and bilateral collaboration, they recognised that global learning and information sharing is needed to speed the advancement of CCS towards deployment internationally.

de Coninck *et al.* (2009) did see an overall increase in international CCS-related cooperation, which was likely to accelerate global technical learning and she provided guiding principles for future efforts. Additionally, de Coninck and Bäckstrand (2011) went on to map CCS-related organisations in an attempt to explain the growing diversity, overlap, and fragmentation within the international CCS community. They found that many organisations were complementary in nature and that different parties would intervene to provide different governance functions at different periods of time. Hagemann *et al.* (2011) had simultaneously undertaken some preliminary study of multilateral CCS initiatives, noting the over-reliance on soft governance functions as opposed to financial support, while also presuming China to be a willing adopter of larger-scale demonstration and that they didn't need any convincing. Adding to the work of these scholars, I respond to Stephens' call to identify how the International CCS Community is structured, how it functions, and how it communicates to influence the CCS-related policy processes, focusing on its interactions with China.

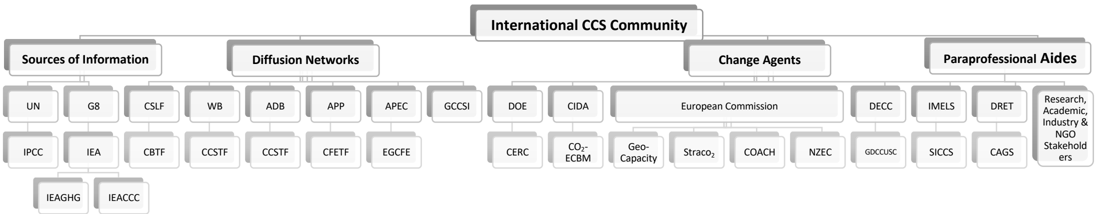


Figure 6.5. Structure of the International CCS Community[2]

Figure 6.5. provides a better understanding of how the International CCS Community is structured and the following discussion will help us to better understand its functions, communications, and its influence more generally but specifically on Chinese parties. From the outset, it was clear that CCS-related information was simultaneously emerging through two politico-technical sources, the first being the international multilateral climate infrastructure of the UNFCCC through its IPCC and the second the rich-industrialised G8 nations supported by its *de facto* energy advisor the IEA.

As noted by de Coninck *et al.* (2011:368-376) the IPCC's work had contributed to gradual normative shifts towards a greater acceptance of CCS in the global south, and my research saw strong evidence of this in China. However, recognising the urgency, it would be necessary for coalitions of more experienced developed countries to undertake efforts to persuade developing countries of the benefits of pursuing CCS, which is where the work of the IEA was of most value. It was the IEA's strategies and targets for demonstration that reverberated throughout political summits and technical and policy publications at all levels, which sought to significantly increase engagement with non-OECD developing countries in an effort to influence national policies and plans. From this, we immediately see CCS emerging from the motivated expert sources in the industrialised western contexts, with a necessity to engage with emerging economies and developing countries through more localised horizontal networks in order to maximise opportunities for global learning and information sharing, particularly towards demonstration.

With limited multilateral support and little financing for demonstration, it was this same group of western industrialised nations and organisations that set about creating international mechanisms to advance CCS demonstration at the speed they deemed necessary. Rogers (2003:373-7,383-4) might describe these as diffusion networks, although they would most certainly be on a much larger political scale than he would have

[2] United Nations (UN), Intergovernmental Panel on Climate Change (IPCC), Group of Eight (G8), International Energy Agency (IEA), Carbon Sequestration Leadership Forum (CSLF), Capacity Building Trust Fund (CBTF), World Bank (WB), CCS Capacity Building Trust Fund (CCTF), Asian Development Bank (ADB), Asia Pacific Partnership (APP), Clean Fossil Energy Task Force (CFETF), Asia-Pacific Economic Cooperation (APEC), Expert Group on Clean Fossil Energy (EGCFE), Global CCS Institute (GCCSI), US Department of Energy (DoE), US-China Clean Energy Research Centre (CERC), Canadian International Development Agency (CIDA), China-Canada CO_2 Enhanced Coal-Bed Methane Recovery Project (CO_2-ECBM Project), European Commission (EC), Support to Regulatory Activities for CCS ($STRACO_2$), Cooperation Action with CCS China-EU (COACH), Near-Zero Emissions Coal (NZEC), UK Department of Energy & Climate Change (DECC), UK-China (Guangdong) CCUS Centre (GDCCUSC), Italian Ministry of Environment, Land, and Sea (IMELS), Sino-Italy Cooperation on Application of CCS to Coal Fired Power Plants (SICCS), Australian Department of Resources, Energy & Tourism (DRET), China-Australia Geological Storage of CO_2 Project (CAGS).

ever anticipated. Holding the prospects of more frequent, easy and effective interactions between the developed countries diffusing CCS and the developing countries potentially adopting, these homophilous partnerships have the potential to increase credibility and trust, thus the capacity to form and change opinions. We should acknowledge that Bäckstrand (2008:92-93) and de Coninck *et al.* (2011: 373-375) accused western industrialised nations as being hegemonic and mini-lateral. However, we should also recognise that while these more experienced parties wanted to share the message of CCS for their own national interests, they also wanted to benefit from the international activities of others, particularly in the developing world where conditions and opportunities might be more favourable. As distinct opportunities to make more homophilous partnerships, all of these CCS-related diffusion networks had the common goal to share and obtain lessons and learnings, and to create the conditions necessary for new global demonstrations.

At the more political levels, Coninck *et al.* (2011: 373-375) sees the CSLF as promoting the availability of CCS as a technological option and one influential Chinese Governmental official did indeed note its provision of abundance of ambitious and positive information that displayed CCS as a solution (G02). Although de Coninck (2011:369,375-6) criticised the G8 for exerting its western influence over the MDBs to do its own bidding, the WB and ADB played important early roles in providing the finances for country-level capacity building that had been formally requested by developing countries at the highest political levels. There is no doubt that developed countries had their own national interests in mind as they funded these activities. Additionally, Lai *et al.* (2012:643) did note the long-term over-reliance on international funding and the limited commercial interest in countries, such as China for CCS projects, but this would be necessary to support the advancement of CSS demonstration in emerging economies and the developing world, where it had great potential. Of course, the industrialised nations would also benefit.

Despite also being criticised by Bäckstrand (2008:67,91-94,97,99) for being another attempt at unilateralism that might circumvent the more “Eurocentric” UNFCCC Kyoto Protocol, the APP would be an important regional partnership between the developed and developing countries from the previous G8 ministerial meetings. Despite investing heavily in joint governance arrangements that laid out a new vision to address shared challenges on a more equal footing, the APP didn’t survive beyond a number of years, but it did create opportunities to build bilateral partnerships that were sustained beyond the APP’s final meeting. Similarly, APEC was also seen as an attempt to circumvent the Kyoto Protocol and there is no doubt that western industrialised nations (particularly the US and Australia) saw it as a gateway to lucrative economic markets to promote low-carbon technologies. However, it too promoted itself as another opportunity for multilateral cooperation based on mutual developed-developing country respect and was praised for having an inclusive atmosphere that cultivated a spirit of cooperation. With the US and China using the APEC Leaders’ Summit as an opportunity to announce ambitious climate commitments and to outline their future bilateral CCS engagement, Marcu (2014:6) saw this was a total breakdown of the Kyoto Protocol-style separation in climate change negotiations between developed and developing countries.

Also established in response to the G8's call and serving the same collectives of countries as the other diffusion networks, the GCCSI was criticised by de Coninck (2011:375) for being a hegemonic exercise to serve Australia's national interests. Perhaps also a consequence of losing its governmental funding but the GCCSI became a membership-driven NGO that combined global expertise, coordinated activities, and shared knowledge, while working with other multilateral entities and international institutions to forge strategic alliances and form public-private partnerships and investment alliances. So much so that Stephens *et al.* (2012:144-5) and Hagemann (2011:5705-7) argued that the establishment of the GCCSI led the creation of an increasingly-interconnected international CCS community and de Coninck (2011:372-7) would see it as counteracting the fragmentation that existed within the CCS landscape. Unfortunately, even the well-resourced GCCSI didn't have the ability to facilitate demonstrations.

While undertaking multilateral activities through diffusion networks, there is clear evidence that the same western industrialised nations have been simultaneously diffusing CCS through change-agent-led bilateral activities. Through this study I have identified six change agents, namely the US DOE, CIDA, EC, DECC, and IMELS, as well as DRET. Although it was not possible to clearly match examples against all the seven distinct change agent roles identified by Rogers, each of these has displayed clear change agent behaviours and an overt desire to influence Chinese parties' adoption of CCS. Finding it quite challenging to clearly distinguish the change agent's roles in this study, which could be a focus for further investigations, there were common themes that emerged throughout. For example, 'developing a need to change' almost certainly began with high-level events that included political declarations with commitments to work closely on joint challenges and maximise available opportunities. Quite often the industrialised countries offered small amounts of funding, which was just enough for CCS activities that might motivate the Chinese Government to develop a national strategy but far from being enough for a domestic demonstration.

In addition to diffusion networks, there needed to be a sufficient volume and timing of communications, client orientation, compatibility with need, change agent empathy, and the change agents contact with the lower-status clients. To enable this, many of the change agents 'established information exchange relationships' through bilateral programmes and projects, such as the CERC, CO_2-ECBM Project, GeoCapacity, $STRACO_2$, COACH, NZEC, SICCS, CAGS, and the GDCCUSC. Arguably established as a response to the G8's objectives and to achieve the change agents' national interests, many of these bilateral initiatives were innovatively designed to create an equal partnership and a level-playing-field with China. Through providing Chinese parties with opportunities to carryout desktop investigations, laboratory tests, and small-scale pilot projects, which produced valuable data and research results, these bilateral activities were useful in not diagnosing

China's problems and determining if CCS can be a possible solution but in developing the skills and enhancing the experience of their partners while providing research outcomes that identified design and policy options.

So far, these change agents started with high-level events that included political declarations with commitments to work closely on joint challenges and maximise available opportunities, then the establishment of bilateral programmes and projects designed to create an equal partnership and a level-playing-field with China, then activities that would help determine if CCS can be a possible solution to China's problems by providing research outcomes that identified design and policy options, while simultaneously developing the skills and enhancing the experience of Chinese partners. Building on these roles, the 'creating the intent to change' and 'translating intent into action' activities appear to be the exchange of information and sharing of experiences, quite often through meetings, seminars, training, site visits, and other capacity building and communication activities. These were seen as useful methods of bringing people around the technologies, such as students, academics and professionals allowing them to network with other Chinese parties and international experts. A prime example of this being the GDCCUSC, which outlined the benefits, challenges, and likely timings for CCS demonstration and deployment in Guangdong by 2030, while also creating domestic platforms to share information, tools, skills, and expertise.

Rogers (2003:173,366-370) sees 'stabilising adoption and preventing discontinuance' and 'achieving a terminal relationship' as "reinforcing messages" and creating a "self-renewing and self-reliant behaviour," respectively. We did see some change agents limit or withdraw from bilateral activities but this was more a harsh reality that the partnerships were not working or that they had reached a point with which they were offering more than receiving in return. Although much progress had been made through these bilateral activities, they appeared to hit limits when it came to the reality of the costs of constructing and operating a large-scale commercial demonstration and the attempts to attract additional donors, public-private partnerships, or equity investors, were never fully realised. However, there were some signs that CCS was starting to become embedded in China, such as the MOST-ACCA21 NZEC Project Management Office and the GDCCUSC as a registered Chinese non-profit with a physical office in Guangzhou that would bring together technical experts and policy specialists from industry and academia to drive forward domestic efforts for a Chinese demonstration.

Of course, it goes without saying that paraprofessional aides played an important part in the diffusion of CCS within China. Universities and academics, as well as research laboratories and institutes, were seen as a useful source of online information and were actively involved in Chinese technical and policy-related activities, while also offering opportunities for international contacts or commercial projects. Quite often leading or participating in bilateral initiatives or projects, some supported China's early pilot and demonstration activities and even acted as a model for how to organise partnerships domestically. Many industrial and commercial companies were also participants in joint bilateral initiatives and continued to consult and advise Chinese parties on the technicalities of CCS, while the NGO parties appeared to provide neutral policy-related guidance, while providing small grants for research, and bringing stakeholders together for roundtable discussions.

Responding to my research questions at the beginning of this chapter, I have now identified how the International CCS Community is structured, how it functions, and how it communicates to influence the CCS-related policy processes, particularly in China. To help me do so, I employed Roger's concepts of sources of information, diffusion networks, change agents, and paraprofessional aides. To summarise, I identified two distinct but interconnected politico-technical sources of information, both of which had an influence on global CCS messaging and impacted the technologies' adoption within China. The first was the pragmatic and policy-neutral IPCC, which operated within the confines of the more politically-challenging UNFCCC but had a trusted yet restrained influence on adoption. The second was the more nationally-motivated G8 countries, which were supported by the policy-promoting and data analysis-driven IEA. Functionally, the IPCC contributed to creating gradual normative shifts towards a greater acceptance of CCS in the global south, but it was the G8's political proclamations and the IEA's story lines that sought to persuade emerging and developing countries of the benefits of pursuing CCS, ultimately seeking to influence their national policies and plans towards pursuing demonstrations.

Subsequently, I identified International CCS Community-related diffusion networks, all of which had the aim of promoting and advancing CCS, while frequently quoting the G8 and IEA's goals for demonstration projects as their objectives. Offering opportunities to have more effective interactions between developed and developing countries, these homophilous partnerships held the potential to form and change Chinese opinions towards CCS. Holding strong links to the G8 members, the CSLF was effective at amplifying the IEA's messaging at the political levels, while promoting the advancement of CCS demonstration in emerging economies. Also responding to the G8, the WB and ADB provided small amounts of funding and built the capacity of developing countries to prepare them for their own domestic efforts. Diffusion networks at the regional levels, such as the APP and APEC, provided a new style of governance that allowed developed and developing countries to work more closely to tackle joint challenges and take advantage of new opportunities. With many of these networks facing challenges and critiques, it was the creation of the GCCSI that appeared to make the International CCS Community more balanced, with developing countries like China taking a more active and somewhat more equal role. However, diffusion networks alone would not be enough to ensure developing countries would be enticed or equipped to adopt CCS.

Sequentially, we saw national-level change agents undertake bilateral CCS activities with China. Holding prior experience of CCS at the national level, they all faced challenges of some sort in advancing CCS domestically, so sought partnership with China to share and gain joint learnings. Undertaking behaviours and functions that demonstrated the explicit intent to influence Chinese parties' adoption of CCS, these functional activities typically began with developing a need to change through high-level events that included political declarations with commitments to work closely on joint challenges and maximise available opportunities. Establishing information exchange relationships through their bilateral initiatives, these were quite often innovatively designed to create equal partnerships on a level-playing-field with China and offered opportunities to carry out research and projects that produced valuable data and results which sought to create the intent to change.

Aiming to translate intent into action, these change agents would provide opportunities to exchange information and share experiences, quite often through meetings, seminars, training, site visits, and other capacity building and communication activities. Despite ambitions to work towards achieving a terminal partnerships relationship (which would signify diffusion success), we didn't see any significant or secure stabilisation of Chinese parties' adoption of CCS. Unfortunately, most partnerships still felt unproductive or unequal and many came to a natural conclusion or continued to linger unproductively for some time. However, much of this may be down to the huge costs associated with CCS demonstration, with both sides and third-party investors unable or reluctant to finance at the time. Despite this, there were some early signs of self-renewing and self-reliant behaviour, most notably from the domestic efforts of the GDCCUSC, which created Chinese CCS networks and began to make significant steps towards China-based demonstrations in close partnership with others.

To conclude, the messages regarding CCS *did* originate from motivated expert sources (through the western-industrialised change agent nations and international organisations) and spread via numerous horizontal networks (the international diffusion networks and bilateral initiatives and partnerships). Recognising that both sides were heterophilous in their knowledge and experience of the innovation, we should acknowledge that they were homophilous to the extent that they understood they needed equal partnerships to enable CCS advancement. As such, this provides evidence of the existence of a hybrid model of the innovation diffusion, something which was not recognised previously. This refutes Blaut (1987:30) and McMaster and Wastell (2005:385-397) earlier criticisms of diffusionism, where they see it as elitist, imperialist, and colonialist and only employing pseudo-scientific arguments as moral justification to appease uncomfortable questions, respectively. However, my research does support Blaut (1987:30) assertion that diffusion doesn't only take place between individuals though interpersonal communications but also takes place between communities and cultures.

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Chapter Seven: Sino-International CCS Cooperation and Collaboration as 'Communication Channels' – One-way linear channels diffusing CCS as a uniform package creating opportunities for modification and re-invention via two-way convergent communications

This chapter delves deep into the CCS-related soft governance activities to better understand how international parties cooperate, collaborate, and communicate to influence Chinese decision-making processes. This responds to the call from Bäckstrand *et al.* (2011:277) for CCS researchers to move beyond communications studies related to public perception and to the prompt from Stephens and Liu (2012:146-148) to investigate the multitude of new communication mechanisms within the CCS community and their possible influence on CCS-related policy processes, which these scholars say has not yet been studied.

Theoretical Framework

From a theoretical perspective, it is important to ask if these communications are primarily one-way/linear with CCS being diffused as a 'uniform package that is ready for adoption' (as in a centralised diffusion) or two-way/convergent channels where there is 'the need for reinvention and for possible modification' (as in decentralised diffusion). I use Rogers' theory of 'communication channels' and deploy his conceptual components of 'communication campaigns,' 'exemplary/experimental demonstrations,' and 'perceived characteristics,' which will help me organise my findings and come to my final conclusions. Ultimately, I will argue the existence of a hybrid model of diffusion, whereby one-way linear channels diffuse CCS as a uniform package that creates opportunities for modification and re-invention via two-way convergent communications (See Table 7.1).

Research Questions	Conceptual Components	Centralised Diffusion	Decentralised Diffusion	Hybrid Model Of Diffusion
3. By what means or through what methods do international parties cooperate, collaborate and communicate with Chinese parties to share information about and their experiences of CCS? 4. Are the communications channels primarily one-way/linear where CCS is being diffused as a 'uniform package that is ready for adoption' (a centralised system) or two-way/convergent channels where there is 'the need for re-invention and for possible modification' (a decentralised system)?	**Communication Campaigns** **Communication Channels** **Exemplary and Experimental Demonstrations** **Perceived Characteristics**	One-way (linear) models of communication of diffusing a uniform package	More of a two-way convergence model of communications with a degree of reinvention occurring as the innovation is modified to fit particular conditions	**One-way linear channels diffusing CCS as a uniform package creating opportunities for modification and re-invention via two-way convergent communications**

Table 7.1. Applying hybrid diffusion to the DOI theory (Communication Channels)

As seen in the previous chapter, change agents often engage in interventions, which Rogers (2003:366) defines as “actions with a coherent objective to bring about behavioural change in order to produce identifiable outcomes.” One commonly employed intervention, particularly as a strategy to speed up diffusion of an innovation, is the application of a diffusion ‘communications campaign,’ which we look at in the next section.

Communications Campaigns

According to Rogers (2003:128,236,378-380), a communications campaign is “an organised set of activities and messages with the intent to generate specific effects on the part of a relatively large number of individuals within a specified period of time and through an organised set of communication activities.” Based on the secondary-sourced case studies on international entities (Annex) and supported by the primary-sourced data gathered from my interviews with Chinese parties, I identified (highlighted below) the communication campaigns led by international entities that are seeking to influence the decisions of potential Chinese adopters (Figure 7.2.). Given the descriptions of these communications campaigns in the case studies and what have already been discussed in the previous chapter, I won’t repeat these points here. However, I would like to look at the different roles of the communication campaigns within the international CCS community more generally.

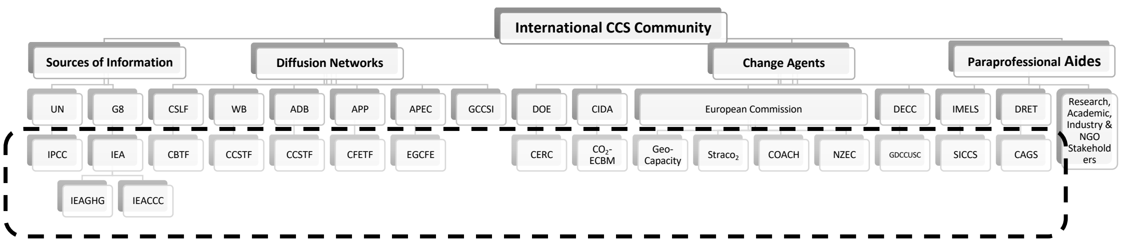


Figure 7.2. Sino-international CCS communication campaigns

Rogers (2003:128,236,378-380) determines that while many believe communication campaigns to have minimal effects, they can be effective if they take on five key roles (Figure 7.3.) and will be successful if they employ these during communications with members of the intended audience. The likelihood of a communications campaign succeeding can also be increased through the processes of increased ‘targeting’ and ‘tailoring,’ which we have already covered in the previous chapter but will touch on again here. Analysing these against Rogers’ five key roles below (Figure 7.3.), this section is not to provide an extensive analysis of each communications campaign but instead to offer significant examples of when the characteristic functions of a communications campaign have been employed and to explore the impact of that action.

Figure 7.3. Communications campaign roles

Starting with **'utilising formative research,'** we see a number of communication campaigns drawing their influence from different sources. The IPCC and IEA looked at their earlier assessments and analyses but these publications were uncertain and hesitant to fully endorse the technologies. The China-Canada CO_2-ECBM Project, CSLF, US-China CERC, and the CAGS were all sparked by research outputs from other parties, such as the IEA Greenhouse Gas Research Programmes (IEAGHG), the US DoE's National Energy Technology Laboratory (NETL), the Asia Society, and the APP, respectively. The EC largely built on its earlier EU-based studies but adapted these to China, with each project feeding into the next. The World Bank 'CCSTF,' APP 'Clean Fossil Energy Task Force (CFETF),' UK-China 'UK-China (Guangdong) CCUS Centre,' and Sino-Italy Cooperation on Application of CCS to Coal Fired Power Plants (SICCS), all held initial bilateral meetings and/or wider symposiums/workshops to draw on the expertise, experience, and resources of Chinese partners, reaching consensus on the way forward.

When looking at **'setting reasonable goals,'** all of the communication campaigns had similar specific yet reasonable objectives, although some were more ambitious than others. In general, they involved exchanging information and sharing experiences to remove the technical uncertainties and policy hesitations around CCS demonstration. Overall, the aim was to build confidence around the technologies and create the conditions possible for large-scale projects in China and potentially wider-scale technology deployment, which contributed to the G8's goal of 20 projects by 2020. In the absence of financing, joint working group action plans and soft targets usually included technology and policy assessments, small pilot projects, and road-mapping exercises, which allowed for flexibility to conditions and circumstances. Although not legally binding, these structured arrangements were set so Chinese parties would learn from the experiences of international partners, while international partners shared in any technological learnings.

'Audience segmentation' was quite often used from the political to working levels, with ministerial/official and expert/working level meetings that focused on different policy/technical areas or sector-specific issues. After the overall objectives were agreed, communication campaigns allowed for Chinese parties to be further segmented into work packages and matched with international partners, often completing sub-working group tasks, such as interlocking or interrelated assessments. Audiences were often separated, with policy seminars, technical workshops, and lower-level capacity building activities that targeted specific countries, sectors and industries, with communication materials sometimes tailored to suit local conditions and circumstances. On occasion, audiences and activities took a phased approach, whereby there was less public-sector assistance and more private-sector involvement. Experiences from CERC, GAGS and the $STRACO_2$ showed that appropriate segmentation and well-considered partnering was crucial for effective two-way/convergent communications.

The '**use of mass media messages'** surrounding ministerial meetings and governmental declarations played a positive and re-energizing role. However, it was technical assessments and policy reports, as well as road maps, that were the most widely-used and impactful forms of media. Although technically not mass media, CCS-related stakeholder conferences, policy seminars, and technical workshops, as well as capacity building activities, were influential methods of providing information to large numbers within the Chinese CCS community, which also allowed opportunity for vital feedback. Many communications campaigns also had communications infrastructure to exchange data between partners and to share experiences more widely on websites and other platforms.

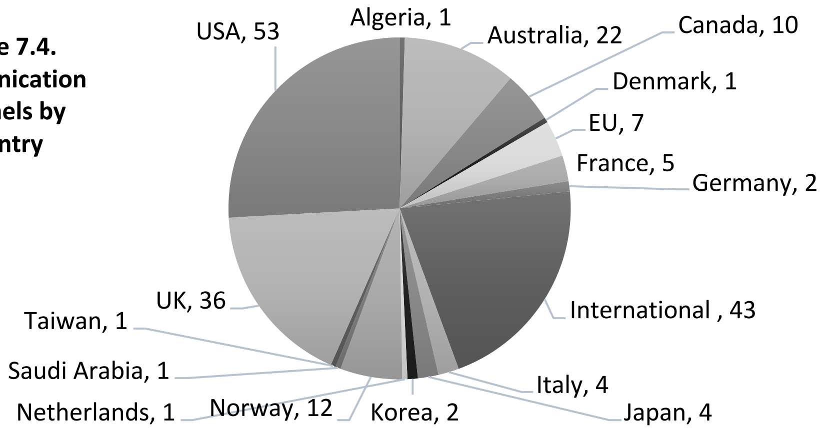
Finally, on **'triggering interpersonal networks,'** it was only natural that increased contact and communications would see the forging of interpersonal connections and the triggering of networks which would last for some time. When confidence grew around the technologies the capabilities of Chinese parties also increased and it was hoped that conditions in China would enable an environment for CCS demonstration in the near term, and lucrative opportunities in the medium to longer term. Therefore, communication channels were convenient channels to build trust, and for change agents to extend these networks further, while they wait for these opportunities to arise. Quite often communications channels were embedded within these campaigns.

Communications Channels

Rogers (2003:18) defines a communication channel as "the means by which messages get from one individual to another" whereby "the nature of the information exchange relationship between a pair of individuals determines the conditions under which a source will (or will not) transmit the innovation to the receiver and the effect of such a transfer." He categories these into cosmopolite versus localite, mass media versus interpersonal, and linear versus convergent types of communications, and maintains that they all hold differing roles for different parties in creating knowledge about the innovation and persuading adopters during their decision-making processes (Rogers, 2003:18,205,211-2).

From the 205 cosmopolite (Sino-International) communication channels identified through my interviews with the Chinese stakeholders, 43 were attributed to international organisations (those identified as sources of information or diffusion networks), while nation states also had significant numbers: US (53), UK (36), Australia (22), Norway (12) and Canada (10). Although the EU had few (7) channels, much of the activity from EU countries could also be attributed to EC projects. Figure 7.4. provides a visual representation of the volume and intensity that some nations have interacted with China.

Figure 7.4. Communication Channels by Country



By sector, 50 of these channels came from multilateral bodies, 37 from academia, 31 from governments, 28 from research, 25 from industry, 17 NGOs and 17 from pilots (Figure 7.5.).

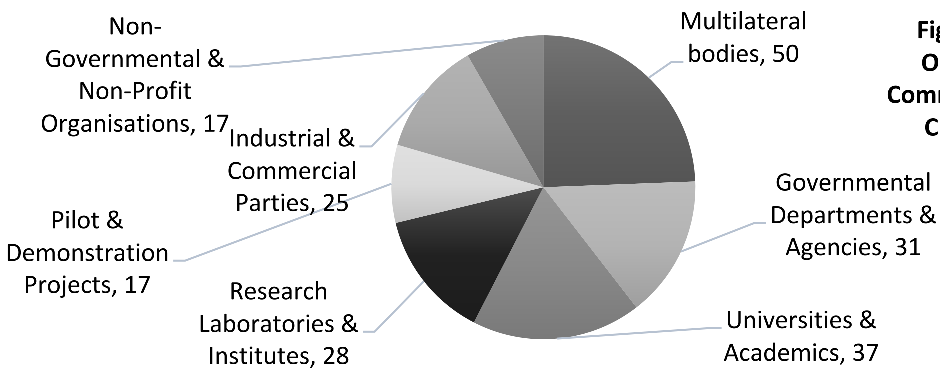
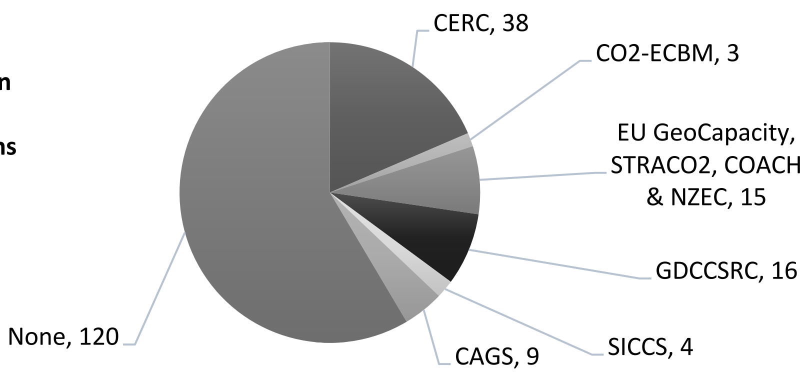


Figure 7.5. Origins of Communication Channels

Referenced earlier, the Sino-international communications campaigns also contained communications channels, with 38 attributed to CERC, 16 to GDCCSRC, 15 to EU projects (GeoCapacity, $STRACO_2$, COACH and NZEC), nine to CAGS, four to SICCS, and three connected to the Canada-China CO_2-ECBM project. 120 were not linked at all (Figure 7.6.).

Figure 7.6. Communication Channels by Communications Campaign



Based on the supplementary literature and secondary-source case studies on international entities (see Annex) and supported by the primary-sourced data gathered from my interviews with Chinese parties, I categorised the international (cosmopolite) communications channels into either 'mass media, linear, knowledge' or 'interpersonal, convergent, persuasive' channels. Below I look at these in more detail.

Mass Media, Linear, and Knowledge Channels

'Mass media, linear, knowledge' channels (Figure 7.7) are channels whereby CCS-related information is shared in a one-way format, not requiring a response or feedback. From the Communications Survey with my Chinese responses, I learned that websites and e-newsletters were the most common, with academic journals, international conferences and capacity building activities also commonly used.

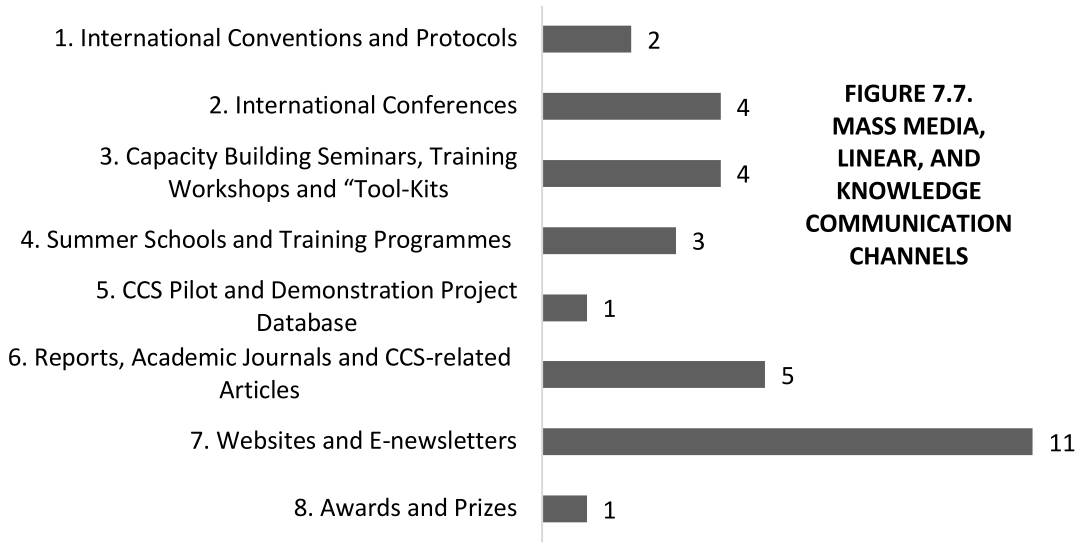


FIGURE 7.7. MASS MEDIA, LINEAR, AND KNOWLEDGE COMMUNICATION CHANNELS

International conventions and protocols (such as the *London Convention* and *London Protocol*, the *UN Convention on the Law of the Sea*, and the *UNFCCC* and its *Kyoto Protocol*) required consensus between a large number of nation states (both industrialised and developing) or agreement between closest neighbours. As we saw in earlier chapters, these have often proven to be particularly troubling sticking points for CCS, with the potential to thwart the hopes and plans of its proponents. Following the failure to fully integrate CCS within the CDM, this appeared to cause greater friction between those in the industrial and developed world (i.e., Australia, Saudi Arabia, and the IEA) with those in emerging and developing economies (a coalition of developing countries led by Brazil). Although not entirely successful, the increased attention given to CCS during this time was instrumental again in raising the profile of the technologies internationally and drawing interest from many parties, not least China. However, with uncertainty and negativity surrounding the annual UNFCCC Conference of Parties also causing great scepticism and hesitation, the role of the IEA, CSLF, GCCSI and other bodies are to advocate for the technologies at a global level (de Coninck, 2011:376, Zakkour *et al.,* 2014:6949).

International conferences (such as those held by IEAGHG and NETL) have been important tools for bringing the evolving international CCS community together and have steadily grown in both size and participation, which demonstrates the increased interest in the technologies and their shift towards commercialisation. In addition, initiatives (such as COACH, NZEC and CAGS) often provided funding for partners to attend international CCS events and encouraged them to share their research findings and information about the projects in general. While very much community building and networking events, many of the proceedings are readily available in publications, journals and/or online. However, these types of events are often expensive and exclude those with few resources (de Coninck, 2011:371, Stephens et al., 2012:131-6).

Capacity building seminars and training workshops (such as those by the WB, ADB, CSLF, APEC, GCCSI, CERC, GeoCapacity, and CAGS) were often held alongside international high-level events but were considered crucially important to enhance domestic expertise, build local experience, and create the right conditions for CCS development in the near future, particularly within the emerging economies and developing world. The organisers and speakers were often from industrialised developed countries with the presentations and content were often targeted to specific countries and tailored towards particular audiences (Bachu, 2009:4719-23). One particular example is the workshops offered by CERC, which were intended to provide project partners with the knowledge, tools and resources (guidelines, best practice case studies, portals, blogs and webcasts, as well as tool kits) necessary to navigate complex issues, such as intellectual property rights (Marlay, 2012:20; Yu and Baird, 2014:3; Lewis, 2014:546,549,552-3; Lewis, 2015:7-13; Yang, 2016:5). GCCSI also offered its *CCS Regulatory Toolkit* and a *Communications/Engagement Toolkit for CCS Projects*. APEC provided a *Building Capacity for CO_2 Capture and Storage in the APEC Region: A Training Manual for Policy Makers and Practitioners (2005 and 2012)* and *Community Outreach Strategy*, as well as other materials, which meant that others could become trainers and communicators themselves. CAGS produced an online dictionary of CCS-related terms and CCS-related brochure for the general public (Bachu, 2009:4719-23; Wright, 2014:7-17).

Summer schools and training programmes (such as the IEAGHG, COACH, and CAGS) draw many parallels to the capacity building activities mentioned above. Generally open to wider audiences from different disciplines and countries, these schools were often targeted toward younger students and early career researchers. These activities aim to equip the next generation of CCS scientists and professionals with a broad understanding of the technical and non-technical aspects of CCS development, as well as cross-fertilising parties to establish early CCS networks internationally. These also create partnerships domestically and can lead to students sowing CCS seeds internally within their own schools and research (IEAGHG, 2016:4-5; Stephens et al., 2012:136).

CCS pilot and demonstration project databases (such as those from the IEAGHG, CSLF, DOE/NETL and GCCSI) showcase the overall number, locations, scale and technical specs of publicly-declared large-scale integrated projects (LSIPs). These can be an important indicator of the success and struggles of the CCS industry internationally and a gage for the level of government commitment, private sector investment, and entrepreneurial activity at regional and national levels. Although having the potential to reinforce the importance and relevance of CCS, depending on the data entailed, these can be either encouraging or disparaging. They can also highlight those projects that are stalled or have failed, which can cause great concern within the CCS community and wider industrial and investment circles. However, such databases can also be important depositories of diverse technical data with a wider range of project-based learnings, which can allow for international analysis and cross-border learning, with the potential to influence public policy and private sector investment (Reiner, 2008:24; Klass et al., 2008:107; Van Alphen, 2011:33).

Academic journals and CCS-related articles (such as the IEAGHG *International Journal of Greenhouse Gas Control Technology*, *Carbon Capture Journal*, and *Carbon Sequestration*) have been growing steadily throughout the last decade or so, both in terms of numbers and reputation (Shackley, 2012:118-9; Stephens, 2011:383; Stephens *et al.,* 2012:136). Many of these may be the direct research outputs of bilateral initiatives. Research shows that CERC published over 400 papers and 80 plus conference presentations, while CAGS produced over 29 mainly scientific and technical papers. COACH led to over five papers, three book features and a magazine article, as well as around 10 conference presentations.

Figure 7.8. Websites & E-Newsletters	IEAGHG "Greenhouse News"	APP website and e-Newsletters	CERC DoE-managed (http://www.us-china-cerc.org)	MOST-managed (http://www.cerc.org.cn/)
CERC ACTC website and newsletters	US DoE website	NETL weekly newsletters	MIT CCS Technologies Program website	PTRC website (www.ptrc.ca)
STRACO$_2$ website (www.euchina-CCUS.org)	COACH website (www.co2-coach.com)	NZEC websites (www.nzec.info and www.CCUSchina.info)	CLEAN website (www.clean.org.cn)	Linkschina website (www.captureready.com) Weibo ("captureready")
GDCCUS website http://www.gdccus.org/en/	University of Cambridge Centre for CCS	GCCSI (www.globalCCUSinstitute.com)	CAGS periodic project newsletter and (www.cagsinfo.net)	GDCCUSC quarterly magazine "Near Zero Emission CCUS" (www.gdccus.org)

Most importantly, websites and e-newsletters were important mechanisms for partners to both communicate often for administrative reasons and to share their research findings internally (Figure 7.8.). They were also important tools to share knowledge and information (by way of publications and presentations) with the wider energy, climate and CCS communities and to increase the visibility of the projects, their objectives and their outcomes. Whilst continuing to be important resources for news and articles, many provided updates on international CCS-related events and activities more widely. Finally, awards and prizes (such as the CSLF Global Achievement Award and the DoE Award of

Distinction) have the potential to reinforce the importance of CCS R&D efforts for individuals, organisations, and pilot or demonstration projects. If targeted towards particular people or specific technical and/or geographical areas, these awards have the ability to inject enthusiasm into the local CCS community, justifying their efforts toward the technologies' development, and even legitimising increased focus.

Interpersonal, Convergent, and Persuasion Communication Channels

Rogers (2003:367-8) maintains that "feedback from the client system must flow through the change agent to the change agency so that it appropriately adjusts its intervention programs to fit the changing needs to clients." In terms of interpersonal, convergent, and persuasion communication channels, Figure 7.9. shows that formal and informal subject specific networks were by far the most common, with mobility schemes, personnel exchanges, and personal connections the second most common.

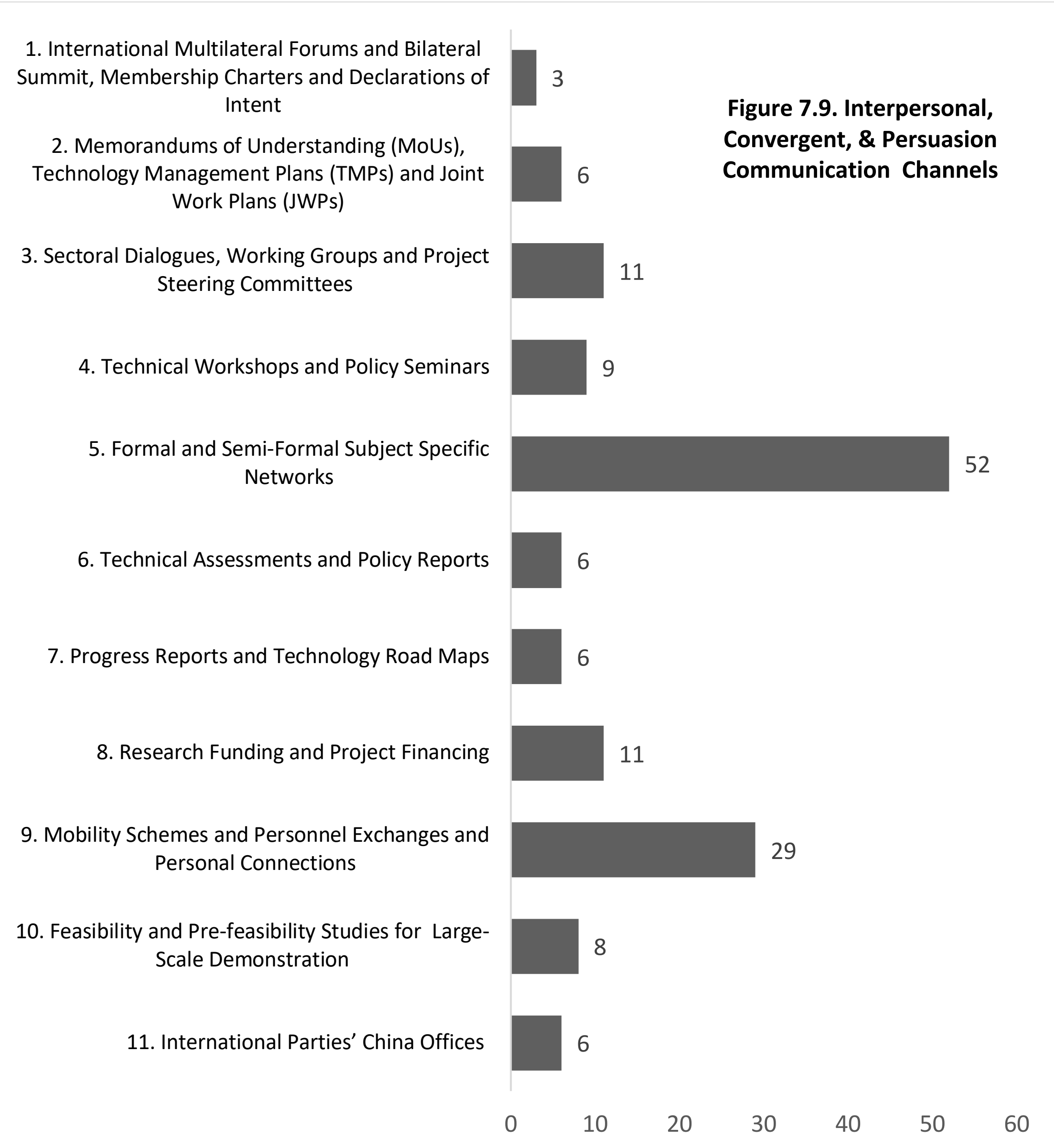
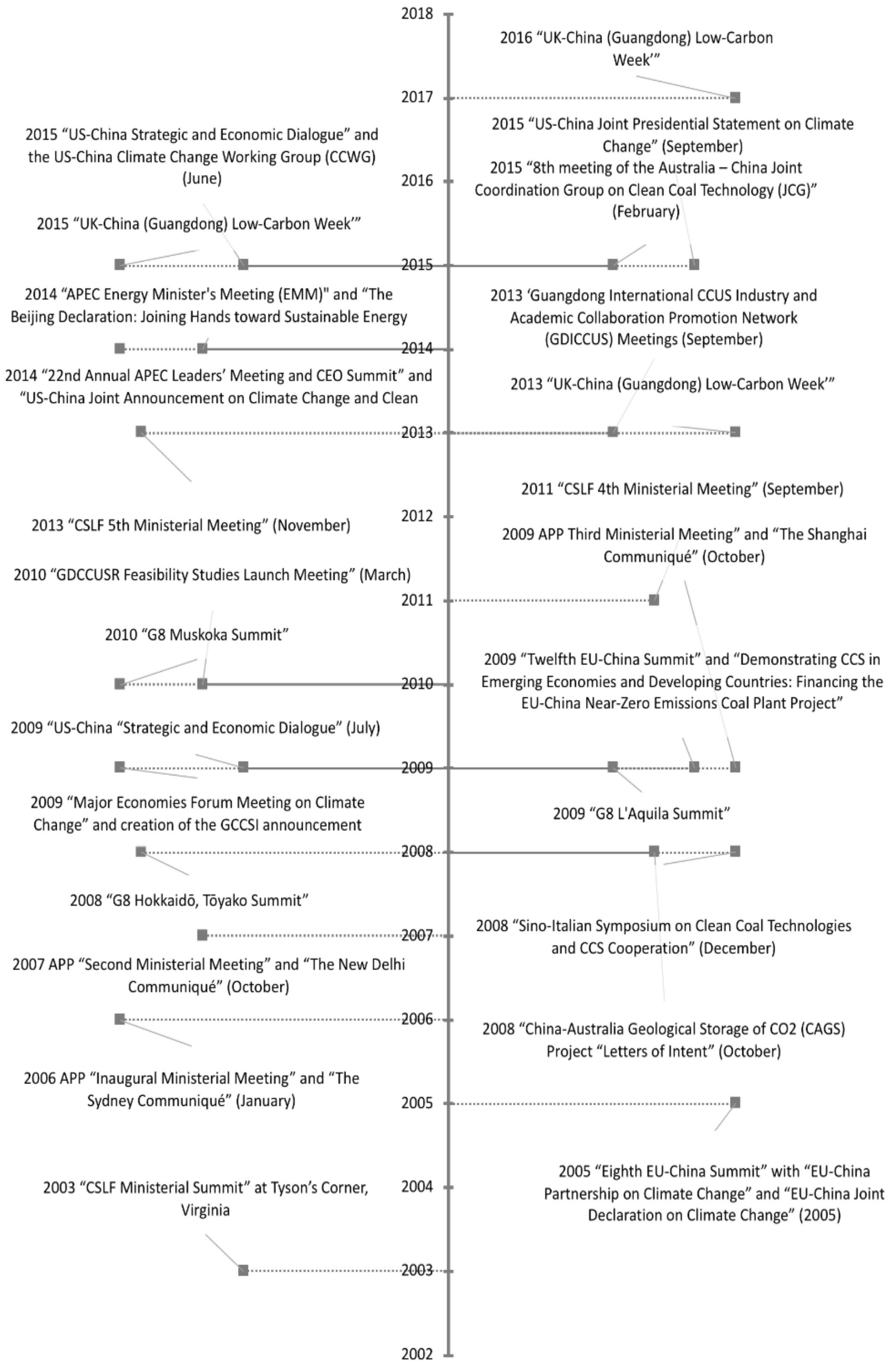


Figure 7.9. Interpersonal, Convergent, & Persuasion Communication Channels

Figure 7.10. International Multilateral Forums, Bilateral Summits, Membership Charters, and Declarations of Intent

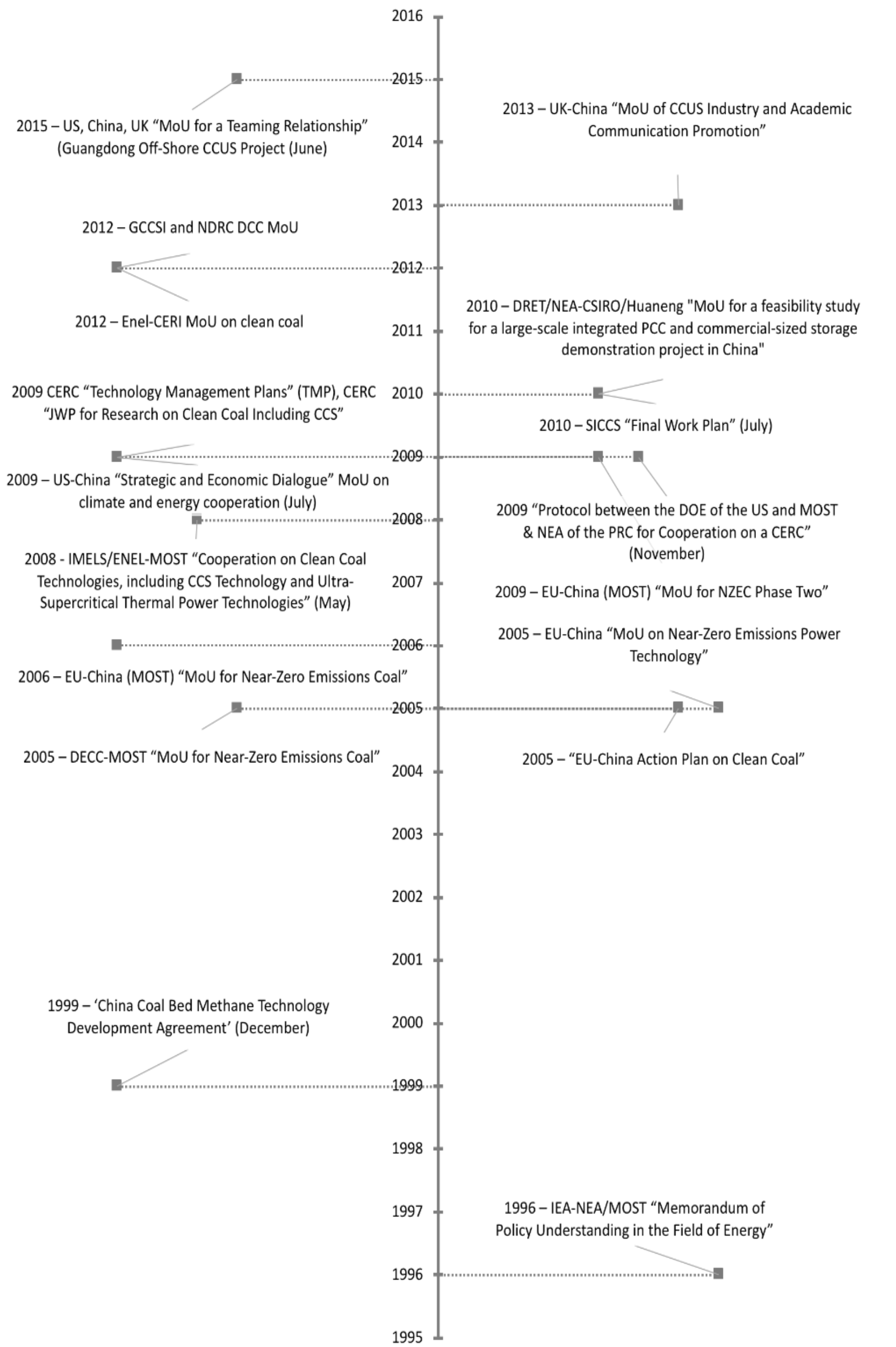


International multilateral forums, bilateral summits, membership charters, and declarations of intent (Figure 7.10.) can focus attention and efforts on energy and climate issues, as well as promoting CCS as a technological solution to abate GHG emissions. Providing a vehicle for interested parties (such as government and industries) to pursue their own self-interests, these events can also act as sounding boards to send strong messages (for example the US and China climate commitments) outside the formal international negotiations. Acting as a mechanism to persuade parties or push partners in certain directions, they also create a non-threatening atmosphere where commitments were non-binding and declarations take into consideration individual national circumstances, while also providing a benchmark from which to measure contributions and monitor progress (i.e., 20 demonstrations by 2020) (Bäckstrand, 2008:67,91-94,97,99).

From interviews, I found that these high-level governmental meetings, charters, declarations and communiqué can also send stronger messages to those at the lower levels (industry, research, academia, NGOs and financers) that they should (re)focus their attention towards CCS. As powerful motivating mechanisms creating new support and renewed momentum around the technologies, regular meetings also have the function of discussing recent developments, defining new directions, and setting future priorities, in the spirit of cooperation (On, 2013:1-7). However, they are also open to criticism, due to questions around their true motivations, often thought of as arenas for improving diplomatic relations through less controversial topics, such as climate change. They can often lack real legitimacy and unaccountability by not enforcing strict emissions targets and could be described as mere talking shops, with little-to-no real action towards emissions reductions (Bäckstrand, 2008:67,91-94,97,99). However, one interesting aspect of such forums is that although many are created and/or established by individual countries, in order to bring their neighbours together as partners, there is a degree of shared infrastructure where countries can use these international platforms to launch their own bilateral initiatives and make national announcements and commitments. We saw this through the CAGS.

Memorandums of Understanding (MoUs), Technology Management Plans (TMPs), and Joint Work Plans (JWPs) (Figure 7.11.) have been important mechanisms to enable direct engagement between international organisations, national governments and China at the highest levels. Often used to form strategic alliances (outside the UNFCCC system) on bilateral energy and climate goals, these country-to-country partnerships offered possibilities to overcome more specific joint challenges and provided opportunities for collective industrial and commercial opportunities, such as joint demonstrations. Setting out the issues and scope for cooperation, these understandings provide access to Chinese organisations, personnel, and (on occasion) their data, while defining the roles, obligations and (monetary/personnel) contributions of partners. However, we should also acknowledge that these were not always strictly adhered to, particularly on the Chinese side.

Figure 7.11. Memorandums of Understanding (MoU), Technology Management Plans (TMPs), and Joint Work Plans (JWPs)



Besides being more flexible, these agreements offer parties the expertise and experience of foreign partners who often assist in their local efforts, while providing avenues of industry, research, academia and even NGO partners with opportunities to work more closely and efficiently. They were also often critical governance documents to avoid project failure arising through relationship problems by outwardly addressing challenging issues, such as intellectual property, by removing any uncertainty about the exchange of research data and hesitation that would inhibit the sharing of project experiences. Often arduously negotiated over long periods, they are not necessarily legally binding or add additional protection, but they do lead to greater clarity, trust and openness and for closer collaboration, enhanced coordination and (hopefully) increased innovation. There is also evidence that private sector MoUs and business ventures often followed on from those initiated by the government.

Sectoral dialogues, working groups, and project steering committees (Figure 7.12.) are often composed of government policy, energy, climate and finance officials and professionals that offer governmental access. They can establish joint strategic directions and directly influence policy-making institutions and decision makers. Individuals at equal levels often meet periodically during structured events to frequently review progress and achievements. These groups often work outside the international climate negotiations and are typically immune to higher-level diplomatic pressures and disputes. However, it is usually at this level that the government is advised on whether or not to continue supporting bilateral efforts, to increase or decrease its funding, and whether or not there is a need to change direction, focus or scale. These groups provide a link and retain close contact with industry, research, academia and the non-profit sectors in their own countries, often inviting them to take part and provide input and feedback at meetings or at side events. These act as critical tools for improving relationships, for reinforcing the communications between both sides, and for refining strategies.

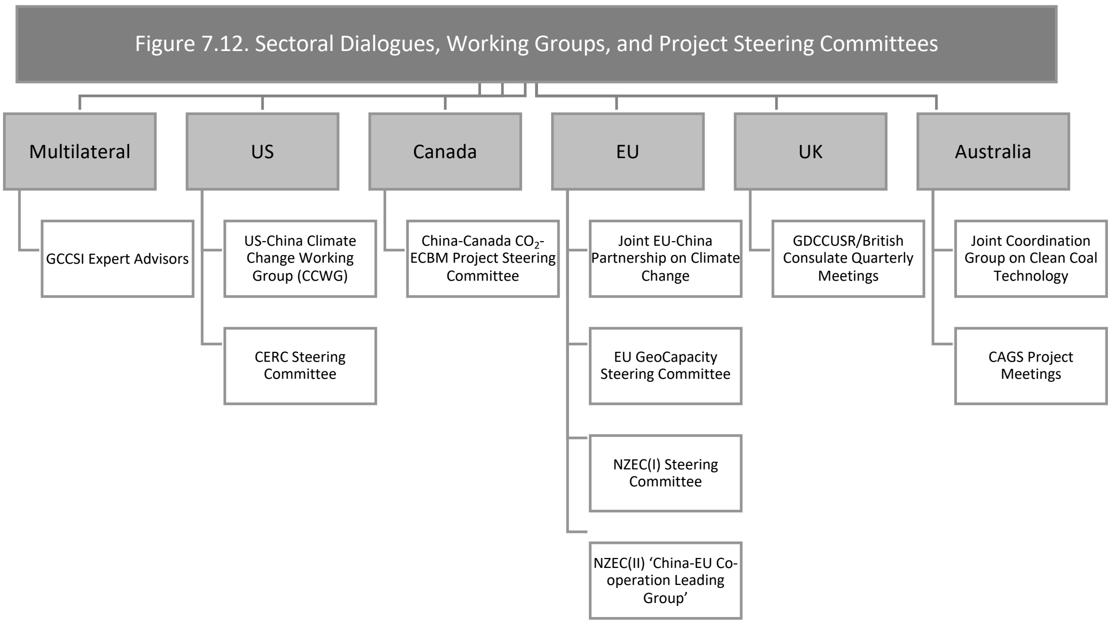
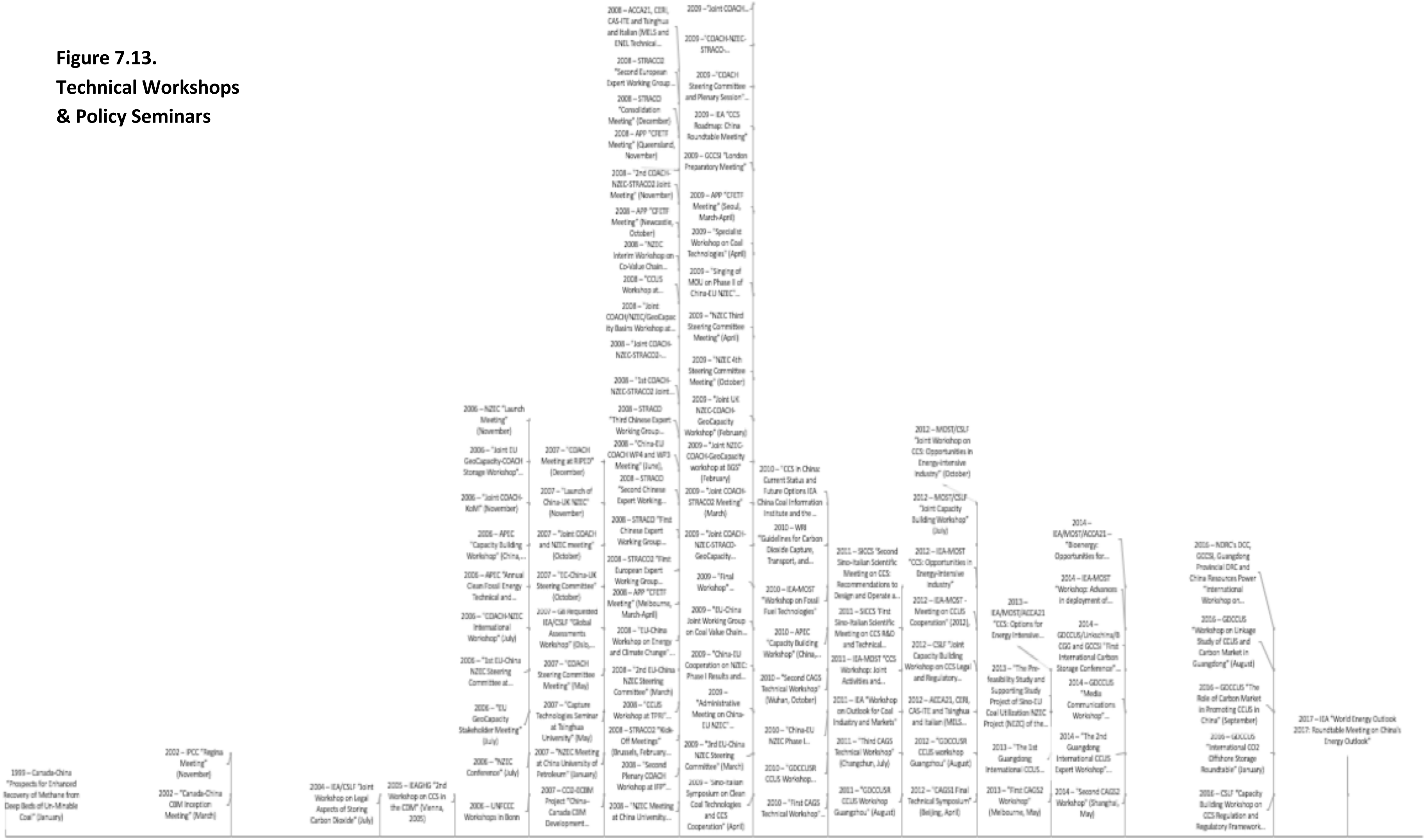


Figure 7.12. Sectoral Dialogues, Working Groups, and Project Steering Committees

Technical workshops and policy seminars (Figure 7.13.) can be used to bring together expert parties to enable deeper scientific, technological, regulatory and socio-economic discussions and investigations into the technologies' potential, to clarify any outstanding uncertainties or hesitations. They can also be used to define specific definitions and terms (i.e., capture ready) and to identify lucrative opportunities, while again creating local collectives, country alliances and regional and international networks throughout and beyond the discussion and report writing processes (discussed below). They have also proved to be useful tools for industrialised and developed parties to introduce the concept of CCS to wider audiences and to engage with those in the emerging and developing worlds, to gauge domestic interest and to better understand local issues and opportunities. Such workshops have brought together many stakeholders in order to develop their own projects or formulate policies and regulations, while allowing for modification and tailoring to suit different interests and concerns. Often targeted towards those at different stages of the CCS value chain, this has the possibility to empower local decision makers and to create a sense of ownership, which has the potential to lead to a more conducive CCS enabling environment. Drawing the attention of the wider stakeholder community, a number of these events also included members of the national and local media, which helped to spread the word about CCS within China.

Formal and semi-formal subject-specific networks (such as the IEAGHG's formal networks, CERC Consortia, the EU Projects WPs, and CSLF, APP, APEC, GDCCUSC working groups) provide opportunities for peer and other stakeholder interaction, the exchange information and the sharing of experiences, in a more neutral and non-committal setting. Members often come together to work on specific research projects or publications that focus on specific technical or policy areas and their joint expertise and experience is often shared with other organisations (i.e., the IPCC) and for various international projects. Coming together periodically to learn from each other and set future research directions (often coinciding with other meetings or events), these networks have the potential to speed up the interactions between both sides, to get around issues related to commercial secrecy and IP as well as having the potential to directly and more adequately remove the uncertainties and hesitations of potential adopters, thus speeding up the diffusion processes. Groups within groups, there were often research consortia, task forces, and sub-task forces, primarily working towards technical efficiencies, cost reductions and/or providing greater certainty to create a market for CCS technologies and enable deployment of the technologies. Often, there were networks specifically around CCS pilots and demonstrations and at the later stages there were more localised China-based networks.

Figure 7.13.
Technical Workshops
& Policy Seminars



Technical assessment and policy reports (Figure 7.14) have been used to bring together the wider expert communities and to draw on their knowledge and expertise to explore more detailed issues around CCS technologies. Creating international and local networks, these reports provide greater detail, clarify key issues (such as capture potential, storage capacity and overall mitigation contributions) and remove critical technical and economic uncertainties (such as the energy penalties and cost concerns), while providing greater assurances around safety (risk and social acceptance). By acting as strong advocates for the technologies (often over other technology options or as part of a mitigation portfolio), these reports have often raised the technologies' profile both internationally, nationally and locally, with the potential to create a sense of urgency towards intensify efforts and/or and necessity to increase the allocation of resources. Parties often referred to these as a scientific basis for policy making during the formulation of national energy, climate and CCS-related programmes and plans, with the reports also referenced and quoted during the UNFCCC's international climate negotiations.

Often produced by credible organisations, over time these assessments and reports also have the potential to create a gradual normative shift towards greater acceptance of the technologies and increased legitimacy for their application as an international low-carbon option, while also reinforcing the existing carbon lock-in (de Coninck *et al.*, 2011:368-376). Including technical examples, policy suggestions and regulatory recommendations, these reports often offer useful models, best practice and guidance. At the higher levels, the material and data from these reports has also been used at numerous conferences, workshops, presentations, and webinars, while at the lower levels used for evidence and justification towards demonstration. Joint efforts in producing these technical assessments and policy reports have also been important learning tools for international parties to learn more about the real opportunities and challenges faced by CCS in China, to offer technical and policy assistance to Chinese parties, and to build closer connections with partners. Additionally, foreign-supported "hands-off" research and investigations that are solely undertaken by Chinese parties can be used to fill the knowledge gaps that inhibit domestic CCS development. Increasing local knowledge and capacity, they can create a domestic CCS-readiness, particularly in the lead up to possible demonstration projects. These studies also have the potential to influence Chinese policy makers, while building more direct opportunities for learning by doing.

Figure 7.14. Technical Assessments and Policy Reports

IPCC

- "Third Assessment Report" (2001)
- "Special Report on Carbon Capture and Storage" (2005)

G8, IEA & CSLF

- "Near-Term Opportunities for Carbon Capture and Storage" (2007)

IEA & IEAGHG

- IEAGHG "Putting Carbon Back in the Ground" (2001)
- "Uncertainties in Relation to CO_2 Capture and Sequestration – Preliminary Results" (2003)
- IEAGHG "Opportunities for the Early Application of CO_2 Sequestration Technology" (2002)
- "Legal Aspects of Storing CO_2" (2005)
- IEAGHG "CO_2 Capture Ready Plants" (2007)
- "Legal Aspects of Storing CO_2: Update and Recommendations" (2007)
- "World Energy Outlook - Special Insights on China and India" (2007)
- "Carbon Capture and Storage in the CDM" (2007)
- "Cleaner Coal in China" (2009)
- "CCS Model Regulatory Framework" (2010)
- "Cost and Performance of Carbon Dioxide Capture from Power Generation" (2011)
- "Policy Strategy for Carbon Capture and Storage" (2011)
- "Facing China's Coal Future: Prospects and Challenges for CCUS" (2012)
- "Carbon Capture and Storage Legal and Regulatory Review" (2010, 2011, 2012)
- "World Energy Outlook" (2000-2015)
- "Energy Technology Perspectives" (ETP) (2006-2016) series

WB & ADB

- WB "Coal in China: Overview and Possible Areas of International Co-operation" (2006)
- WB "Cost of Pollution in China" (2007)
- WB "Carbon Capture and Storage in Developing Countries: a Perspective on Barriers to Deployment" (2011)
- ADB "Opportunities for CCS Deployment in China under Low Carbon Transformation Scenarios" (2014)
- ADB "Oxy-Fuel Combustion Technology Assessment" (2015)
- ADB "Selection of Early Opportunity CCS Demonstration Projects in the PRC" (2015)

GCCSI

- "Strategic Analysis of the Global Status of Carbon Capture and Storage – Report 3: Country Studies: China" (2009)
- "Defining CCSR: An Approach to an International Definition" (2010)
- "Accelerating the Development of CCUS: Industrial Utilization of Captured CO_2" (2011)

$STRACO_2$ & NZEC

- $STRACO_2$ "Final and Synthesis Reports" (2009)
- NZEC "CCS in Energy Intensive Industries" (2009)
- NZEC "CCS Sustainability Assessment" (2009)
- NZEC "Emissions Sources and Source-Storage matching in Jilin Province" (2009)
- NZEC "Review of CCS Activities in China" (2009)
- NZEC "Stakeholder survey of CCS in China" (2009)
- NZEC "Phase One Final Report" (2009)

BGS

- "The Underground Disposal of Carbon Dioxide Summary Report" (1999)
- "New potential carbon emission reduction enterprises in China: deep geological storage of CO_2 emitted through industrial usage of coal in China" (2012)

GDCCUSC

- "GDCCUSR Report Five – CCUS Capacity Building and Public Awareness in Guangdong" (2010-2013)
- "GDCCUSR Report Four – Techno-economic and Commercial Opportunities for CCUS-Ready Plants in Guangdong" (2010-2013)
- "GDCCUSR Report One – Analysis of CO_2 emission in Guangdong" (2010-2013)
- "GDCCUSR Report Three – CO_2 Mitigation Potential and Cost Analysis of CCUS in Power Sector in Guangdong" (2010-2013)
- "GDCCUSR Report Two – Assessment of CO_2 Storage Potential for Guangdong" (2010-2013)
- "CRP Haifeng Plant CCR Report Five – Cost, Financing Options and Financial Options and Financial Risk Management" (2015)
- "CRP Haifeng Plant CCR Report Four – Huizhou-Haifeng CCUS Cluster Plan" (2015)
- "CRP Haifeng Plant CCR Report One – China Resources Power (Haifeng) CO_2 Capture Pre-feasibility Study" (2015)
- "CRP Haifeng Plant CCR Report Six – The Synthesis Report" (2015)
- "CRP Haifeng Plant CCR Report Three – CO_2 Geological Utilisation and Project Opportunities" (2015)
- "CRP Haifeng Plant CCR Report Two – Feasibility of Reusing CNOOC Offshore Platform for CO_2 Injection" (2015)
- "Developing the Public Engagement Strategy for the Guangdong CCUS Demonstration Program" (September 2015)
- "CRP Haifeng Testing Platform Engineering Study" (2016)

NRDC & WRI

- NRDC "Identifying Near-Term Opportunities for Carbon Capture and Sequestration (CCUS) in China" (2009/2010)
- WRI "Guidelines for Carbon Dioxide Capture, Transport, and Storage" (2010)10)

Progress reports and technology road maps (Figure 7.15.) were often funded and/or supported by nation states (G8, Norway) and organisations (IEA, CSLF, GCCSI, ADB). These publications outline the policy developments, technical achievements and project successes/failures towards the G8's targets and have been used by the international CCS community as an inventory and accounting exercise. They were also useful tools for international parties to increase global coordination by formulating plans, setting milestones, and recommending actions in order to maximise efforts towards development, demonstration and deployment. Quite often having a more global outlook, they could also focus on specific regions (i.e., the Balkans) or countries (such as China and South Africa) and within particular sectors (such as power generation, cement, and oil). Allowing international parties to influence foreign governments and industries, thus extending their reach beyond their borders, these were often targeted towards emerging economies and the developing world. Often greeted with great enthusiasm by domestic CCS proponents who valued the opportunity (and foreign expertise) to effectively formulate plans for the technologies, my interviews showed that these road maps were treated by some Chinese parties as interfering with national developmental and economic growth patterns. Road maps also have the potential for parties to slow down or stall their CCS development, demonstration and deployment by setting more medium to long-term goals and targets to suit national needs or industrial requirements.

Figure 7.15. Progress Reports and Technology Road Maps

Research funding and project financing (Figure 7.16.) is a useful way for industrialised/developed (donor) nations to fund CCS projects in emerging/developing (beneficiary) countries. Often channelled or filtered through MDBs (or the GCCSI), this very limited funding gives them the prospect of having some say in the direction (and perhaps even the projects) in which they support. Such funding and financing can also be used as key foreign policy tools, allowing parties to exert their own influence and protect their national interests. Using the conditions and opportunities of other regions and countries, they can share any risks (along with the results) with others at the same time. Although not large enough to support demonstration, the research funding provided is often accompanied by technical assistance efforts and capacity building activities, which could initiate local CCS-related research, encourage domestic demonstration and stimulate government and private sector investment. While the ultimate objective is often to create a CCS development enabling environment, these activities also run the risk of stalling Chinese CCS advancement due to continued expectation and dependency on foreign capital and technical knowledge, without strong local stakeholders, policies and projects. However, not all cooperative research and projects were fully funded, with some bilateral initiatives (the CERC, China-Canada CO_2-ECBM Project and CAGS3) calling for joint financial arrangements and/or equal contributions, often with expectations of domestic private sector involvement. There has been criticism, however, that China has relied on existing domestic public-sector funding streams, with little or no CCS-specific financial mechanisms or significant contributions from the private sector (Gu, 2013:16-17).

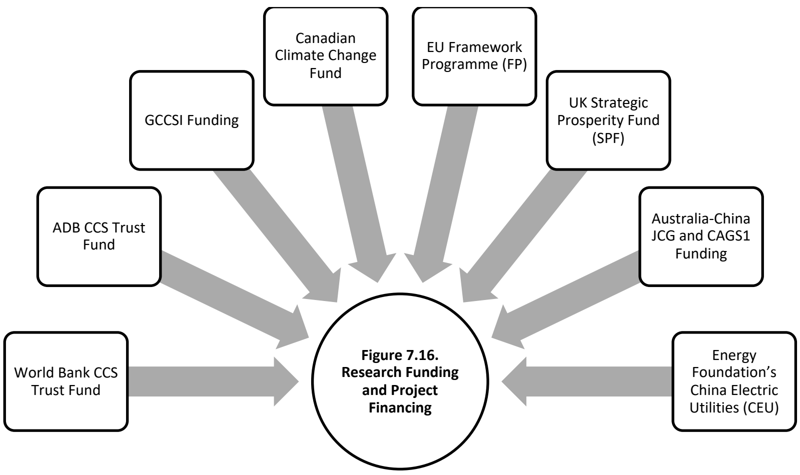


Figure 7.16. Research Funding and Project Financing

Mobility schemes (such as through COACH, NZEC, CERC, GeoCapacity, and CAGS) and personnel exchanges[3] often provided opportunities to first learn about CCS, to familiarise Chinese parties with the facilities and projects on the other side, and to build stronger relations between project partners with foreign partners. Chinese parties often assisted

[3] To Berkeley Lab, University of Saskatchewan (UofS), NTNU, SINTEF, KTH, GEUS, University of Cambridge, Cranfield University, Heriot-Watt University, Edinburgh University and Imperial College London, University of Nottingham, Geoscience Australia, CO_2CRC, University of Adelaide, University of Queensland, CSIRO, Monash University, China Geological Survey.

in China-specific research, guidelines of methodologies and many partnerships and collaboration continued outside the formal exchanges. Such activities were seen by some as producing a valuable project outcome, such as the establishment of an international network. Personal connections were also made through third-party organisations (IPCC, DECC, IEACCC) and/or collaborations (NZEC, COACH). Depending on the status of these individuals, their words carried great significance during international and local events. However, people-to-people exchanges are undoubtedly important.

Pre-feasibility and feasibility studies for large-scale demonstration[4] often took place over a number of phases, stages or steps and involved the evaluation, modelling and small-scale testing for CCS pilots and demonstration. Involving local or project specific site selection, characterisation and/or simulation, these activities produced front-end engineering and project designs with aspirations to scale-up tests to pilots to demonstrations and eventually to fully-integrated commercial-scale projects and marketisation. Often following knowledge sharing and training activities, these feasibility studies are usually under agreement between government parties on both sides and subject to negotiation with industry stakeholders, often under competitive tender. Allowing international partners to explore Chinese conditions as a potentially cost-effective living laboratory and to speed up the project process, this was a much cheaper process than supporting fully-fledged demonstration and had the function of motivating local parties to start thinking about the real thing. The incentives for Chinese parties to take part in these activities were the financial arrangement included and the expertise offered by foreign partners, as well as a practical learning-by-doing experience. These studies are often very expensive, time consuming and the final outcome is uncertain, and may not lead to actual demonstrations.

China offices (Figure 7.17) allow foreign partners to have a physical presence within China with the hope of cooperating more closely with domestic Chinese partners. Besides creating a buzz around the cooperation and CCS technologies, these offices were also useful to increase knowledge sharing, disseminate information, and improve capacity building and training activities for best practices. Perhaps this was also particularly important due to the lack of one single government department and the seemingly lack of domestic coordination around domestic CCS projects. Some were solely foreign, while others were joint collaborations or internationally funded research centres. Others, however, purposefully chose to create entirely virtual cooperation centres which were housed across its research institutions in both countries. The rationale behind this was that it would be less-burdensome and would minimise travel and expenses.

[4] Such as UK NZEC, Norwegian Ministry of Petroleum, Canadian CO_2-ECBM Project, Sino-Italy Cooperation on CCUS Technology (SICCUS) project, GDCCUS "CRP Haifeng Testing Platform Engineering Study," Australia-China PCC Feasibility Study Project, CAGS3 Pre-feasibility Research Projects.

Figure 7.17. International Parties' China Offices

Exemplary and Experimental Demonstrations

Exemplary and experimental demonstrations are considered more of a change agent activity than a communication channel, Rogers (2003:177) states that "change agents often seek to speed up the innovation-decision process for individuals by sponsoring demonstrations of a new idea in a social system." Although both have the goal to increase knowledge about the effectiveness of the innovation, he points to two different types of demonstrations which perform two very different functions. From the 205 cosmopolite channels identified, 20 can be considered exemplary demonstrations and seven experimental (Figure 7.18 and Figure 7.19.).

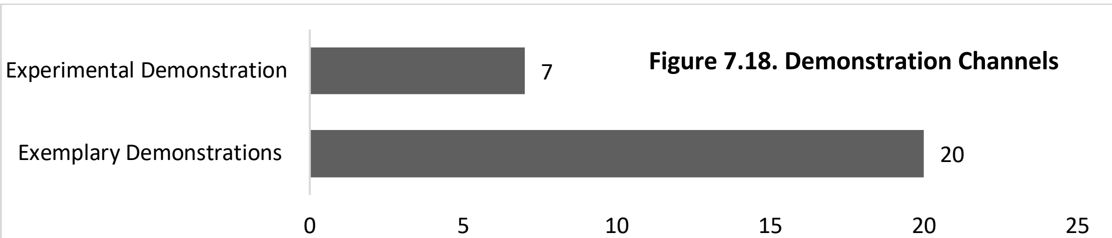


Figure 7.18. Demonstration Channels

Through showcasing exemplary demonstrations, potential adopters of a new idea are aided in evaluating an innovation if they are able to observe it in use under conditions similar to their own. Such observation may occur naturally when an individual views another's experience in using the innovation. Change agents may also try to increase the observability of an innovation and thus speed its rate of adoption by organising a demonstration of the innovation. Conducted with high public visibility the demonstration's managers should also have an attitude of optimistic assurance about the innovation's effectiveness (Rogers, 2003:177).

Exemplary demonstrations and on-site visits have been useful tools by the international CCS community to showcase the technical developments of CCS globally. Many on-site visits take place during other events (such as during the IEAGHG Summer School, in Beijing, when parties visited Huaneng's Gaobeidian Plant). We also see clear evidence of this during the APP's "flagship projects," that were intended to promote and publicise the technologies while illustrating the vision of the partnership and ultimately leading to self-perpetuating action. However, with negative media stories and rumours around the technical, managerial and commercial challenges of certain projects, CCS can be portrayed as a waste of time, money and effort. This can also be highlighted when potential adopters are given the opportunity to meet with project staff and engage in detailed questioning about the technical and financial details, particularly towards scaling-up. In later stages, as more domestic CCS efforts have become advanced, there have also been increased opportunities for foreign parties to visit Chinese pilot and demonstration projects.

Experimental demonstrations that are conducted under field conditions can also be a useful strategy by change agents to allow the innovation to be evaluated. The demonstration is often effective because it combines the perceived competence credibility of the change agent with the perceived safety credibility of the demonstrator. Importantly, the attitude of the demonstration managers should be one of healthy scepticism toward the innovation, while it can be particularly effective if the demonstrator is a respected opinion leader within the system (Rogers, 2003:389). In China, experimental demonstration has often been facilitated by international organisations and carried out through joint initiatives (such as APP CFETF and CERC ACTC). The reason for this is that a wide range of project combinations, technical configurations, geographically diverse conditions, and varied socio-economic conditions under different political and financial circumstances are needed for CCS to develop at pace internationally.

Many emerging economies and countries in the developing world that urgently require emissions abatement and don't have the capacity to fund and/or facilitate pilot and demonstration projects, so there is a great potential for these parties to collaborate. By gaining access to such big experimental platforms, there were also opportunities for technical learning, significant financial cost savings, and the potential access to foreign markets. Early Chinese pilot and demonstration projects required expertise and experience from a wider range of disciplines and sectors and brought together stakeholders from different industries and countries and included difficult issues to navigate, such as financing and intellectual property. These collaborations then led to other base-line studies and detailed investigations, as well as best practices manuals (containing tools, techniques and methodologies) that have been used along the CCS value chain and shared throughout the developing CCS community. With the ultimate goal of pilots and demonstrations to provide evidence, create certainty and give assurances, positive joint experimental demonstrations could eventually lead to entirely Chinese demonstrations. However, any early negative experiences with these experimental demonstrations could also affect the long-term attitudes towards the technologies.

Figure 7.19. Exemplary and Experimental Demonstrations

Exemplary Demonstrations

- FutureGen Project
- Weyburn-Midale CO_2 Monitoring & Storage Project
- Kemper County Energy Facility
- SaskPower Boundary Dam
- Duke Energy IGCC Plant Edwardsport
- Shenhua Ordos Integrated Project
- CO_2CRC's Otway Pilot Project
- ZeroGen
- Gorgon
- National Carbon Capture Centre
- National Energy Technology Laboratory
- EC Study Tour of Europe
- NEL/TÜV SÜD Group
- University of Edinburgh
- Technology Centre Mongstrad
- SINTEF
- Sleipner CO_2 Storage Project
- Ketzin Pilot Project
- Rotterdam (ROAD) Project
- Energy Australia's Iona Gas Plant

Experimental Demonstration

- FutureGen Project
- Huaneng Thermal Power Plant in Beijing
- Sinopec's Shengli Power Station and CO_2 Capture Facility
- Sinopec's Shengli, CCUS site near Zibo
- Weyburn-Midale CO_2 Monitoring and Storage Project
- Yanchang Petroleum's Jingbian site
- Yangchang's coal-to-chemicals Yulin

In addition to Sino-international CCS-related communication channels that were both one-way linear (a centralised system) and two-way convergent (a decentralised system), there is further reason to believe that a truly hybrid model of diffusion does indeed exist and the application of both channel types at different time and for different purposes has the potential to speed up the innovation diffusion, development, and decision processes. However, it's important to explore the content of these CCS-related communications, particularly related to the 'perceived characteristics of the innovation,' and the possible impact they might have on Chinese adoption.

Perceived Characteristics of an Innovation

According to Rogers (2003:15-17,116,219-229), the ‘perceived characteristics of an innovation’ (by potential adopters) can affect its rate of adoption. He identifies five key characteristics (relative advantage, compatibility, complexity, trialability, and observe-ability), which he says can influence both the rate of adoption and continuance, making the messages about these characteristics crucial throughout the diffusion process.

Rogers (2003:5-6,18-21,223) also acknowledges that diffusion investigations show that although objective scientific facts are not entirely irrelevant, most individuals do not evaluate an innovation on the basis of scientific studies alone, especially to the very first individuals who adopt. He argues that key to diffusion communications is the influence of subjective evaluations of peers through interpersonal channels, which has the potential to energise the diffusion process, particularly influencing later adopters. While potential adopters can gain valuable information on the advantages, disadvantages, and potential consequences of adoption, those that have already adopted can seek reinforcement that they have made the right decision, while also engaging in problem-solving which can lead to a continuation or discontinuance of the innovation.

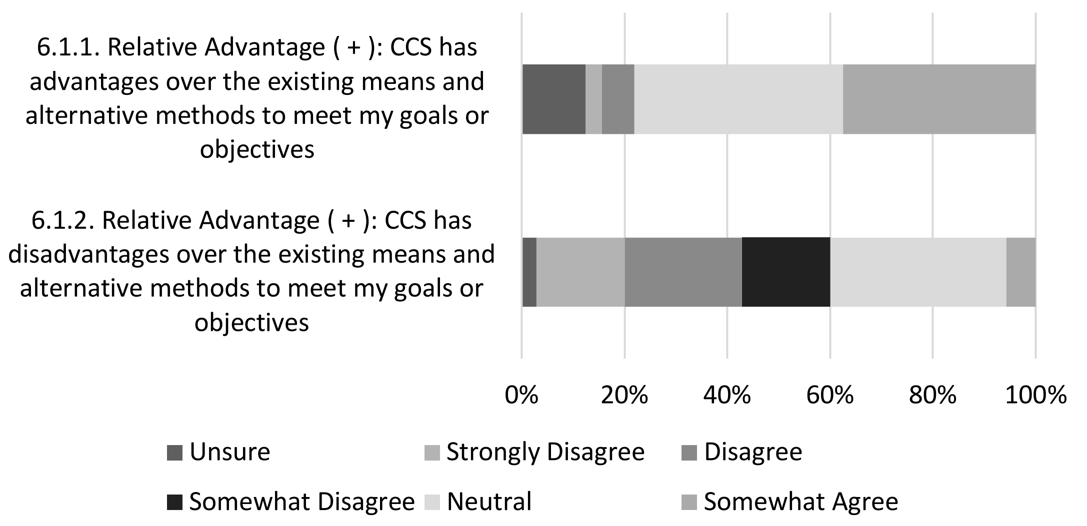
Although not a study of CCS discourse analysis (which goes well beyond the boundaries of this research but could be a subject for future research), I used secondary-sourced case studies on international entities (Annex) and supported by the primary-sourced data gathered from my interviews with Chinese parties to extract what could be used to tailor storylines and communication strategies, while aligning this to Rogers’ ‘perceived characteristics of an innovation’ (Figure 7.20).

Positively related to the rate of adoption (the more advantages it has the more likely it is to be adopted), Rogers (2003:15,69,176,223-235) states that an innovation should have a degree of perceived ‘**relative advantage’** over its predecessor or other alternatives, perhaps in terms of time-saving, practical use, overall convenience, lower (capital/operating) costs, economic profitability, and/or status and social prestige. Importantly, although relative advantage is often seen in the near-future, for a preventative innovation (designed to lower the probability of some unwanted future event) this may be hard to demonstrate, due to its delayed or even unseen rewards. However, he goes on to say that change agents can increase relative advantage by emphasising rationality, possibilities for gaining approval and/or improving status, and perhaps offering incentives or rewards, as well as providing a cue-to-action.

Case studies (Annex) show that the relative advantage of CCS was under question, until the IPCC recognised the great potential of capture technologies to abate GHGs and the IPCC provided evidence for parties to confirm the technologies mitigation possibilities (Meadowcroft *et al*., 2009:5-7, Langhelle, 2009:241; Van Alphen, 2011:82; Vergragt, 2009:201). This provided assurances to stakeholders that the technological uncertainties could be overcome in time, which created a normative shift around the technologies' legitimacy, placing it higher up on national political and international negotiating agendas (de Coninck *et al.*, 2011:368-376). When compared to other technologies, the IEA's storylines argued that CCS is the only technology to realistically help meet emissions reductions targets in the time needed (Meadowcroft, 2009:273-4). Likewise, the GCCSI (2015:1) places CCS as the most critical technology for achieving low-emission pathways and downplays the prospect of renewables providing the energy needed within the timeframe given. With regard to China, the EC presented CCS as the only option to ensure significant GHG emissions reductions for this key carbon-emitting country and made this a central focus of this cooperation (Romano, 2010:3-4; DECC, 2009; Gu, 2013:17; DECC, 2009). However, a key relatively advantageous message used by IEA was that any investment in CCS now will be significantly less than costs anticipated without CCS deployment, making it an economically feasible mitigation option in the long term (Kapetaki, 2016:13). Economic monetisation of environmental impacts had been used by the WB emphasising the potential cost savings to be made through CCS in China, when compared to other low-carbon alternatives.

All of these relative advantages provided arguments that CCS is an essential component in the portfolio of options, which was used by the G8, IEA, ADB, and GCCSI. As seen in Chapter 5, when asking my Chinese respondents whether CCS has an advantage over alternatives, we see that slightly more respondents were 'neutral' than 'somewhat agree,' although this was significantly more than disagreed combined. When asking them is CCS has disadvantages over alternatives, they gave similar results, showing that overall CCS was considered more advantageous (Figure 7.20).

Figure 7.20. Perceived Characteristics of an Innovation (Relative Advantage)

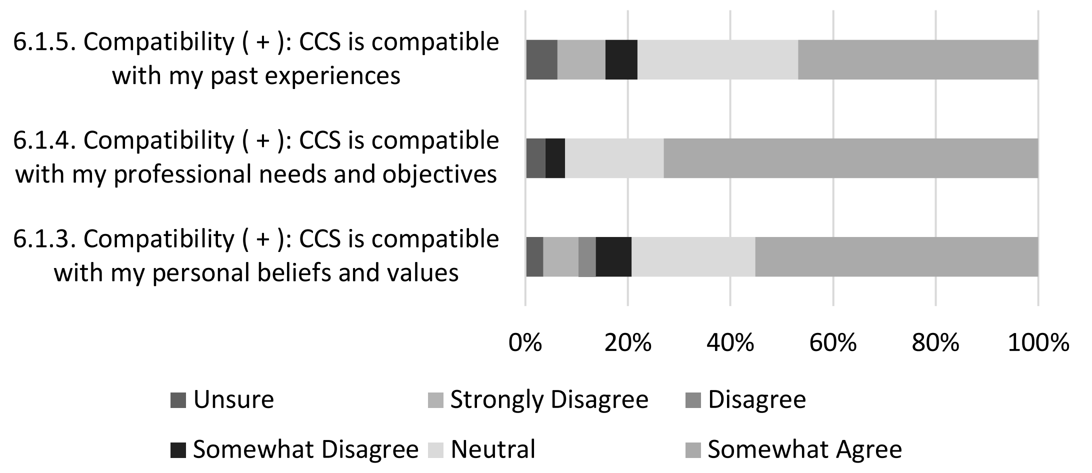


Also positively related to the rate of adoption is the '**compatibility'** of an innovation with an individual's or social system's existing socio-cultural values and beliefs, their previously introduced ideas or past experiences, and the client's current needs. Using interpersonal communications, change agents often seek to assess the perceived needs of their clients and to propose (or carefully generate a need for) the innovation that will meet these needs (Rogers, 2003:15,241-6,249). Therefore, it is important for change agents to fully research, understand and consider these aspects in the development of their diffusion positioning strategies. To do so, it may be useful for them to engage with and better understand the indigenous knowledge system in which the innovation is to be diffused, and how to effectively bridge old behaviours with the new innovation (Rogers, 2003:251-2,254-7).

Using case studies to investigate messages of compatibility with China, I obtained the most obvious finding that CCS technologies and policies can help the country achieve its national GHG emissions ambitions and keep global temperatures below the "2ºC guard-rail" needed for climate stability (Kapetaki, 2016:13). Common in IEA publications is the estimated geological storage capacity and that this is sufficient to adequately sequester large volumes of GHG and avoid atmospheric emissions. Another IEA argument for compatibility would be that CCS allows China to continue consuming coal to meet its growing energy demand, while reconciling its climate obligations and protecting economic growth. The IEA and GCCSI see further fossil-fuel exploitation as essential for energy security and CCS as an important weapon in the fight against climate. Likewise, APEC saw CCS as an enhancement of regional and domestic energy security through phasing out fossil-fuel subsidies, although framed this as creating possibilities for low-carbonization investment, commercialisation, and market opportunities. The IEA, ADB, and UK, all recognised the near-term demonstration and longer-term commercial possibilities for the Chinese coal-fired power-generation and energy-intensive industrial sectors, while promoting techno-economic feasibility assessments and policy analyses and roadmaps, which demonstrated China's technological, geological, and industrial compatibility and offered recommendations and short to long-term deployment scenarios.

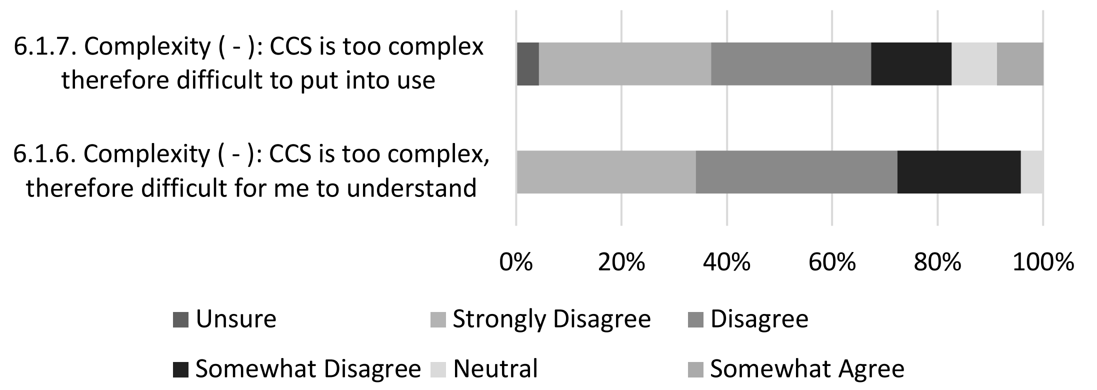
As mentioned earlier, Meadowcroft (2009:273-4) cautioned us about the statistics and predictions that were routinely cited by governments, industries, researchers, and academics, as these could further cement the storyline that fossil fuels will continue to have a role for many decades and that CCS is "eminently reasonable," thus restricting the possibilities to break the existing deeply-embedded societal practices and systems that inhibit more radical change. Likewise, Hansson (2012:77-8) sees such storylines of fossil-fuel dependency "inevitable-ness" and "a potential smoother transition [to decarbonisation] offered through CCS" as leaving few other options than for the technologies' to be deployed and calls for political support and financial resources to be provided. As seen in Chapter 5, my Chinese respondents saw CCS as largely compatible with their personal beliefs and values, professional needs and objectives, and past experiences (Figure 7.21). Although this is not surprising, given their characteristics.

Figure 7.21. Perceived Characteristics of an Innovation (Compatibility)



Complexity is "the degree to which an innovation is perceived as difficult to understand and use," which can directly negatively affect its rate of adoption within a social system. Although some innovations are clear in their meaning to potential adopters, others may not be and can be classified on the complexity-simplicity continuum (Rogers, 2003:16,257). As seen in Chapter 5, my Chinese respondents saw CCS as not at all too complex to understand but did consider it slightly more difficult to put into use (Figure 7.22.).

Figure 7.22. Perceived Characteristics of an Innovation (Compatibility)



In order to make CCS easier to understand and use, international entities (such as G8, IEA, CSLF, and GCCSI) have provided key definitions, defined concepts, set standards, and estimated costs, as well as creating norms. Many have become widely accepted by the international CCS community and some have influenced Chinese parties' innovation-decision and adoption processes. For example, the *UN London Protocol* (1996) de-classified CO_2 (with a purity ≤90 percent) as a hazardous substance, permitting carbon dioxide streams from capture processes to be sequestered off-shore, which had a positive international regulatory influence and removed some of the uncertainties around CCS. The IEA, CSLF and GCCSI, also tried to influence CCS by providing national-level legal provisions/recommendations and regulatory framework models that allow the development, modification and tailoring. APEC, APP, IEAGHG, EC, and GDCCUSC developed applicable technical methodologies, useful best practice manuals, industry guidelines, and other tool-kits. These are often shared through capacity building activities (by the IEAGHG, CSLF, APEC, WB, ADB, EC, GDCCUSC, CAGS) aimed at advancing technical knowledge, increasing management skills, enhancing regulatory frameworks, and developing financial mechanisms, often adapted to meet local needs. There was often an element of skill development through 'learning-by-doing' exercises, which created China-specific guidelines, methodologies, techniques, case studies and lessons learned, which were important preparations for demonstration, and as a prerequisite to building investor confidence. Crucially, it was important to share the message that CCS is safe and clean and that risks can be minimised through taking the necessary precautions (GCCSI, 2015:1).

Rogers (2003:16,258) defines **Trial-ability** as "the degree to which an innovation may be experimented with on a limited basis" and it can be a positive contributor to the potential likelihood and rate of adoption. He says that Innovations that can be divided into separate parts or tried in instalments can provide an opportunity to remove any hesitations and uncertainties. By holding the possibility of learning-by-doing, potential adopters can experience the innovation under their own circumstances, with the possibility to change, customise or even reinvent the innovation to better suit their own situation or needs (Rogers, 2003:16,258). As seen in Chapter 5, when asked if they had made any attempts to test or trial some aspects of CCS, 73 percent said "Yes" (Figure 5.48.) and when asked if the experience had been positive or negative their responses were overwhelmingly positive (Figure 5.49). When I asked the 25 percent that said "no," if they had the capabilities to do so, 82 percent said "yes" and only 18 percent said "no" (Figure 5.50.).

One of the key messages was the G8/IEA/CSLF call for at least 20 large-scale demonstrations globally by 2010 and widespread deployment beyond 2020, which percolated throughout the international CCS community. The G8 and IEA also recognized that demonstration in emerging economies and the developing world would be needed to reach meaningful emissions reductions, with China playing a central role. The IEA called for multiple projects with different technological combinations and under varied conditions and set out plans, with milestones and recommended actions, in an attempt to motivate stakeholders and mobilise resources (IEA/CSLF, 2010:5; IEA/CSLF, 2010:9). By documenting global developments from other regions and countries, the G8 laid out pathways to overcome the technical, financial, regulatory and social challenges to CCS development, while others (ADB, DoE, GDCCUSC) laid out detailed plans for demonstration in China. It was emphasised by many parties that, in order to reduce research replication and avoid the duplication of funding, there is a need to exchange technical data and share project experiences through international cooperation and other global platforms, with the goal of accelerating learnings and gathering cumulative evidence from different projects and regions.

Figure 7.20. Perceived Characteristics of an Innovation

- ***CCS…***
- … has great potential to abate GHG emissions
- … is a legitimate climate change mitigation technology
- … is the only technology to realistically help meet reductions targets
- … is economically feasible and will cut costs in the long term
- … is an essential component in the portfolio of options

Relative Advantage

- ***CCS…***
- … can help meet national ambitions and keep temperatures below "2ºC guard-rail"
- ... storage capacity is sufficient to adequately sequester large volumes of GHGs
- … allows for the continued coal consumption to meet China's growing energy demands
- … fossil-fuel exploitation is essential for domestic energy security
- ... possibilities for low-carbon investment, commercialisation, and market opportunities
- … in the power generation sector is necessary for continued economic development
- … -techno-economic assessments and policy analyses provide deployment scenarios

Compatibility

- ***CCS…***
- …-related key definitions, concepts and norms help others understand
- … models, frameworks and toolkits offers examples of best practice
- … capacity building can resolve managerial, project and financial issues
- … is safe, as risks can be minimized through taking the necessary precautions
- … technical issues can be resolved through training, testing and experimentation
- … uncertainties can be resolved through the sharing of information and experiences

Complexity

- ***CCS…***
- … development requires at least 20 large-scale demonstrations by 2010-2020
- … should be widespread by 2020-2050 in order to make serious mitigation contributions
- … advancement depends on demonstration in emerging and developing economies – particularly China
- … technical data exchange can reduce research replication and the duplication of project funds
- … needs international cooperation and platforms to share knowledge, tools, skills, and expertise

Trial-Ability

- ***CCS…***
- … personal and project experience sharing can reduce stakeholder uncertainties around the technologies and hesitations about cooperation
- … pre-feasibility and FEED studies identify the best possible near-term options
- … -related financial incentives, tax cuts and emissions trading will provide strong messages to investors
- … technical policy, regulatory and IPR certainty can create an enabling environment and attract investment
- … demonstration plants are politically visible signals to transform external perceptions

Observe-Ability

Rogers (2003:16,258-9) defines **Observability** as "the degree to which the results of an innovation are visible to others," with highly visible positive results leading to a greater rate of adoption. The ability to stimulate peer discussions around the innovation also holds an opportunity for interpersonal communications and the sharing of subjective evaluations about the innovation. However, not all innovations are easily observable, or indeed describable. Some innovations may be solely software-based, meaning they are not so easily apparent or visible to potential adopters and can diffuse at a much slower rate. The sharing of personal experiences and project outcomes is seen as a way to reduce stakeholder uncertainties around the technologies and hesitations about cooperation. As seen in Chapter 5, when asked if they had observed demonstrations, tests, or trials of CCS that have been carried out by others, 87 percent of my respondents said "yes," while 13 percent said "no" (Figure 5.51.) and when asked if these left a positive or negative effect, the response again was overwhelmingly positive (Figure 5.52).

In the absence of real demonstrations, international parties would often assist in the development of Chinese pre-feasibility and FEED studies, which would identify the best possible near-term options. Targeting specific partners or industries, these techno-economic analyses and identification of scenarios, this sometimes led to scaled-up demonstration. Although, with financing a major challenge, observable incentives, tax cuts and emissions trading, may provide strong messages to investors. However, as we'd seen with capacity building, there needs to be a firm policy, regulatory, legal and socio-economic foundations to create the enabling environment needed to attract this investment and stimulate the market. Hoped by the EC, a concrete and politically visible large-scale demonstration plant, might have the potential to catalyse change at the national level and to transform external perceptions of China (EC, 2009; Romano, 2010:4-8). It was hoped that this would prepare the ground for more Chinese pilots and demonstrations so that this could be replicated throughout the country, inspiring others.

Summary, Analysis and Conclusion

At the beginning of this chapter, I set out to respond to the call from Bäckstrand *et al.* (2011:277) and Stephens and Liu (2012:146-148) to move beyond communications studies related to public perception and to investigate the multitude of new communication mechanisms within the CCS community. I have done this by delving deeper into the CCS-related soft governance activities to better understand how international parties cooperate, collaborate, and communicate to influence Chinese decision-making processes.

Starting with communications campaigns, we saw that international entities were indeed engaging in interventions with the intention to bring about behavioural change and to produce identifiable outcomes. Covered earlier, within the annexed case studies and the previous chapter, we saw communication campaigns launched by not only change agents but also through sources of information and as part of the diffusion networks. Looking at the roles of these campaigns, we see that utilising the formative research of others was common but that the bringing together of international and Chinese expertise, experience, and resources, through bilateral meetings, symposiums, and workshops, was most common and had the ability to identify objectives and reach consensus on the way forward. All of the communications campaigns identified had quite specific and achievable objectives, with sequential activities such as joint working group action plans, policy assessments, small pilot projects, and road-mapping exercises. These were all centred around the exchange of information and experience sharing towards removing technical uncertainties and policy hesitations and creating the Chinese conditions and confidence for a CCS demonstration. We saw the use of mass media messages as playing a positive and re-energizing role, although it was the bilateral technical assessments, policy reports, and road maps that were considered the most widely-used and impactful. Audience segmentation from the political to the paraprofessional levels allowed for information to be shared and influence to be exerted across various aspects, with a clear longer-term consideration to include both the public and private sectors. Additionally, we also see evidence that this increased contact and communications forged closed interpersonal connections and triggered interpersonal networks that have lasted for some time.

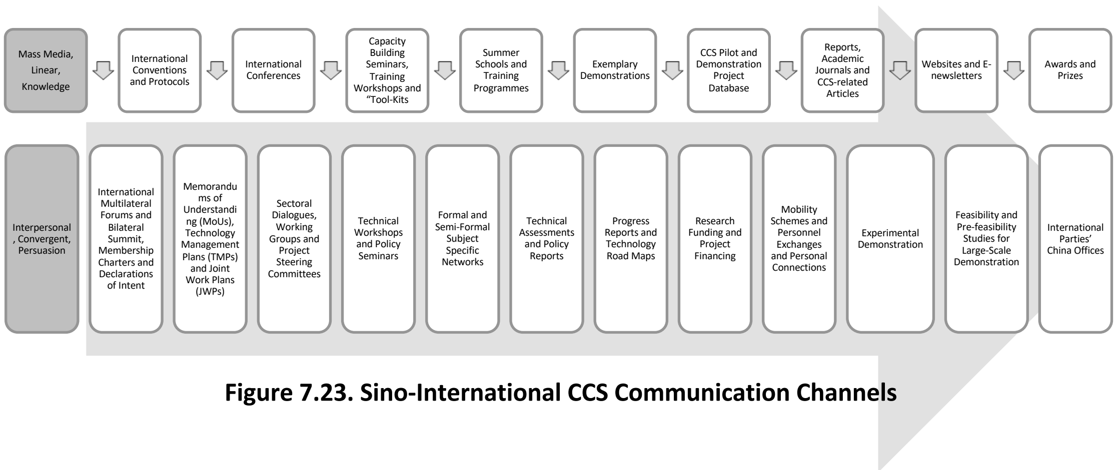


Figure 7.23. Sino-International CCS Communication Channels

We discussed the 205 cosmopolite communication channels, most of which could be attributed to change agency countries and many to communications campaigns. However, we should also recognise that they came from many sectors, demonstrating the diversity of international interactions. Categorising these into two types (Figure 7.23.), the most common form of 'mass media, linear, knowledge' channels was websites and e-newsletters, followed by academic journals, international conferences, and capacity building activities. For 'interpersonal, convergent, persuasive' channels, formal and informal subject-specific networks were by far the most common, with mobility schemes, personnel exchanges, and personal connections also frequently used. Falling into both categories, exemplary demonstrations were most prevalent with Chinese respondents but experimental demonstrations were also quite common. Interestingly, the Chinese interviewees had reported being negatively influenced by media stories around the exemplary demonstrations and not being persuaded by conversations with project developers during on-site visits. Experimental demonstrations were more persuasive.

I won't go into the influence of each individual channel again here, although I can confirm that this is consistent with the views of other scholars. de Coninck and Bäckstrand (2011) had previously recognised the growing diversity, overlap, and fragmentation within the International CCS Community. They had acknowledged that different parties could intervene to provide different soft governance functions at various intervals to suit their intended objectives, which is what we have seen throughout this chapter. Despite believing in the urgent need for such activities, de Coninck (2011) also argues that these decentralised and low-effort actions often lack teeth and result in the most important decisions never being made, which delays CCS advancement. This also confirms the views of Hagemann *et al.* (2011), that the International CCS Community holds a particular interest in China. He notes the focus on setting technical directions, facilitating information exchange, and building networked partnerships, which lack the hard financing and regulatory functions needed to lead towards commercial deployment. I agree with these scholars that there is a prevalence for soft (and an absence of hard) governance activities with China but I disagree that this has not had an impact. As seen through the previous chapter and the case studies, the volume and intensity of interactions and the multiple influences on Chinese decision makers at all levels have clearly had an impact on decision making. Targeted and tailored, these communications hold the potential to foster legitimacy, to gain group consensus more widely, to mobilise the vital resources needed to increase the chances of the technologies' long-term acceptance. To note, we look more closely at the Chinese adoption experiences in the next chapter and bring these two elements together when we look at the rate of adoption in Chapter Ten.

The perceived characteristics of an innovation are clearly important and have an impact on its rate of adoption. Therefore, it is crucial for those who are diffusing CCS to ensure their messages around relative advantage, compatibility, complexity, trialability, and observe-ability are consistent with their objectives. Unfortunately for CCS, its relative advantage was not absolute and its status as a preventative innovation means that some of its advantages would be delayed and its rewards unseen. However, we see the scientific finding of the IPCC create a normative shift around the technologies' legitimacy, placing it higher up on national political and international negotiating agendas (Meadowcroft *et al*., 2009:5-7, Langhelle, 2009:241; Van Alphen, 2011:82; Vergragt, 2009:201, de Coninck *et al.*, 2011:368-376). We also saw the international parties using bilateral activities to better under the compatibility of CCS to China (perhaps to assist in any necessary adjustments to the diffusion approaches) and to identify storylines that demonstrate the rationality of adopting CCS. Meadowcroft (2009:269-274), Coninck *et al.* (2011:373,376-7), and Hansson (2012:77-8) previously addressed the issue of optimistic storylines used by enthusiastic CCS proponents who developed their own CCS-related discourses, although they never looked at their influence on Chinese parties. In Figure 7.20., I laid out what I considered the prominent storylines that emerged from my analysis of the supplementary literature and secondary-source case studies on international entities and the primary-sourced data gathered from my interviews with Chinese parties. My Chinese respondents didn't see CCS as too complex to understand but did consider it slightly more difficult to put into use. However, we have seen great efforts by both diffusion networks and communications campaigns to make the application of CCS as easy as possible. In China, the degree to which my respondents had trialled CCS was high and their experiences were positive. My survey data seemed to suggest that an equally high number had observed positive impressions of CCS trials but my interviewees were far less optimistic about CCS demonstrations.

To conclude, from a theoretical perspective, I sought to understand if CCS communications between international and Chinese parties were primarily one-way/linear, with CCS being diffused as a 'uniform package that is ready for adoption' (as in a centralised diffusion), or two-way/convergent channels, where there is 'the need for re-invention and for possible modification' (as in decentralised diffusion). We saw a rich diversity of both 'mass media, linear, and knowledge' and 'interpersonal, convergent, and persuasive' channels, some of which portrayed CCS as a complete concept that was received passively by Chinese parties and some which were tailored and targeted towards specific Chinese audiences and showed the technologies as needing further advancement. Working side-by-side, mass media messages were key to providing up-to-date information but also played an important role in providing positive information about CCS and a re-energizing role within the Chinese CCS community. However, it was the bilateral meetings, symposiums, and workshops, that were used by the International CCS Community to better understand Chinese needs and reach bilateral consensus on the best way forward. We saw the international community share emerging definitions and understanding of CCS but audience segmentation allowed for a more structured peer-to-peer dialogue around the meaning and purpose of the technologies, while taking account of local conditions and circumstances. From this, I argue the existence of a hybrid model of diffusion, whereby one-way linear channels diffuse CCS as a uniform package than create opportunities for modification and re-invention via two-way convergent communications.

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Chapter Eight: Chinese CCS Community as the 'Less Knowledgeable and Experienced Parties' – Chinese stakeholders as passive acceptors of CCS who create and share information along the domestic development process to reach a mutual understanding of the technologies

We saw from the literature review that CCS presents many opportunities for China, such as the possibility to meet its international obligations by reducing its GHG emissions, and the potential to sustain its economic momentum through enabling continued fossil-fuel consumption, as well as protecting its economic security and maintaining domestic stability (Fan, 2011). However, despite formulating initial policies and launching small-scale projects through special funding and niche subsidies, there have been reports that the Chinese Government's support for CCS is inadequate and inconsistent, and that the technologies have garnered little favour with industry and other actors (Morse *et al.,* 2009). Following Minister Xie Zhenhua's declaration that the country's acceptance of CCS would be conditional on international financing, there were reports of accusations that Chinese parties will only participate in CCS-related activities if all costs are covered (Drahos, 2009). Furthermore, Jaccard and Tu (2011:411) stated that China is "showing enthusiasm but not too much" and that approach has created uncertainty around the country's real appetite for CCS (Wilson, 2011), which has led to frustrations from international partners cooperating with China. Liang and Reiner's (2013) performed earlier surveys of Chinese stakeholders' perceptions and behavioural issues towards CCS but these were primarily quantitative and did not look at the issues in any great depth. This chapter provides a comprehensive qualitative and a more nuanced assessment of China's appetite for CCS and Chinese parties' motivations for engaging with the technologies, as well as the prospects for future domestic demonstration and deployment.

Theoretical Framework

It is important to ask if Chinese parties are relatively passive acceptors of CCS (centralised diffusion) or if they actively participated in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding of the meaning of the technologies (decentralised diffusion). Employing Rogers' theme of the 'less knowledgeable and experienced parties,' and by looking at the Chinese CCS community as a 'social system,' I explore a Chinese CCS 'innovation-development process' and its 'instrumental actions and motivations,' with a hope to look at its potential 'rate of adoption' in the next chapter. Ultimately, I argue the existence of a hybrid diffusion model, whereby Chinese stakeholders as passive acceptors of CCS who create and share information along the domestic innovation-development process to reach a mutual understanding (See Table 8.1).

Research Questions	Conceptual Components	Centralised Diffusion	Decentralised Diffusion	Hybrid Model Of Diffusion
5. What are the motivations and behaviours of the Chinese parties engaging in CCS-related activities and what does this tell us about the current and future domestic development of the technologies? 6. Are Chinese stakeholders relatively passive acceptors of CCS (a centralised system) or do they actively participate in the creation and sharing of CCS-related information with both international parties and amongst themselves in order to reach a mutual understanding around the meaning of the technologies (a decentralised system)?	**Social System** **Innovation-Development Process** **Instrumental Action and Motivations**	Diffused to relatively passive acceptors	Participants create and share information with one another in order to reach a mutual understanding	**Chinese stakeholders as passive acceptors of CCS who create and share information along the domestic development process to reach a mutual understanding**

Table 8.1. International CCS Community as 'More Knowledgeable and Experienced Parties'

Social System, Innovation-Development Process, & Instrumental Actions

Rogers (2003:67,23-4) defines a '**social system**' as a kind of "collective learning system," which may include individuals, informal groups, organisations, and/or subsystems. Each unit is distinguishable from the others and cooperates at least to the extent of seeking to solve a common problem or reach a mutual goal, and these objectives are what bind them together. Additionally, Rogers (2003:19,26-27,147-148,213) tells us that the social system often constitutes the boundary from which the innovation diffuses and that there are a number of key elements, such as the system structure, communication structures, and behavioural patterns, which act as mechanisms that can either facilitate or impede diffusion (Dearing, 2009:4). At some point a decision needs to be made on when and how an innovation is diffused within the social system, with 'gate-keeping' activities often performed to assist in this process (Rogers, 2003:156-157). These parties often sit at the initial stages of the diffusion process, within the 'innovation-development process.'

According to Rogers (2003:139,144), "innovation development occurs as people talk, when information is exchanged about needs and wants and possible technological solutions to them." He describes the 'innovation-development process' as all the decisions, activities, and their impacts, that occur from recognising a need of a problem, researching a solution, the development of those ideas, commercialisation of an innovation, diffusion and adoption of the innovation by users, and the consequences of its adoption. He describes this as the five stages of the 'innovation-development process.' Typically, conventional diffusion investigations have started at the point of first adoption within a social system (diffusion and adoption), although Rogers (2003:136) points out that this often leads to important developments, events, decisions, and actions, throughout the innovation's development being ignored and the significance of this within diffusion and adoption being left unknown. Therefore, this study intends to look at these aspects.

When looking at these earlier stages of innovation development, a useful approach to better understanding the motivations behind CCS development would be to examine its 'instrumental actions' of an innovation. Rogers (2003:139-40) defines this as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome." If we were to make such obvious assumptions, we might say that the application of CCS (the instrumental action) has the potential to abate GHG emissions from fossil fuels and industrial sources (the cause), thus reducing their concentrations in the atmosphere (the effect) and stabilising and mitigating climate change (the desired outcome). However, Rogers (2003:125) advises us to treat such "given definitions or causes of a problem" with caution, asking us to further question 'why' innovations are developed, diffused and adopted. I plan to do that here.

Such purely altruistic primary instrumental actions might place CCS well within the definition of being a 'preventative innovation,' which Rogers (2003:69) defines as "an idea that an individual adopts at one point in time in order to lower the probability that some future unwanted event may occur." The dangers of such a definition would be that the perceived benefits and desired consequences of this type of adoption are both unclear and uncertain, perhaps expected sometime in the distant future, if at all (Rogers, 2003: 176,233). If CCS were to fall under this definition, its relative advantage would be reduced significantly, making motivations for adoption weak and diffusion slow and difficult, perhaps even impossible. In order to avoid such a scenario, it is important to acknowledge this and look for alternative (although complimentary) motivations for CCS development, diffusion and deployment in China. This leads me to explore the motivations of the Chinese CCS Community through the innovation-development process and to discover the instrumental actions various stakeholder groups find for these technologies.

Chinese CCS Innovation-Development Process: Motivations

An important part of the journey to discover what CCS means to Chinese stakeholders is to identify why they see value in working towards its development. Such 'why' questions have seldom been probed effectively by diffusion researchers, as motivations are often difficult to investigate (Rogers, 2003:115-116). In many cases, it might be that "a problem or need may rise to high priority on a system's agenda of social problems through an agenda-setting process" or "scientists may perceive a future problem and launch research to find a solution," or perhaps lead users might "recognise the problem, envisage a solution, create a prototype and in some cases lobby a manufacturer well in advance of market demand" (Rogers, 2003:115-116).

After carefully teasing out this information from Chinese respondents during interviews, I allowed these stakeholders the opportunity to inform me how they individually and collectively define CCS. Looking at CCS as a concept that contains both the hardware and software components, as we discussed in Chapter Three, my key focus was to identify its instrumental functions and to discover why Chinese stakeholders might see value in working towards CCS development. Leveraging one of the main advantages of undertaking this primary-data audience-based investigative approach (as opposed to secondary and/or scholarly literature), we can learn the underlying difficulties encountered by these stakeholders, which sets this study apart from other investigations.

Bordenave's (1976) Motivations for Adoption

Borrowing from Bordenave (1976), Rogers (2003:132) provides four key motivations for the development and diffusion of innovations, which holds greater significance to the Chinese CCS innovation-development process than I had initially anticipated. These are laid out neatly in Table 8.2. and are described in more detail in the following paragraphs.

Development Stage	Theoretical Motivation (Bordenave, 1976)	Opportunity/ Motivation	Challenge/ Difficulty
1. Needs/Problem	Promotion of public welfare	Climate Mitigation	Domestic Priorities
2. Research	Increased production of goods for export	Coal Consumption	Energy Security
3. Development	Maintenance of low prices for urban consumers	Energy Generation	Technological Competition
4. Commercialisation	Increased profits for society's elites and industrialists	Profit Making	Cost and Financing

Table 8.2. Opportunities/Motivations and Challenges/Difficulties

Finding different stakeholders and motivations more prominent at different stages of the innovation-development process this took more of a paralleled (although staggered and integrated) formation than the linear sequence described above. Rogers (2003) did, however, say that all stages do not necessarily happen in an ordered or lineated manner, if at all. One particular issue with such linear assumptions and differing motivations is that this can quite often cause communicative issues along the innovation-development process, which can lead to a stalling in the technologies' advancement. Therefore, based on my analysis and for the purposes of discussion, I have taken the approach to examine the primary motivations at different stages, with reference to the stakeholders involved.

Ultimately, as different parties have different motivations (and challenges) at different stages of the innovation-development process, I loosely used Bordenave's (1976) four key motivations to structure my argument. Although the final three motivations (coal, energy, and profit) may seem contradictory to the idea of CCS as a preventive innovation for "the promotion of public welfare," Rogers (2003: 115-116) tells us that "economic factors are undoubtedly very important for certain types of innovations," which is certainly the case for CCS. In fact, I found that non-altruistic motivations are also instrumental in driving CCS development further along the innovation-development process, although they struggle without the right policies and support, which we will see later. For reasons of clarity, I have outlined my main assumptions in Table 8.2. and Figure 8.3. This should provide the basic narrative structure of the Chinese CCS innovation-development process.

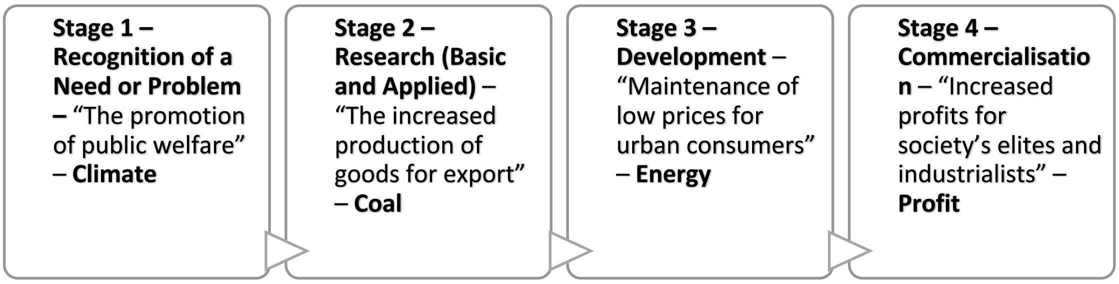

Figure 8.3. Chinese CCS Domestic Innovation-Development Process

The final stages of Rogers' innovation-development process (diffusion and deployment, effects and consequences) are still to be fully considered for CCS within China. Therefore, as CCS is currently only in the early development stages, there has been a lack of significant third sector and/or public engagement with the technologies, meaning their views are not sufficiently represented within this study. The views of these groups may be part of any further research, when CCS progresses beyond commercialisation.

Recognition of a Need/Problem – "The promotion of public welfare" – Climate

According to Rogers (2003: 137), "often the impetus for the development of an innovation comes from the recognition of a problem or the realisation of a need, which then stimulates the research and development activities designed to create an innovative solution." He states that such recognition "may arise through scientific exploration or anticipation of a potential future problem, as well as the approaching or current priority needs faced by a social system." Therefore, it was important to recognise the problems or needs faced by Chinese parties, to ask why they seek CCS as a solution, and to identify what this means for the prospects of CCS advancement within China.

Increase in Environmental and Climate Awareness

We have already been subconsciously looking at CCS through the lens of "the promotion of public welfare," so it should come as no surprise that the most common function mentioned by Chinese stakeholders was the abatement of GHG emissions and climate change mitigation. This was even the case for those who don't believe in anthropogenic climate change or see CCS as having more utilitarian and less altruistic purposes. Commonly agreed that there has been an increase in environmental and climate awareness in recent years, such issues have not only become socially popularised but in some cases even patriotic issues in China, thus leading the government and industry to pay more attention to such problems and to proactively seek solutions (G02;A07;I13;A19;A20;A28;A30;A32).

Rise of CO_2 Emissions and the Government's Response

As environmental problems and issues of air quality are already very visible in China, alarm bells sounded loudly in June 2007, when there were reports of China's CO_2 emissions overtaking those of the US. Now the largest global gross emitter, this again prompted the Government and industry to take action (G02;A03;R09;A28;A32). Later that same month, the Chinese MOST released the "Scientific and Technological Actions on Climate Change (2007-2020)," which aims to coordinate and enhance climate change-related scientific research, technological development and capacity. This document referred to CCS as "one of the key tasks in the development of GHG control technologies in China" (MOST, 2011). At the same time, NDRC issued "China's National Climate Change Programme." Whether or not the unexpected overtaking of US emissions and the publications of these two important documents, in the same month, have any direct relationship cannot be fully determined. However, the fact that two key institutions in the development of CCS in China actively responded to climate issues around this time may provide us with a preliminary starting point for the Chinese CCS innovation-decision process. We saw this concern around China's emissions again in 2011, with projected increases of 100 percent within the next 50 years (Fan, 2011; Wilson, 2011; Morse *et al.,* 2009).

International Obligations and Domestic Priorities

Such actions and reactions sound both optimistic for climate change and positive for CCS, however, seldom are such stories of environmental protection so simple and straightforward. Although it is true that environmental awareness had grown considerably in China in recent years, it became clear from the Chinese interviewees that they see CO_2 emissions and climate issues as distant international problems, having little immediate impact on their daily life or livelihood (R01;A03;I05;R23). Other industrial pollutions, such as Nitrogen Oxides (NO_X), Sulphur Dioxide (SO_2), and Particulate Matter (PM^{10} and $PM^{2.5}$) were considered more of an urgent problem, particularly as they are more visible through haze or smog and are deemed more immediately harmful to human health, not to mention having a greater threat to national political, economic and social security (G02;A07;R23;R24;R35;A38). Such thoughts are compounded with stakeholders believing that, as a developing country, China has much more pressing domestic issues, such as improving the domestic economy and raising the national living standards, which should be given first priority. Even with the historic emissions of industrialised countries and in the interests of development equality, some believed this approach to be justified (R01;A07;R24;G27;A30;R35). This is not to say that CO_2 is ignored completely, just that efforts towards CO_2 technological abatement is considered “not an issue of high priority” (R16) and more of a long-term “logical next step” (A32) in China’s pollution-control strategy, one which will cost more due to the sheer volume of CO_2 and the key energy and resources industries that it impacts (R01;G02;R16;A17;A32;A38).

Political Pressures and Environmental Limits

For CO_2 emissions reductions and climate change issues in China, CCS-related stakeholders consider these issues to be “not that urgent” (G02) and “not yet considered a domestic emergency” (R35). Crucially, this sense of lack of emergency and urgency does not come down from the environmental pressures of CO_2 emissions itself or even international pressure on China for reductions but on the Government’s portrayed attitude towards the issue. One government stakeholder believes that “if the pressure for the CO_2 reduction [is] not that high, it can be [an] option but if the CO_2 reduction pressure is very high, you have to do CCS” (G02), so we can then assume that the future of CCS is thus inextricably linked to domestic pressures and internal perceptions of urgency. Another said, at the moment “for the Government, for [the] administration, they don't think CCS is such [an] urgent technology to develop” (A17).

Although there seems to be some domestic political pressures to reduce emissions, there is also a somewhat tenuous scientific argument that “there is still a lot of space for carbon dioxide to reach the two degrees” needed for climate stability. Therefore, it is thought that there is still time and scope for government, industry and other stakeholders to try other abatement and mitigation options before CCS, such as energy efficiency and energy switching, which have the added bonus of creating “new values and are also better for the other prospects for the environment” (R04). Such arguments demonstrate the attitude of Chinese stakeholders towards China’s emissions strategies, focusing primarily on more conventional low-carbon technologies in the short-term, while keeping a close eye on the status of national CO_2 emissions limits and the prospects of CCS in the long-term (G02;A26;R35). The problem with such a long-term outlook is that many anticipate CO_2 emissions to continue to rise, possibly peaking at 2030, with CCS application a possibility closer to that date (R04;A11;R22).

Perceptions of Urgency and the Emergency Response

The problem with such stakeholder perceptions is that this relegates CCS development to the end of a long list of priorities, puts it in last place in the competition with other low-carbon options and, due to its ability to reduce large-amounts of CO_2 emissions at relative speed, defines it as the “emergency response” in the tool box for climate mitigation (R04;A07;A19;R20;R23). The problem with this classification is that it once again places climate issues and CCS as distant objectives and abstract ideas, showing the need for both the problem and solution to be brought to the forefront in stakeholders’ minds. One way of achieving this would be to link them both to immediate domestic problems, such as fuel consumption and energy production and to demonstrate how they can be part of the solution today, pointing out that no matter what stage of development or industrialisation a country is at, tackling these issues head-on is part of a comprehensive development strategy (G02;A11;G12;R14;R22).

Research – “The increased production of goods for export” – Coal

According to Rogers (2003:140), basic (fundamental) research can be defined as “original investigations for the advancement of scientific knowledge and that do not have a specific objective of applying this knowledge to practical problems.” Conversely, applied research “consists of scientific investigations that are intended to solve practical problems.” Given that applied researchers are the main users of basic research, there is usually an “interplay between scientific methods and practical problems,” which often results in the development of an innovation for specific purposes. Recognising that CCS can be considered an international import, with early motivations triggered by enhanced climate awareness and increases in domestic CO_2 emissions, it is safe to assume that most CCS-related research has been applied to resolve these problems. Not taking this for granted, we should ask what problems Chinese researchers have been responding to, and why.

Coal Consumption, Energy Security and Economic Development

Going back to what Rogers (2003:137) said about scientists “perceiving a future problem and launching research to find a solution” […] “which can then become a high priority on a system’s agenda of social problems through an agenda-setting process,” this seems to have been the case in China. Playing a key role of advising on issues of national and international importance, the research and academic communities, particularly institutes of the CAS, continue to play an important role in alerting government departments and SOEs to critical issues that affect both domestic industrial and economic development (R01;R04;R06;A11;R16;G27). We know that the increase in CO_2 emissions has already been on the radar since the turn of the century but now the issue of China’s domestic coal consumption began to cause serious concern, particularly due to its links with CO_2 emissions, national energy security and continued economic development. As these two communities sought to better understand the current situation, they set out to identify potential solutions and provide scientific and policy advice, whilst also supporting collaborative projects on a technical basis (G02;R04;R06;A17;A21;R22;I40).

China is highly dependent on domestic coal as an essential part of its energy structure and its economic development relies on the "almost 100 percent of traditional coal-fired power plants" to produce energy to power industries. This means there was a common expectation that vast amounts of CO_2 emissions are inevitable, at least until 2025 or 2030 (G02;A03;R04;I05;A11;A17). If tighter restrictions on CO_2 emissions are implemented, this is seen to affect the future production of energy from coal-fired power plants and the overall availability of power generated domestically, which would undoubtedly impact national economic development and security (R22;R23). This was a harrowing thought to all Chinese stakeholder groups interviewed, particularly those within government and industry. Following the emergence of knowledge about the potential of CCS in China, excitement grew that "if climate change is real, then CCS would be the only way that China can continue to use coal in a secure and sustainable way" (R01) and that it would be "the ultimate solution for keeping using coal" to "balance this kind of problem" (A21). While one looked at it optimistically saying "coal has the future, so CCS has a bright future" (R24), others went so far to say that "our energy mix is coal dominated, so CCS is necessary... we have to adopt" (A17) and "if we want to use coal, use fossil fuels, CO_2 is the main greenhouse gas for global warming, so we have to use CCS, no choice" (G02).

Not everyone seen CCS as the ultimate solution, claiming that China was entering a "new normal economic state," where CO_2 emissions and coal consumption had already begun to decouple and decrease and that other cleaner low-carbon technologies and renewable energy sources had already started to play a greater role, which might cancel out any potential need for CCS before 2025 or 2030 (A11). However, it was generally assumed that it may take longer than 2030, perhaps even 2050, for China to shake-off its dependency on low-cost fossil fuels, making future levels of high CO_2 emissions a certainty and CCS in the long-term much more likely (R01;A03;I05;R06;R16;A17). While reflective of the sudden changes of the status and importance of these technologies in China, we can see that when discussing CCS as a tool for CO_2 reductions and climate mitigation, it is seen collectively as a preventive innovation with uncertain prospects. However, when aligned with the issues of national importance and domestic security, the same technologies become desirable, if not imminently necessary. Curiously, both opposing views were often held by the same interviewees.

CCS Opposition & Pessimism

Opinions within government and industry were already warming towards CCS, now that it was seen as a technical solution to some quite important issues of national interests. Besides those already working on CCS, the reception within the research and academic communities was frosty, to say the least. In the early years, when approaching potential bodies to support CCS research, some within the research and academic communities were met with comments such as "this is useless," "this is impossible," and "why do you do this, this is nothing," which undoubted affected access to funding and other important resources, thus significantly limiting possibilities for early CCS-related research (R06;A07;R09;A19;R35). The reasons for some of these negative remarks was that some others were either opposed to the idea of anthropogenic climate change or supported other, cleaner, low-carbon mitigation efforts or renewable energy sources. Such voices have been quite vocal about the issue, even at CCS-related conferences and meetings (A03;R06;A07;I10;A11;I13;R20;A30;A32;R36). Although legitimate opposition can act as constructive criticism for the continued improvement and advancement of any field, at the project application and assessment level a number of stakeholders reported unjustified critique, with peers asking 'why' they would investigate such research, as opposed to 'how' they investigate. Feeling that they spend more time debating the value of CCS to often unsympathetic and/or unknowledgeable assessors, as opposed to the value and progress of their research and projects, this is without a doubt a hindrance to CCS development within research, as well as nationally (R06;R09;R35).

One important source of support for new research directions and technologies in China comes from the Chinese academicians within the CAS and the Chinese Academy of Engineering (CAE). Such respected high-level individuals (and their institutions) possess significant influence with government and industry, as well as within the research and academic communities. Given that the support from these individuals holds the potential to either facilitate or impede CCS-related research, quite a few interviewees mentioned that a number have been quite strongly opposed to CCS, with one researcher saying they "can cause many problems for us," requiring them to seek support from other prominent figures, while also suggesting that they "can misled the Government" away from the potential possibilities of CCS development (R01;R04;R09;A11;A17;A32;R35). This appears to be determined by the discipline of the academicians and their attitude towards anthropogenic climate change, as well as the prospects of CCS being the technological response. Other researchers reported having relative freedom within CAS to study what they wanted, although admittedly they were at more senior levels (R09;R35). Such lack of institutional or departmental support has far reaching consequences for the individual researcher or academic. As professional prospects and potential opportunities are often linked to official or institutional research priorities, if research is not in-line with pre-determined plans this may affect their internal assessment, jeopardising their short-term opportunities for promotion and potentially their career in the long-term. The problem with CCS-related research is that in the majority of institutes it currently ranks within the last category of importance for research directions (R01;R04;A11;A21;A28;R35). So why has there been so much CCS-related activity in Chinese research and academic circles?

CCS Opportunities & Positivism

As touched upon earlier, along with the growth of concern over key strategic issues, various stakeholders in all sectors began to organise conferences, seminars and workshops, in order to learn more (and spread their ideas) about CCS. Inviting key national, as well as international, stakeholders from different fields and industries, they were able to ask questions and provide answers that would form and create opinions on the prospects of CCS within China (A21;A39). Admittedly, the level of awareness at these early events was quite low, meaning that few people in China had a truly comprehensive knowledge of CCS technologies, its potential and the possible consequences of its application (A21;R24). It was events like these that are believed to have contributed to the inclusion of CCS to the *National Medium and Long-Term Program for Science and Technology Development (2006-2020)*. Issued one year before the *Scientific and Technological Actions on Climate Change (2007-2020)* and *China's National Climate Change Programme*, this is believed to have been one of the earliest mentions of CCS in an official Chinese Governmental document (A11;A21). However, although playing a part in placing CCS within the Chinese research "agenda setting process," these activities were also influential in "setting the agenda" within CCS research itself. These early meetings were partly responsible for not only the hype around CCS but also the opportunities that might come from involvement in this new research direction (R09;A19;R24;A31;A32;A39).

According to my Chinese interviewees, CCS quickly became the "hot topic" in research and academic circles and this new field attracted both welcome and unwelcome attention (R01;A03;A07;I13;A19;G27;A32;R35;A38;A39). Influenced by a host of aspects, Chinese researchers and academics began to explore their own position and the possibilities within this new research area, while also introducing the concept to their colleagues and graduate students in the form of CCS-related research clusters, many of which would not have otherwise existed and many of these went parties on to excel in CCS research and activities (R01;A03;R09;R20;A28;R35). With the absence of formal undergraduate taught courses and only a few informal lectures, CCS research nevertheless appears to remain firmly at the graduate research level and at the discretion (or demand) of supervisors. As discussed earlier, many of these supervisors were educated or worked for considerable periods abroad (in the UK, Canada, Norway, Japan and US), later returning to China to share the concept of CCS (R01;A03;R04;A17;A19;A26;A28;A32;R35;R36;A38;A28). This was the beginning of the formation of the Chinese CCS community, or to put it more theoretically, the CCS innovation's social system (A03;R06;R09;G12;A28;A39;I40).

Of the Chinese interviewees, some continue to work within CCS-related fields, and some have already moved to other areas and interests. There seemed to be additional motivations within research and academia communities, other than Bordenave's (1976) "the promotion of public welfare" and "the increased production of goods for export." Although there was still attention given to the aforementioned key strategic issues, there was also considerable interest in new funding opportunities that might be available through the rise in CCS importance. There were often pressures on researchers and academics to self-source funding for their individual projects, so there was (what was described as) a migration towards CCS research. There are claims (and in some cases self-confessions) that the funding received was not always used primarily for CCS projects (if at all) and such trends had repercussions of the overcrowding of the research space and creating greater competition for the already scarce resources (A07;G27;A30;R35;I40). This increase in researchers and academics working on CCS might seem like a positive development, however, stakeholders expressed that not all resources were being used effectively or efficiently, when compared to other more established research areas (R35).

Funding was not the only individualistic motivation for those becoming interested in CCS. Besides the possibilities for increased foreign engagement in this new and international field, many stakeholders were attracted by opportunities to have closer contact with government officials and potential collaborations with industry partners. Such interactions might improve their reputation or standing within the professional communities, which some also believed it may even provide personal "fame" in their fields, thus demonstrating status-seeking behaviours. Other advantages emerged, within what some seen as an already over-saturated research field, such as the possibility of academic publications within this new novel research area (I05;R06;A07;R09;A11;A19;R20;A21;R24).

Realising the Realities of CCS

Following the flurry of domestic research interest between 2004 and 2012, most of the Chinese CCS-related feasibility and scoping studies have already been undertaken, ranging from geological evaluations, CO_2 storage potential, EOR suitability, CO_2 source investigations, CO_2 separation studies and reservoir reaction studies, as well as transportation work and others (R06;A19;R23;A39). Many stakeholders mentioned the first call of support was often the National Basic Research Program of China (Program 973) and the National Natural Science Foundation of China (NSFC) (R06;R09;R20;A30;A31;A32) and this primarily remains an avenue for basic (usually desktop or lab-based) research of any variety, as long as it is significant to China's national interests. Although not CCS specific, this means CCS-related research often unsuccessfully battles for recognition and resources against other research fields and technologies with greater perceived importance (A11;R20;R24;A30), as well as other individuals or institutions in higher positions or with greater personal contacts (A03;R35). Additionally, there is the perception, and based on previously-supported projects, that the 973 Program funding projects have prioritised support for CCS-related EOR projects (A19), particularly those based in Northern China, thus deterring some from applying (R24). In some cases, such competition is often provided first to key institutions with established reputations, who have significant achievements and long-standing ties. Further support to less engaged stakeholders (who also have great potential) could also be encouraged, with greater clarity and transparency of the research funding system (and recipient reporting) mechanisms (A03;R35).

Success in smaller basic research projects provides a "good basis" for larger amounts of funding for CCS projects available through the National High-Technology Research and Development Plan (863 Programme) (A03;A32). Since the mid-2000s there have been groups of academics who hoped to launch CCS projects through the 863 Programme by inviting potential experts and professors from various companies and universities together, some of whom had no previous experience of CCS. This showed the beginning of CCS moving from the relatively small basic research laboratory phase to the larger, more challenging pilot and demonstration phase, as well as the realisation of the technical difficulties of scaling up and the costs associated with such moves (R24;A32;A33). However, even today, some consider funding through this program to be somewhat underdeveloped and unavailable (A11). For this reason, many within research and academia felt that while small-scale research is encouraged and given support, other larger projects proposals do not receive the support they might deserve (R04;I05;R06;A07;R09;I10;G12;I13;R14;I18; A19;R24;A31;R35).

Administrative Centre for China's Agenda 21 (ACCA21)

One key institution mentioned by most Chinese stakeholders within the research stage was MOST's ACCA21. Holding the opinion that "without ACCA21, CCS won't get much support in China" (G02), interviewees believed that it's up to the Government to fill the void and support the research and demonstration of these technologies internally (R35). As a relatively influential body, ACCA21 plays an important role and has multiple influential functions. Firstly, following international trends in science and technology (G02;R04;I18;G27), ACCA21 has been involved in providing input for the drafting and implementation of government plans and programmes, for which part of its involvement in CCS arises (G02;A21). Secondly, by assisting with the inclusion of CCS technologies within China's national "Five Year Plans," and through "publishing their priority fields, CCS sometimes becomes the top priority" (A21), this has again helped to promote and set the domestic CCS-related research agenda and the programme for national-level activities (R04;I05;R09;A11;A21;A31;R35). Thirdly, at a functional level, ACCA21 plays an important part in attracting new and organising older stakeholders (R09;R35), often acting as a liaison between stakeholders within and between different sectors and helping to design and coordinate project teams, while not directly involved in project execution itself (G02). Fourthly, importantly, while one of its main functions is to support and provide assistance on project and funding applications, ACCA21 does not provide any funding itself (G02;A07;R09;A11;I18;A32;R35;A39). Finally, ACCA21 works continually on domestic CCS knowledge sharing and capacity building through conferences, seminars, workshops and training activities to raise the knowledge level of Chinese stakeholders and to share recent developments of international and national importance (G02;R09).

At the same time, ACCA21's capabilities are not boundless. Its main CCS-related objective is to support the R&D stages of the technologies, so influence diminishes as CCS moves towards the commercialisation stage (A11;R24). Much less powerful than NDRC (I18;R35), it is reported to have difficulties coordinating differing stakeholder interests and opinions and is limited to simple mediation to resolve issues between project partners, particularly with and between industrial partners, even if they are government funded projects (A07;I18;R24). ACCA21 has played (and continues to play) an influential role in the establishment and coordination of a recently-created Chinese CCS Alliance, as a possible solution to this problem and providing all stakeholders an opportunity to resolve issues which might arise within partnerships and projects.

Technology Transfer and Systematic Research Failures

In the previous paragraphs we touched upon problems between CCS stakeholders in academia and industry, as well as industrial partnerships. As we talk more about industrial partnerships in the next stage (development), at this point we should discuss the relationship between academia and industry and the progression of CCS from the research stage to development. Rogers (2003:150-152) describes technology transfer as "the application of information to use" whereby "results of basic and applied research are put into use by receptors." Often implied that this is a one-way process of technological hardware transfer from institutes and universities to companies, in reality it is more of a two-way back-and-forth communicative process between researchers and academics and industrial developers, which jointly creates a meaning around the technology. Rogers (2003:150-152) notes three primary levels of technology transfer, with considerable effort needed at each stage to ensure that the transfer occurs effectively and does not fail. Similar to the innovation-decision process (discussed later), these are: knowledge, use, and commercialisation. Without the inclusion of "interpersonal communication exchanges about the technology over an extended period of time," it is unlikely that the technologies will be transferred successfully. For this reason, we should avoid any notion of a completely linear method of one-way communication for innovation development. This we have seen in earlier chapters and will discuss again later.

Although the area of technology transfer is an investigation in itself, some of what Rogers has said strikes a chord with the views provided by some Chinese CCS stakeholders, so I feel I should at least address this partially here. There have been many examples of successful relationships and partnerships between Chinese researchers and academics in the research, development and commercialisation of technological innovations, some of which are closely related to CCS (A28;A29). However, a number of Chinese stakeholders raised concerns about how systematic failures, inadequacies and inefficiencies within the Chinese R&D processes might be affecting the move of CCS from the research stage to development and eventually to commercialisation. Referring to a lack of communication fluidity between R&D stakeholders and little natural progression through these stages, the potential for continuous discovery, experimentation and improvement of CCS science and technologies may be compromised.

Not only having misunderstandings of the meanings behind the technologies, there is often a certain degree of animosity between partners, which have serious implications for the projects and innovations being developed. Academic partners often sought theoretical answers and concrete scientific findings, while industrial partners appeared to value the readiness of commercial opportunities and quick financial returns, often cutting corners on what they deem as unnecessary actions or additional costs with a goal to maximise profits (A07). The large degree of connectivity between Government and SOEs means the current systems of professional promotions and rewards based on producing results suggest that industrial partners have greater political and economic pressures to perform. Some attributed this to China's difficult shift from applied economics to a more market-based economy, thus perhaps favouring quick results over a more holistic development, which is an area that may deserve further investigation (A07;A31;R35).

CCS Research Stagnation or Stabilisation

Through the conferences and research activities that have taken place between 2005 and 2012, the knowledge base of Chinese CCS-related stakeholders has improved significantly, which has only contributed to their increased understanding of the challenges of applying CCS to Chinese circumstances (R04;A11;A19;A21;A27;A30;A39;I40). Although this could be interpreted as a cooling-off of an already frenzied research area or indeed a loss of interest in these technologies by the Chinese stakeholder groups, it has been described more as a "period of stability," whereby stakeholders can again take stock and discuss what has been achieved and what the future research directions might be (R06;A17;A39). As many stakeholders have either temporarily or permanently left the CCS research field, this period has further solidified the Chinese CCS community, which continues to optimistically promote CCS research nationally (R22;R24;I40). However, many were still reeling from opposition in the early days and having already invested considerable personal and professional time, effort and resources into CCS development, there are some who feel that this once promising research direction has diverted their potential and caused them to lose out on important professional opportunities in their career.

Many are continually pondering a return to more conventional research areas, which don't limit their long-term potential, especially considering the medium-term expectations and possible long-term rewards from potential CCS commercialization. This also has the potential to deter more experienced professionals from continuing to invest time and energy in CCS research without gaining immediate results, like those offered in many other research fields (R01;R06;A07;A21;R35). Although much has been learned from the experiences of the previous few years, a significant amount of money and resources has been spent with little financial return, which was a cause for considerable concern. Given many of the CCS-related engineering, logistical and geological issues were already better understood, the direction of how to move to the next stages of CCS development is of critical importance, if the technologies and their supporters are to survive. One ray of hope is that following the successes of national feasibility studies, researchers and academics appear to have turned their attention to regional investigations of the potential for CCS at the provincial and local level (R22;R23;R24).

Next Steps: Energy Systems Modelling Research

Gaining a better idea of the contributions CCS can make to China's emissions reductions and energy strategies, recent research has moved to modelling China's optimal combinations of CO_2 abatement options, low-carbon technologies, and clean energy sources, leading to 2030, 2050 and beyond. There was a "need to know, to some certainty, what will happen with the cost of every energy area, every energy source" (A11), so Chinese stakeholders were investigating what might constitute China's energy mix in the coming decades, including the outputs of every technology, the emissions produced or negated, as well as the associated costs. Having to factor in great uncertainty, findings can only provide hypothetical answers in the short-term without a real understanding of the influence of external factors and the long-term potential. Additionally, much of these types of investigations depend on the good will of other stakeholders to share complete and accurate sets of often sensitive data to enable realistic results. Only when all likely scenarios have been fully investigated might China be in a position to make an informed decision regarding CCS (A07;I13;R16;I18;R20;A21;I37). However, such research does have the positive application of acting like simulations which feed into government policy and industry business plans on short-medium term technology development. There are fears that as time moves quickly and progress towards CCS stalls, opportunities are being missed, with targets continually being pushed backwards and deadlines forever made later (R09;A11;R16;I18;R22). This is consistent with the fears from de Conick (2011) mentioned in the previous chapter, where she argues that such decentralised soft-governance functions and low-effort actions often lack teeth and result in the most important decisions never being made.

Development – "Maintenance of low prices for urban consumers" – Energy

Rogers (2003:141-6) sees the development stage as "the process of putting a new idea in a form that is expected to meet the needs of an audience of potential adopters," with "lead users" often taking the first steps in this process. Often difficult to separate research from development, I do so in this stage by looking primarily at the development of CCS within China's SOEs, whose activities occupy almost all of China's industrialised CCS activity. One further distinction is to primarily looking at development of CCS through the pilot studies and demonstrations of the technologies in the field, as opposed to desk-top or laboratory-based experiments, which was the focus of the previous stage.

Normally important at the diffusion stage of the process, trials and demonstrations for Rogers (2003:157, 389-90) have "the primary goal" of "effective evaluation and advancement of knowledge about the innovation." Through a display of the effectiveness of the innovation under field conditions, all stakeholders (both developers and adopters) are able to observe the credibility, competence and safety of the innovation under "real life" conditions, thus aiding in their evaluation and quickening the rate of development, diffusion and adoption. Firstly, we should ask what interest industrial stakeholders have in developing and demonstrating CCS?

Policy and Regulatory Anticipation leading to Technological Readiness

Some Chinese interviewees from industry spoke of their need to fulfil increasing social and environmental obligations and expectations, as well as protecting their corporate image (I10;I13;I37;I40). There was also increased anticipation of impending government policy and regulation on industry's contributions to national CO_2 emissions reductions and global climate mitigation, with signs from high-level politicians and senior engineers and experts that indicating that such measures had been on the horizon since the late 1990s. Due to a greater understanding of the links between atmospheric CO_2 and climate change, industries and enterprises began to look for ways to mitigate such adverse effect from their business interests. Large SOEs, such as the Shenhua and Huaneng Groups, are still heavily dependent on the production and consumption of large amounts of CO_2 producing coal. Therefore, it was only with good business acumen that they took early signals seriously and began to seek ways to move towards cleaner, more low-carbon and competitive business models (I05;A11;I13;R20;A32;A33;I37;I40).

CCS provides the dual functionality of reducing CO_2 emissions in the atmosphere and permitting a continuation of using China's cheap and relatively abundant coal resources, so the technologies became one possible solution to everyone's problems. Acknowledging uncertainty surrounding the Chinese Government's plans to introduce policies and regulations, eventually imposing restrictions on coal consumption, fossil fuel power generation, and/or CO_2 emissions (or all three), these industries set about exploring the possibilities of CCS as a technical solution to their needs in an effort of technological readiness (R04;I05;A11;I13;I18;A26). Additionally, state-owned engineering companies with their eyes on future potential opportunities, see a correlation with other industrial processes, such as coal-liquid gasification, and began to work with other SOEs on CCS-related projects for technological development (I37). At this point, there was general interest in the functions of CCS, not only for climate reasons but wider opportunities.

As Rogers (2003:389-90) states that the primary goal of demonstration is the "effective evaluation and advancement of knowledge about the innovation," we should then consider what aspects of CCS need to be evaluated and known, and why. The main issues identified by stakeholders include the energy penalty (on the CO_2 capture side), leakage and safety (on the CO_2 storage), and governance and stakeholder management, as well as the CO_2 classification, utilisation and transformation (on the policy and regulatory side). Firstly, it is only appropriate to provide an overview into the achievements and merits, as well as outlining difficulties and challenges of developing and demonstrating CCS in China at this stage.

Achievements, Merits, Difficulties, and Challenges, of Demonstrating CCS in China

Providing many advantages to technological development and industrial projects, there is great scope for both CCS demonstration and the technologies' potential deployment within China. This was due to Government interest, reduced costs, and a history of successful engineering, construction and infrastructure feats, not to mention the large number of CO_2 point sources, volumes of emissions, and varied geologies and vast landmass (R06;I13;I34;A39). There were ten CCS-related projects launched under China's *Eleventh Five Year Plan (2006-2010)*, doubling to twenty for the *Twelfth Five Year Plan (2011-2015)*, with additional plans within the *Thirteenth Five Year Plan (2016-2020)*, so significant progress had already been made in a short space of time (G02). On the capture side, China's Huaneng Group had pilots at the Beijing Gaobeidian Plant and the Shanghai Shidongkou Plant, with continuing plans for the IGCC+CCS demonstration at GreenGen in Tianjin and for a project in Yuhuan, Zhejiang Province. On the storage side, the Shenhua Group has a project in Ordos, Inner Mongolia, with Sinopec at Shengli Oilfields, Shandong Province, and PetroChina in Jilin Oilfields and the Shaanxi Yanchang Petroleum Group recently working toward their own full-chain CCS project (R01;R06;A11). At the same time, there have been criticisms that many projects demonstrate existing technologies, duplicate the research objectives of others, and are perhaps mere "pride projects" (R35), "star projects" (A07) or "half show technical study" (A17). Some disagree and say that all projects are vital and valued (I13;R22;I37), and that duplication may again come down to different funding streams or as a result of China's reported systematic research inefficiencies (A17;R24;A32). Regardless, while all are considered positive additions to the development of CCS in China, each of these pilot and demonstration projects face common challenges (which I must point out are not specific to the Chinese situation), which hinder the progress of CCS advancement nationally.

The first of these challenges is that currently CCS demonstration projects are much too small (A11) and need to be scaled up. For example, the Beijing Gaobeidian plant captured only 3000 tonnes of CO_2 per annum (tpa), the Shidongkou plant captured only 100,000-120,000 tpa, and the GreenGen project was expected to capture over one million tpa. Unfortunately, the plans for GreenGen were shelved in 2012 and work returned to the laboratory stage, primarily due to fears of the energy penalty involved and a lack of policy support (I05;I18). By "returning to the drawing board," this could perhaps be attributed to a greater understanding by SOEs of the costs associated with demonstration (R01) and industry's desire for quick returns (A32;I34). It was recognized that there was a need for a "new motivation" (G12) towards CCS development in China, leading to the publication of the *Notice of National Development and Reform Commission (NDRC) on Promoting Carbon Capture, Utilisation and Storage Pilot and Demonstration*. Issued in 2013, this was a display of government commitment to CCS demonstration, in an attempt to reaffirm industrial support towards the technologies. The reality of the situation, however, is that with huge sums needed for large-scale integrated, commercially viable, demonstration projects, SOEs were content with spending just millions not billions of Chinese Renminbi (RMB) needed and looked to the Government to foot the bill (I05).

Although some believe that many smaller pilot and demonstration projects might have a better effect on CCS development (A11), Rogers' (2003:16) ideas on the divisibility (or partial trialling) of an innovation, with the ultimate goal of full adoption, might be a solution in the short-term. Some noted the potential that through demonstration the total costs of CCS would be likely to come down in the medium-long term, although this was not enough to convince stakeholders to invest at that time (A11;I34). There is, however, speculation that the Chinese Government is exploring the option to provide some kind of "green funding," which may include CCS, but this is still uncertain (R16). Acknowledging that the scaling up of CCS projects remains challenging and uncertain (A11;G12;I13), there is an urgent need for large-scale and fully-integrated CCS demonstration projects in China to allow at least five to ten years for projects to mature and develop (A11;R16;A21) . This would provide a real understanding and accuracy of the capabilities, costs and safety aspects of CCS technologies in China (R16). As a "very clear roadmap for the future" (A11), the "Chinese CCS Road Map" originally estimated three or four fully-integrated, commercial-sized demonstration projects by 2020. While such ambitions were unrealistic (A11), some attribute this to a lack of supporting government policies (I05).

The CCS Energy Penalty

Gaining increased knowledge of the energy penalty associated with the operation of CCS capture installations (estimated to be anywhere between 10-30 percent of the power being generated by some facilities), some Chinese stakeholders now see this as "unacceptable" (R01;A17) and CCS as "not a real option" (G12). Considering "energy more important than money" (A39), China's energy consumption was already rising sharply year-on-year and was not expected to peak until at least 2030, meaning such realisations did little to ease the already unsettling worries of national energy security and domestic economic development (I13;R16). Losing its competitive advantage of allowing continued coal consumption (R22), CCS then became primarily a CO_2 abatement technology, producing no energy by-product of its own (R16;I18;I34;A39), reducing its attractiveness.

Although such circumstances are considered "unavoidable" (A33), CCS again found itself as the least attractive option than other low-carbon technologies that can also ease China's energy supply pressures. However, some experts believe there are technical solutions to this problem and that additional research and demonstration can achieve technological efficiencies. Additionally, the current focus on CO_2 utilisation showed there is a potential to not only reduce the energy penalty and associated costs but to also assist in producing additional energy (R01;R14). Others argue against such optimism, saying that any technical improvements that can be made will be negligible and achieved over a long period of time, thus falsifying such claims (I37). Interestingly, in a hope to justify the application of CCS technologies, one stakeholder likened the energy penalty to the electricity use for water treatment plants pollution control (G12), however the disparities of energy quantities and pollution volumes make this argument unjustified.

CO_2 Storage, Risk, Leakage and Safety

There is often a moral argument for not storing CO_2 in geological formations but few Chinese interviewees mentioned such issues. Admittedly, this is probably due to most interviewees coming from related fields, such as engineering and geology, where CCS was less an anomaly. There also seemed to be a lack of interest or involvement of domestic NGOs, perhaps due to their alignment with international NGOs who appear to support CCS, as well as the myriad of other environmental issues they deal with (A17;A30). Most interviewees, even those who disputed anthropogenic climate change, saw the value of scientific knowledge and technical capabilities for the geological storage of CO_2 as positive. They believed that if CO_2 is to be stored, then deep saline aquifers, disused coal beds, and oil fields, are perhaps the most suitable locations (I05;I13;R20;R24). However, although most completely support CO_2 capture and storage research without question, they showed concern about the consequences of actually storing CO_2 underground and the risks it might bring (R06;I13;R14;R16;R20;A21;R36).

Most Chinese interviewees were both personally and professionally comfortable with the concept of CO_2 sequestration, although many noted that the main difficulties in this regard were to appease the fears of what they described as irrational or informed parties who worry about leakage (A03;R04;I10;I13;A19;A21;A25;I40). The risks of leakage were considered low and reduced by careful site selection, detailed planning and continuous monitoring. However, although the likelihood of leakage through explosion or earthquake was rare, it was not unknown. It is important to point out that while much of the equipment and functions of CCS are already being used in other engineering and chemical industries and processes with more dangerous substances under more volatile circumstances (such as natural gas storage), CCS appears to receive greater negative attention, mostly due to unawareness of the technologies and processes involved and the lack of practical evidence to support a record of safety (A19).

There are two ways in which the fear of leakage and safety credentials of CCS can be made clear through a large amount of research and testing in the field. The attainment of positive findings can create general assurances of the safety of storage and proof that CCS is a viable technology (I10;I13;A21). One major drawback to the view that without proof there is no CCS in China is that to provide such proof a significant amount of time is needed to better understand and prove the long-term fate of CO_2 underground (R04). Understanding that as a gas it can be stored for thousands, if not tens of thousands, of years in different geologies under differing circumstances (R35), there is no way to prove this in the medium term (A21). However, ten to twenty years were considered enough time for an estimated probability of 99 percent (R35), so many are calling for assurances for thousands of years which can be guaranteed (R20). Taking this all on board, it looks unlikely that such proof and assurances may be provided for CO_2 emissions reductions to come down using CCS and for any contributions to climate mitigation to be made.

CCS Governance and Multi-Stakeholder Management

As we had seen during the research stage and through our discussions on technology transfer, respectful successful relationships between CCS stakeholders are crucial to the development of CCS technologies. Although ACCA21 brought together various qualified stakeholders from different disciplines and sectors (with differing degrees of technical and non-technical knowledge and abilities along the entire CCS chain) to work collaboratively on projects, there are reported challenges with matching partners and projects. This is often due to both technical issues (such as the positioning of CO_2 point sources and suitable storage locations) and non-technical challenges (such as the negotiation over issues such as project expectations, responsibilities, liabilities and partner disputes) (A07;G12;R14;R16;I18;R24;A26;A31;R35;I37;I40). Acknowledging ACCA21's limited capacity in this regard, there is a need for stronger governance functions and stakeholder management to assist in coordinating, negotiating and mediating issues and problems between the various stakeholders, particularly when things go wrong. It has been suggested that this is a commercial issue (G12), so we will look at this in more detail later.

Chinese stakeholders seem to have a level of confusion over which government departments are responsible for which aspects of CCS governance. Although we have already discussed the responsibilities and functions of ACCA21, the NEA (which is overseen by NDRC) manages the overall policy, development, coordination, and security of China's domestic energy structure, as well as addressing climate related issues. Internally, NDRC has a dedicated Department of Climate Change, which formulates strategies, plans and policies to address climate-related social-economic development issues and international cooperation opportunities. Additionally, the Ministry of Finance (MOF) essentially provides funding for CCS-related projects and the Ministries of Land and Resources (MLR) and Environmental Protection (MEP) have responsibilities over their respective areas. This means a degree of overlap and lack of clarity over which government departments are responsible for which aspects of CCS governance, management, policy and regulation. Acknowledging the situation of CCS-related responsibilities for "science and technology, industry, energy, mining resources, geology and the environment split between at least six departments," one prominent Government stakeholder described this as "like a CCS basketball team" (G12). Unfortunately, it is often up to individuals to, often unsuccessfully, seek to resolve CCS-related issues on their own, costing valuable time and money (A39).

Recognising the absence of an authoritative over-arching institution, which brings together CCS-related management and resources all under one roof, some have indicated that "if CCS was a serious Government priority, then the State Council which wields great power and influence would be involved and such a body might be created" (A11). Some have suggested that perhaps this might be a "special body" created under NEA (R09;G27).

Although, as CCS is only just at the research and demonstration stages in China (I37), some said that “now is not the time” (A39) and that “we haven't got to that point yet.” Others said that Government and industry are still negotiating amongst themselves on “what to do, how to do it, how much it should take and who will pay,” with some believing a new governmental institution would be the “next step” but “we are not there yet” (R24).

The assumption that “we are not there yet” may be short sighted. As CCS moves from research through development, and into commercialisation, problems are continually resolved on an *ad hoc* or project-by-project basis, and this situation has begun to intensify (A17;G27;A30;R35). Considering there are significantly more stakeholders to manage than other large energy or infrastructure projects, from different industries (coal, gas, power generation and oil) and with differing interests and expectations, some interviewees seen a need for greater governance and policy support during the negotiation and contractual stages of project development (R04;R14). This is especially the case when there is confusion or conflicts, which can result in a delay in progress or a halting of the project altogether, which is all too common (A07;I18;I37). Although there are many issues which might be case specific, one commonly mentioned problem related to CCS development is the chemical classification of CO_2 itself, which is critical.

CO_2 Classification, Utilisation and Transformation

One government stakeholder pointed out that the classification of CO_2 varies depending on which government department one speaks with, ranging from a “dangerous or hazardous chemical” to simply “air” (G02). This makes CCS-related governance procedures both confusing and a bureaucratic nightmare. Meanwhile, industrial stakeholders also have differing definitions, with those in the power generation sector seeing it as “resource,” their partners within the oil, gas and coal sectors (especially those working on EOR, EGR or ECBM) seeing it as nothing more than a waste product, for which they are happy to dispose of free-of-charge. Some stated that such companies say “I won’t pay for the CO_2," even though they already buy CO_2 from the market (I18). Others insist that CO_2 is “not a waste gas, it is a resource gas” (A31) and should be treated as such. Other stakeholders who do not profit from the sale or use of CO_2 acknowledged that traditionally CO_2 is a terminal product but the increase of CO_2 utilisation in China meant its intended used should determine its classification (G27,A31).

The reality is that governmental inaction on the classification of CO_2 as a chemical substance will not only continue to delay project partnerships and opportunities like EOR, EGR and ECBM, but will also stall the overall development of Chinese CCS, particularly as its current focus is on CO_2 utilisation (R04). As noted earlier, more commonly known as CCS globally, the Chinese preference to include “U” in CCUS spells out the country’s emphasis on CO_2 utilisation for the technologies’ domestic future. One interviewee noted that, “more and more people paying attention to carbon dioxide utilisation, the Government, the people, everyone actually, is more concerned that the carbon dioxide is not wasted" (A31). As the Government and industry are looking for ways to mitigate against the costs of capture, transportation and storage, utilisation seems a likely possibility to reclaim some of the costs endured, while reducing the risks of storage, easing the energy penalty and having technological development in the process (G02;R04;A11;R16;I18;A19;R20;A30;R35; I37;A39). The problem lies in finding a suitable technological method to do so (A03).

There were increased expectations for CCUS projects to be the focus projects within the Chinese Government's five-year plans (G02;A19;R20;R24;A30;A31). Despite EOR activity in China having been undertaken for around forty years (R35), the Government seems to have now aligned the majority of its CCS funding with EOR projects (R24). However, the problem with EOR projects is the fluctuations in the global fuel prices, meaning there was less interest from Chinese companies to invest or engage in such activities (A30;R35). One proposed solution was for the Government to introduce policies for EOR-related tax incentives to encourage more projects (R35). Suggesting that they would engage in projects "automatically" if this was the case, industry parties seemed to approve (R09).

Another downfall of EOR projects is that while CO_2 can be recycled many times in these processes, there is no real guarantee that any emissions will actually be reduced. Other processes, such as EGR, ECBM and EWR, and the utilisation of CO_2 in the food and beverage industry (to carbonate soft drinks) are also on the Chinese government's agenda, but these are much less developed and the quantities utilised are much too small, making utilisation not economically viable (G02;A03;R04;A07;R14;R16;A29;A33;I37). There were also perceptions of risk associated with storing CO_2 underground, so some interviewees believe that the transformation of CO_2 into additional feed stocks through a process of chemical reactions might be the answer to avoid these difficulties (A28). Through these processes CO_2 is captured but not stored, thus reducing the associated risks and creating a new fuel product, but the problem with CO_2 transformation is that few emissions will be stored, if any at all.

Reducing Uncertainty and Building Assurances

Although there have been certain technical and managerial challenges, CCS demonstration projects in China have been beneficial to the point that they have provided "effective evaluation and advancement of knowledge about the innovation" (Rogers, 2003:157,389-90). Given that there is always a certain degree of mistrust around new technologies, CCS also presents "a kind of uncertainty" for Chinese stakeholders (G02). This uncertainty can be attributed to differing degrees of knowledge around its capabilities, risks and costs (R04;A07;I13;R23;G27;R36). Although, in theory, the technologies are already ripe for commercialisation, the experiences from demonstration have been useful when met with the demands of "just show me the proof" (I40).

One stakeholder expressed concern that some intellectuals and scientists "blame you for promoting the wrong solution for the country" (A21), so demonstrations could provide a "relatively cheap way to convince policymakers and investors" of the facts (R06;R14;A19;A30). If these parties are to be truly persuaded, there is a need for greater efforts towards scaling up of demonstration projects, which would produce a larger body of supporting research and evidence (I13;R23;I37). Through the sharing of such information with all stakeholders, convinced and unconvinced, stakeholder see the potential to create greater confidence around the technologies' future (R06;A07;I10;A03;A30), perhaps in time to make contributions to climate mitigation (R06;I40). Adversely, some have also mentioned that through their own experiences, the more they know about CCS as it moves towards commercialisation, the less positive they feel about the innovation and its future potential (A03;I05;R06;R24;G27).

As the Government and industry look towards CO_2 utilisation as a possible remedy to resolve the technical issues, some say "it's a failure of the demonstration not a failure of the technology" itself (A11), suggesting that CCS may be stumbling at the development stage not due to issues with the technologies but with the lack of supporting governance, policies and regulations (G12;R16;A19;R22;A30). This is the focus of the following stage, commercialisation.

Commercialization – "Increased profits for society's elites & industrialists" – Profit

We have now looked at the main motivations, decisions, and activities within the R&D stages of the Chinese CCS innovation-development process, so at this stage I focus on the efforts towards commercialisation. Rogers (2003:152-3) identifies this stage as the "packaging of research results," or "practices from practitioners," with the intent for "the production, manufacturing, packaging, marketing, and distribution of a product that embodies an innovation." Usually undertaken by private companies, the focus of this stage is to make the innovation desirable for adoption by target audiences.

Although we already know that CCS, both within China and globally, is still a long way from commercialisation (which some anticipate being around 2030 and capturing and storing around one hundred million tons of CO_2) there are signs that preparations are already being made at this point in time (A11). However, although I give considerable attention to companies (mainly SOEs) during this stage, the primary focus is on the relationship between the Chinese Government and industry, which appears to be an increasingly important dialogue but a considerable sticking point in the domestic development of CCS.

Technological Enthusiasm and Policy Apprehension

Despite the challenges discussed in the previous stages, there appears to be a greater degree of enthusiasm from scientific and technical stakeholders than those in policy and regulatory circles, who proclaim that “if you put all the things together, I don't think you would be that enthusiastic” (R16). This might be down to previous efforts concentrating more on the technological development of CCS, with less attention being paid to policy development (R16;R22;A30). Policy researchers determine that “the whole package of policy research” has already been completed. With efforts suspended until more is known, they attribute the lack of policy development down to the “policy lag,” whereby the Government is working towards the formulation of appropriate policies, directives and regulations (R04;R16;G27). Considering CCS as only a “very small piece in the whole environmental things,” there is an assumption that the Government has been working on overhauling Chinese environmental legislation, policies and regulations as a whole.

Although current policy improvements may be somewhat related to CCS, currently there are “none especially for it” (R16). There have been some efforts towards strengthening the regulations for CO_2 storage in China but again these are on an *ad hoc* project-by-project and even site-by-site basis (A30). Whether this delay in CCS specific policy formulation is intentional or merely down to bureaucratic challenges, the fact is that CCS stakeholders in China feel unclear about the true Government’s policy position (R04;I05;A07;R09;R22;G27), with one saying that “the big problem is the Government leaders didn't show the clear idea on the CCS” (A07). Acknowledging that stakeholders are concerned about this lack of policy and regulatory support (R06;A07;R09;R16;A19;R35), there are undoubtedly impacts on decisions taken by industrial parties (G27;A39).

Government and Industry’s Policy-Technology Loop

One stakeholder commented that in the last ten years the Government has not had a willingness or urgency to provide CCS-related policies and regulations and they attribute this mainly to the lack of industry desire or need (G27). Stating that such policies will only be provided when industry “almost asks, not before” and saying that “if they don't ask, then the authorities don’t need to do this” (G27), this then gives the impression that industry is dictating policy decisions to the Government. In their defence, the Government is reluctant to simply impose policies or regulations on Chinese industry and feel that in “this [type of] policy process, we must coordinate, [we] must listen to the views of industry, government wishful thinking is not possible, [it] cannot be unilateral, [it] must be interactive” (G12). While some might say that the technological problems and issues of scaling up need to be resolved before any policy provisions are given (A19;R22;G27), the Government is “autonomously observing and understanding the actions of industry and the international community, with its actions dependent on positive experiences of demonstration, before it will promote reform” (G12).

Others support this belief that both technological and policy developments are not mutually exclusive and need to happen in tandem (R01;G12;R16,G27,A39). One stakeholder said that the “demonstration projects are in parallel with the policy, [and that] some of the ideas are to explore some problems or issues from the demonstration project, then we can complete the related laws and directives, and that's a kind of loop" (R16). Mentioned during the R&D stages, this back-and-forth communicative process between all stakeholders within, as well as between, the stages of the innovation process are paramount to successful innovation development. However, with industry and government having certain presumptions or suppositions on each other's role and provisions within CCS development, "this kind of public policy development, where there is an active dialogue between Government and society, is a very complicated process" with either "some kind of motion or none at all" (G12). The risk being that with industry demanding greater support from Government and Government seeking greater assurances of CCS capabilities, everything is creeping along at a slow pace, risking both the future of CCS projects and everything that has been achieved so far (G12;I40).

National Development and Reform Commission (NDRC) and Technology Neutrality

We briefly discussed the role of NDRC as an important stakeholder during the development stage, so there is a need to further investigate the influence of this key institution, especially why its policy positions on CCS technologies might create confusion and cause uncertainty. As we saw earlier, the NDRC issued *Notice of NDRC on Promoting Carbon Capture, Utilisation and Storage Pilot and Demonstration* (2013) outlines the Government department's support for the technologies' development. Although, having a clear position of technological neutrality, NDRC may support the research, development, and demonstration of CCS for reasons of "technological and management experience" (G12). However, it draws the line when it comes to directly facilitating commercialisation (A11). Non-state parties were also saying that "it is not the duty of the Government to support a kind of special technology" so "the Government will not push any technology." Therefore, the expected approach by NDRC in promoting CCS at the commercial level would be to say "you need to reduce your CO_2 emissions, maybe you [can] use CCS, [you] can also use nuclear power, natural gas, [or] renewable energy, this is your choice" (A11;A03). This does little to advance CCS along the innovation-development process.

This abdication of responsibility for decision making a clear indication to industry that CO_2 emissions are primarily their responsibility and how they choose to abate those emissions is at their discretion, as long as targets are met. Consequently, there are expectations that likely demands for emissions reductions will be targeted firstly towards specific industries/sectors and/or geographical areas, with possible targets of 10 percent annually (A11), which leaves little room for some industries and provinces to use other means but CCS (G02). In saying that, there have been hints that NDRC will introduce "a vision for CCS industrial development" (G12) within the next few years, which may outline the next steps for the technological and policy developments in China. As NDRC is also expected to introduce energy reforms in the near future, it is still unknown what these might be and what they will mean for CCS (I18). This is something policy researchers, industry stakeholders and potential investors will be watching closely (R04;R16).

The Role of Government in CCS Commercialization

Governmental stakeholders claim that the primary beneficiaries of commercialisation (technology development, patents, and profits) are industry stakeholders, suggesting that it may not be appropriate for too much governmental involvement with such activities (G02;G12). Their argument for this is that through their support for pilot projects and demonstrations, the costs of CCS should eventually fall significantly in the coming years (G12). However, NDRC does have a responsibility to understand the contributions CCS might make to national development, to assist in the reductions of cost and to provide the appropriate policies on both energy and climate related issues (A07;A11;I18). Considering the large volumes of CO_2 emissions and growing coal consumption threatening the supply of energy and thus domestic production output, the Government should play an even greater role and intervene more strongly to avoid any type of industry or market failure.

The Government believes it is rightly cautious when supporting individual companies in their quest for the domestic development of CCS-related technologies for commercial opportunities (G12), as the current position is that SOEs are primarily focused, at this time, on using these technologies on their own projects and within their own facilities (I05;R06;A07;I13;R14;A26;A29;I34). They do, however, have significant opportunities to bring these environmental and low-carbon technologies to the market (A07;R14;R20;G27), with some already making moves to acquire 100 percent of its CCS-related Intellectual Property (IP) (I05;I34), perhaps eyeing up potential domestic and other international markets (I05;A07;R14;I34). Likewise, private enterprises and research and academia parties (who have also received government funding) are all developing and patenting CCS-related technologies that may be used in other industries and processes (such as shale gas, well monitoring or water pollution) and have the possibility (and experience) of commercialising CCS technologies (R06;R14;A17;R20;I34).

Through this investigation, I only discovered one – very committed – private SME working directly on CCS. This Jiangsu Province based company patented three CCS-related technologies in a hope to gain an early start in this (perhaps promising) industry. Admittedly taking a risky business approach in the short-term, this company hopes its plans will lead to a lucrative long-term investment (I34). There is one significant downfall to such plans, which may explain why CCS technologies are being kept “in-house” at this time. Considering the commercialisation of CCS is expected to take place around 2030 (A11), and technology patenting periods take between 10-20 years, these technology developers risk not seeing any financial returns from their IP (R35). Although industry stakeholders say that the creation of an international CCS industry (with China leading the way) might create additional employment pathways and economic growth, in reality there currently is no market for CCS technologies and might not be without governmental support (R06;A11;I13;I18;A29;A30;I34;R35;A39). The Government may have more indirect motivations for support in mind, as we see from the next section.

Capture Ready: Bringing CCS to the Power Plants and Provinces

Considering the lack of policy clarity and speculation of the Government's next moves, a typical approach for policy development in China (which might offer us insights into potential CCS policy formulation) is the trialling of policies and regulations (or parts of) on select industries, sectors or geographical locations. Increasing the "trial-ability" of an innovation, which Rogers (2003:16) defines as "the degree to which an innovation may be experimented with on a limited basis," these can provide opportunities for "learning-by-doing." Lessening the uncertainty around adoption, policy trials could hold similar functions to demonstrations during the development stage. One governmental stakeholder stated "no matter if it's a pilot project or a pilot region, it will have a good effect on the evolution of policy in China, such trials are a very good way to deal with problems, so perhaps this is also a good way for CCS" (G12). As mentioned earlier, there are no CCS specific laws, policies and regulations (R16), so this might tell us a lot about the future of CCS specific policy implementation in the near future. Consequently, we might then have to look deeper into other indicators of potential policy trials and signals within specific industries, sectors and/or geographical areas that might give us clues to the government attitude and approach to future CCS's policy. Let's start with the concept of 'capture ready.'

Perhaps in its attempt to encourage CCS within specific industries or regions that might be hesitant (I05;R14;A21), the Chinese Government promoted CCS activity through indirect means. By making moves to phase out older, less efficient power plants (R04), the Government then aimed to strike a delicate balance between their own national priorities and industries' concerns (R24). Since 2014, NDRC has required those seeking permission to build new fossil-fuel power generation facilities to provide comprehensive detailed plans for how they intend to abate their CO_2 emissions effectively. Although many power-generation companies welcome CCS as an opportunity to demonstrate their plans for large emissions cuts, CCS also provides them with "another option to set up, to establish the power plant, otherwise they can't do it." This concept of 'Capture ready' assumes that CCS is "very likely" and that in "five or ten years later, the Chinese government will ask every enterprise in this sector to have the CCS" (G02). Therefore, companies feel like they are benefitting from the immediate rewards of permission to construct new power generation facilities, while also preparing for future policies and mitigation against possible impacts of regulation (R04;I05). Although some considered to "appreciate" these developments as a "good idea," others see the Chinese government as striking a good balance between achieving their goals and meeting the needs of industry (G02;I37).

In reality, what is expected of industry is little more than preparing feasibility studies on how CCS might be applied to power facilities (G02;I37). There is no actual expectation of investment, installation, or operation of any capture facilities, not to mention the storage of CO_2. According to one interviewee, most companies are "not keen to build a CCS project, [but] most of them just try to get the licence" (G02). Additionally, in most cases, provincial governments are not wealthy enough to even support CCS demonstration or deployment, as many have other considerable domestic challenges to contend with (A07;R22;R24;A28). However, some relatively prosperous regions, such as Guangdong Province in Southern China (which has huge emissions volumes, fossil fuel dependency, little capacity for renewables, and tight restrictions on nuclear), have made plans for new capture ready facilities and retrofitting. Although CCS might not be suitable for every locality, we must remember, neither are renewables. For these reasons, some provinces have started to show interest in developing and demonstrating CCS (R06;A11;G12;A19;R22;R24;I34).

Although there are moves by provincial governments and SOEs to incorporate CCS within the power-generation industry, the technologies are much less welcome at the power plant managerial levels. Considering the degree of technological development, the large energy penalties and the lack of an energy by-product, any prospect of applying CCS to their plants will significantly impact the costs of power generation, which will impact the price these plants offer energy to the market and lowering the returns they receive (I05;I18;R22;A33). For that reason, some managers are even reluctant to provide opportunities for CCS testing, piloting, and demonstration within their facilities. In order to bring these stakeholders on board in the early stages urgent policy responses are needed (I05;R22;A33).

One recent development, which might be a possible solution (although is not national policy but is being tested at the provincial and local level since 2015), is the idea of "super clean emissions." This hopes to persuade power plants to adopt new cleaner low-emissions technologies (such as CCS) by allowing them additional time to generate power (I05). Although these efforts only go so far to introduce CCS on a theoretically technical level, there is a need to seek the appropriate policies to enable this to happen (I05). As one researcher pointed out earlier, the Government and industry are still negotiating amongst themselves on "what to do, how to do it, how much it should take and who will pay" (R24). The pivotal question is "who will pay," which we focus on in the next section.

Cost and Profit: Who should pay for CCS in China?

The lack of private Chinese investment in CCS has meant that the limited financing for domestic research, development and demonstration has almost entirely come from the Government. This has lessened in recent years as the technologies have moved towards commercialisation and the increasing costs have become the responsibility of industry and society (I05;R14;I18;A21;R22;R23;G27;A30;R35;A39;I40). Recognising that cost is seen as the "most important challenge to CCS" (R04;I13;R14;R16;A30;A33;A39), alternative funding streams from industry and enterprises are available but limited (A19;A28;A30). One of the biggest drawbacks, which we discussed earlier, is that CCS provides no immediate energy by-product or financial returns (G02;A03;I05;R14;R16;I18;I34;A39). In fact, it is significantly less profitable for industry and enterprises when they consider its large equipment and infrastructure requirements (R35). Favouring quick and guaranteed returns on their investments (G02;A03;R14), 10-20 years are deemed unacceptable (G12).

Many interviewees mentioned that climate change and CO_2 reductions are considered to only have social or environmental benefits, which might appeal to the government and society. Without immediate economic benefits that industry and enterprises value, commercialisation looks unlikely (I13;R14;R23;A26;G27;R35;R36). As one stakeholder pointed out, “this is not [a] financial issue, if global warming is so serious [then] no-one [will] care about how much money is needed to reduce global warming” (A30). Although, as another stakeholder put it “everyone is really thinking CCS is really important and wants other people to do this kind of thing, but for themselves, they won't […] they don't want to reduce too much money to do something good and not earn money” (R35). Referencing estimates of 270RMB (£29.60GBP) per ton of CO_2 captured, as well as an additional 270RMB for other processes such as transportation, stakeholders see little room for technological improvements, therefore fewer chances for costs reducing without policy interventions (I37).

Holding hopes to bring these dual desires of social and economic values more closely aligned, some mentioned a need to develop mechanisms for the sharing of costs, perhaps through policies to monetising CO_2 and creating opportunities for the government and industry to gain some returns on their investments (A11;A30). Due to the lucrative international possibilities of CCS being part of the CDM now disappointedly a lost opportunity (R24;R35), there is speculation that the Government might look towards handling this through “natural tax procedures” with a tax “on every kilowatt hour of energy or every ton of CO_2 produced” using fossil fuels (I18). Such moves would ultimately raise the cost of energy, which would prove enormously unpopular with most stakeholders and would gain definite opposition from power generation companies and power plants (A07;I10;13;A30). One stakeholder warned that “taxes on CO_2, would make people choose to improve the energy efficiency, [and] would not make CCS work” (I37), that is, taxes might not have the desired effect CCS proponents might hope for. Consequently, others also argued that while energy efficiency is already the first priority (and choice) for emissions reductions, greater efficiencies and thus further reductions are increasingly slim (R01;G02;I05;A07;A11).

Given that the Chinese power generation market is governed or “monopolised” by NDRC (A33), this department has the responsibility for the one-to-one negotiations with individual plants over fuel consumption costs and energy supply prices to the domestic market, which makes it the most appropriate agency to resolve this issue (I18;A33). Suggested mechanisms, such as carbon trading or an adjustment in the price of energy, would add a monetary value to carbon, proving to be popular to stakeholders (I05;A11;I13;R14;I18;A19;R22;A39). Additionally, as “the Government will not push any technology” (A11), the introduction of a “carbon tax or carbon trade is a key issue” in

China (A11;G12;R22), with significant emissions reductions to be through the application of CCS technologies perhaps making CCS the first choice by companies.

The Government has already actively been working on creating a carbon market in China since 2013, in order to “get ahead” and “get lots of chances” (A03). During this time, it has developed regional pilots within the Chinese municipalities (Beijing, Shanghai, Tianjin, Chongqing, and Shenzhen) and a number of provinces (Guangdong and Hubei), with hopes that this will eventually lead to the setting up of a nationwide carbon market. Chinese interviewees had also suggested the possibility of a “special electricity price for every ton of CO_2 captured” or “a kind of CO_2 electricity plus” for every kilowatt produced using CCS, which could off-set the costs of installation and operation of capture facilities (I18). However, considering the cost of electricity is already extraordinarily low in China (I10), there is the potential for an increase but these costs would then eventually be passed onto the end consumer. As one interviewee put it, “if they want clean energy, less pollution and a better environment then they would have to pay this higher cost” (I18). At the end of the day there are options available but compromises will need to be made.

One interviewee said that one argument that seems to resurface every few years is that the real costs of CCS have been misunderstood (R06), although most “people do not believe it” (R24). Part of the rationale behind this argument is that investment in CCS now would not only allow the continuation of cheap fossil fuels and the continued energy output and imminently abated emissions but also immediately reduces the likelihood of climate change and can mitigate against any future financial expenditures. A number of interviewees also felt that renewables in China had been heavy subsidised, which has led to a false illusion of the real costs and benefits of the technologies (R01;A07;I10;R16). Many industry stakeholders also believe that CCS should be offered subsidies, tariffs, concessions, and/or targets, in order to compete with other technologies (R04;A07;R09;I10;R23;G27). This leads us naturally into the final discussion in this stage, the competition between low-carbon energy technologies.

Technologies Competition: CCS as Part of a Suite of Technologies

Mentioned briefly during the research stage, the competition faced by CCS is much more prevalent as the technologies move towards commercialisation. Seeming to fluctuate from unimportant to crucial, depending on development stages as well as issues, concerns and opinions of stakeholders, this discussion looks at what Chinese stakeholders have said about CCS when compared to other technologies. Taking into account China’s emissions volumes, some stakeholders believe that “no other useful option can resolve such an amount of CO_2” and to “inject it into the underground is the best and the fastest way” (A19;R20). This is unarguably “definitely the advantage” CCS has over other technologies (A07;R20;R23;A39). The disadvantage of this greatest attribute, however, is that while emissions might be controlled temporarily, fossil fuels and geological storage are finite resources, so there is the need to find a more permanent and sustainable solution, which would require a more long-term systematic change towards renewables (R14;R16). For this reason, CCS is seen by many as only part of the solution, one component in a suite of low-carbon energy technologies (R04;R06;I13;R16). One interviewee saw most current efforts going towards energy efficiency, renewables and nuclear, with CCS currently only having limited potential as part of a more comprehensive national strategy for climate mitigation (A33).

In reality, although energy efficiency improvements are considered the first choice of most stakeholders, there are also huge technological costs involved with such upgrades, not to mention that the potential for continuous efficiencies is already considerably low (R01;G02;I05;A07;A11;I37). As the current situation for renewables is looking slightly more optimistic, some stakeholders maintain that even with its current subsidies, the costs of renewables are still too high, when compared to fossil fuels (I05;R16). Others, however, argue that renewables have the added benefit of producing energy, not only consuming it, and like CCS, the costs will come down as time passes, perhaps as much as 10 percent over the next five years, perhaps making CCS redundant (R06;A11;I18). Some harshly disagree with such claims and this debate seems to re-emerge every few years creating continual uncertainty and confusion over the medium-long-term costs and contributions comparisons between renewables and CCS in China (R06;A07;G12).

The final option for most stakeholders was nuclear, which, although through its relative cheapness has increased its capacity in recent years, is heavily regulated and has annual energy production caps, not to mention its contention due to safety and environmental concerns (I05;R06;A07;R16;R22). Continually CCS is considered “always the last, [and] should be the last measure” (R04;I05;A11;R16;A21). One stakeholder said that “the long-term prospect is not fully accepted by policy maker and the public” (R06), while one governmental stakeholder described CCS as more of a “spare tire in the boot of a tricycle” to be “kept in the boot” in the event of the need to “convert to a four-wheel drive” (G12). However, many had faith in the Government and said that they are closely watching international trends and responding appropriately, perhaps by providing more support to renewables and/or CCS depending on what is happening globally (I05;A11;G12;A30;A38).

Summary, Analysis and Conclusion

CCS presents many opportunities for China and we saw in the previous chapters that Chinese parties have been actively engaging with international partners around the technologies. However, as Jaccard and Tu (2011:411) put it, China is “showing enthusiasm but not too much” and this has caused confusion and frustration for those seeking to diffuse the technologies within the country. Therefore, this chapter provides a comprehensive qualitative assessment of China’s appetite for CCS and Chinese parties’ motivations for engaging with the technologies, as well as discussing the prospects for future domestic demonstration and deployment.

In doing this, I looked at the Chinese CCS Community through the lens of a social system, which Rogers' (2003:67,23-4) says collectively learns about an innovation to solve a common problem or reach a mutual goal, which binds them together. From what we have seen, it was clear that although the Chinese CCS community could be described as a social system engaged in collective learning, it lacked a common problem or mutual goal, which made presenting CCS as the innovative solution for everyone a real challenge. However, there is a way to bring the various stakeholder groups together, which is to create and share information along the domestic innovation-development process in order to create a mutual understanding of CCS, and to find a way to come together to take the technologies towards demonstration and deployment.

Rogers (2003:19,26-27,147-148,213) said it is important to look at the social system's structures, its communication, and its behaviours, and what this means for facilitating or impeding the diffusion of an innovation. Given that CCS has not yet reached the stage of commercial deployment, I focused my attention on the needs, activities, and decisions within the Chinese CCS 'innovation-development process,' and what this means for the technologies' domestic advancement. Importantly, Rogers (2003:139,144) stated that "innovation development occurs as people talk, when information is exchanged about needs and wants and possible technological solutions to them," so I looked for the motivations for Chinese parties along the stages of this decision-making process, aligning these with Bordenave's (1976) motivations for adoption (Table 8.2).

From the outset, we saw a large number of Chinese respondents viewing CCS as a tool for reducing China's burgeoning emissions and making large contributions to the country's efforts to mitigate climate change. As climate mitigation was raised higher on the social system's priorities and CCS seemed to rise within the Chinese agenda-setting processes, key references emerged within MOST's *Scientific and Technological Actions on Climate Change (2007-2020)* and NDRC's *China's National Climate Change Programme*. At this early stage within the Chinese CCS innovation-development process, we saw a relatively straightforward application for CCS and no real opposition towards the technologies' development. However, it appeared that Chinese stakeholders had initially characterised CCS as a preventative innovation, making its motivations for adoption somewhat weaker and its potential diffusion both slower and more difficult, perhaps even impossible.

This categorisation of CCS meant that although the primary perceived benefits (emissions reductions) and desired consequences (climate mitigation) were seemingly clear and certain, the fact that they were considered distant and international (both in terms of time and space) meant it was less of an immediate priority than other more-visible development issues within China. This directly translated into a lack of pressure on behalf of the Government and placed CCS as the last option for climate change mitigation technologies. This lack of pressure lessens the urgency for CCS development, demonstration, and deployment, contrary to what Rogers (2003:15,69,176,223-235) tells us that proponents of an innovation can often increase the relative advantage of preventive innovations by emphasising the rationality of the innovation, while also offering incentives or rewards, as well as providing cues to act. We saw many similar international examples in the previous chapters but we also saw signs of Chinese parties linking CCS to more current domestic problems, such as fuel consumption and energy production, demonstrating how they can be part of the solution to problems today.

We saw that the Chinese research and academic communities, particularly the CAS institutes, play a key advisory role to Chinese Government departments and state-owned enterprises. Raising serious concerns about China's coal consumption and its links to economic development, as well as national security, these two intertwined communities sought to resolve these interlinked problems and their investigations brought them to investigate various technological solutions. Many saw CCS as the ultimate solution to resolve this collection of challenges, having a bright future that would allow China to continue to use coal in a secure and sustainable way, which for them made adopting the technologies completely necessary. This increase in compatibility with Chinese conditions could again be considered a positive development for the technologies' advancement.

At the same time, some within the Chinese CCS community were less optimistic and saw CCS as unnecessary, believing superior alternatives would be able to achieve the same objectives in a more sustainable and timely way. Well-respected and influential academicians and researchers quite publicly opposed CCS, which was sometimes considered fundamentally biased and unjustifiably critical towards the technologies. Curiously, at this stage, I discovered that when speaking with some Chinese research and academic interviewees about CCS as a climate mitigation tool, many were apprehensive of the technologies' potential. However, when discussing CCS in relation to coal consumption, energy security, and economic development, many of the same interviewees were much more optimistic and saw the technologies as very necessary. This gave me the first indication that when seeking to diffuse CCS within the Chinese CCS Community as a social system, proponents of the technologies should not only emphasise their ability to 'promote public welfare' but should simultaneously appeal to Bordenave's (1976) other motivations for adoption (Table 8.4). In direct conflict with Rogers' (2003:67,23-4) assumption that an innovation seeks to solve "one common problem" or reach a "mutual goal," which binds the social system together, we need to bear in mind that CCS responds to many different but interrelated problems as it moves through the Chinese CCS innovation-development process and find a solution if the technologies are going to make their way through to commercialisation and widespread deployment.

Despite the indignation from senior Chinese figures, it seems they weren't able to hold back the wave of Chinese interest in CCS technologies and the plethora of activities that we saw in earlier chapters. Many of the early activities in China were about creating knowledge and raising awareness about CCS but they were instrumental in the technologies' inclusion into key government programmes, which added CCS to the Chinese research programmes and set the research agenda for China's CCS. Quickly becoming a hot research topic, CCS spread quickly within faculties across Chinese campuses. During this time, there was an increase in small-scale 'how-to" activities, where Chinese parties undertook various scoping and feasibility studies on the whole chain of CCS technologies. There also was evidence of Chinese parties working together to move beyond desktop and lab-based research towards small-scale pilots and aspiring towards demonstrations. These are prime examples of researchers and academics working together to create and share information about CCS and early signs of the formation of the Chinese CCS Community.

ACCA21 has been an important body that has supported China's CCS R&D agenda and the technologies' inclusion into governmental plans and programmes, as well as attracting local stakeholders and organising soft governance activities and coordinating project partners, often with international partners. However, this Government agency itself is not able to provide any direct funding for CCS and it lacks the policy formulation and regulatory powers to take the technologies beyond R&D towards demonstration and commercialisation. Despite its limitations, ACCA21 does play an influential role in bringing government, research, academia, and industry stakeholders together and has been a driving force behind the Chinese CCS Alliance, which has been an informal mechanism to both drive forward domestic action and resolve CCS partnership disputes, as well as creating and sharing information.

We saw that generally there were positive interpersonal relationships and partnerships between Chinese researchers and academics but a number of interviewees did raise concerns about the systematic research failures, inadequacies and inefficiencies that might affect the move of CCS from the research stage to development, and eventually to commercialisation. Much of this centred around misunderstandings of the meaning and purpose of CCS, particularly between researchers, academics and their industry partners. Although this seems like a much larger issue, that goes beyond the remit of this study, it is fundamental for the progression of CCS through its Chinese innovation-development process. From what we already know, the various groups within the Chinese CCS Community often have their own motivations, which although sometimes are complementary are also sometimes at odds with each other. For things to move forward, there is a need for the Chinese CCS Community to come to a common understanding.

Many Chinese interviewees believed the CCS research area had entered a period of stabilisation as there was already a greater domestic understanding of the benefits and the challenges of the technologies' application within China. It was at this point that these researchers and academics started to focus on the contributions CCS can make to China's emissions reductions and energy strategies, by modelling the country's optimal combinations of CO_2 abatement options, low-carbon technologies and clean energy sources, leading to 2030, 2050, and beyond. These were not seen as having the impetus needed for driving the technologies forward and the advantages of CCS often highlighted its disadvantages too. There was still a need for CCS to appeal to other sections of the Chinese CCS community, those who had different but complementary motivations.

Many Chinese industries and SOEs recognised the changing national conditions, with impending business regulations, and started to think about protecting their corporate reputation and their bottom line. Those still heavily dependent on the production and consumption of large amounts of CO_2-producing coal saw CCS as a possible technological solution to these challenges with the possibility of additional revenue streams, so began engaging in pilots and demonstrations. Given China has all the industrial attributes and natural conditions for such projects, there was a flurry of Chinese SOE-led projects launched between 2006 and 2016, although many of these were criticised for being uncoordinated or not being the best use of China's resources or time. Involving Chinese academia, research, and industry, we saw multi-partner projects emerge within the Chinese CCS Community.

Although these were great ways to create and share information about CCS within China, many of the Chinese domestic projects highlighted the same challenges and unacceptability around the technologies, such as the high energy penalty, leakage and safety risks, and governance and stakeholder management problems. Losing its relative advantage against its low-carbon competitors, there is an urgent need to scale up the trialability and observability of CCS under "real life" conditions through large-scale fully-integrated and commercially-viable demonstration projects, which Rogers (2003:157,389-90) says can increase the credibility, competence and safety of any innovation. However, that would need huge sums needed from SOEs, which were content with spending millions but not the billions of Chinese Renminbi (RMB), so they looked to the Chinese Government for both policy and financial support.

The importance of CO_2 utilisation appears to be a unifying factor within the Chinese CCS Community, although despite having some promising commercial prospects these also face the same energy, cost, and risk challenges faced by CCS. There has been some progress in China, in what Rogers (2003:157,389-90) would describe the "effective evaluation and advancement of knowledge about the innovation." However, there is still a need to provide the evidence and proof needed to remove the uncertainties around CCS, to create the confidence for industry to invest in large-scale demonstrations, and to persuade the Government to provide the policies needed to drive the technologies towards the commercialisation stage.

With multiple government departments responsible for various aspects of CCS, and the absence of an overarching authoritative institution has made it difficult for Chinese parties and for CCS to move forward. ACCA21 was influential in bringing projects and partners together and providing opportunities for conflict resolution through the CCS Alliance.

However, this wasn't effective in unlocking issues that only NDRC could resolve. NDRC was clearly neutral towards CCS and seemed to be leaving it up to industry and others to determine whether they invest in other low-carbon options. Governmental parties have defended their positions by stating that the policy formulation process must not be unilateral and that they have been interacting with industrial partners, who have yet to send them firm signals that now is the right time to make these provisions.

There was speculation the Government was trialling some policies and regulations on a limited or partial basis, in order to learn from the experiences and adapt to any unexpected consequences. The concept of "capture ready" was somewhat successful in increasing the relative advantage of CCS by allowing companies to build new facilities. This is a prime example of the Chinese Government striking a good balance between achieving their goals and meeting the needs of industry but it is still to be determined whether or not this has been a positive development for CCS. Unfortunately, at this stage of the innovation-development process, CCS is heavily dependent on limited public funding, with private Chinese financing and foreign investment scarce. More than ever, there is still a need to find mutual understanding.

Finally, many saw it as the responsibility of Government and industry to pay the cost for mitigating climate change but were realistic that the initial high costs and few immediate returns made this both challenging and unlikely. This again highlights the need for policy interventions to bring these aspects into alignment, one that would be equally as acceptable to all the stakeholders involved, such as avoiding carbon taxes in favour of carbon trading, which might highlight the relative advantages of CCS over its competitors. Facing tough competition, some of the proponents of CCS highlighted the disadvantages of other energy technologies and referenced CCS compatibility to Chinese circumstances, again emphasising that although CCS might not be perfect it should be considered part of a short-term suite of low-carbon technologies until there is a longer-term holistic solution.

From what we have seen in this chapter, there is no doubt that the behaviours and relationships between different groups within the Chinese CCS Community, as a social system, are important in either facilitating or impeding the development and diffusion of CCS within China. It is obvious that there are different levels of knowledge and optimism about the technologies and their abilities within the stakeholder groups, but also various levels of enthusiasm and apprehension between these groups about the future prospects of demonstrations and deployment within China. It is also clear from my interviewees that there is desire for clarity over the Government's position on CCS and to ensure policy and regulatory formulation keeps up with the rate of technologies' development, which informs the decision-making processes of others. Similarly, it is clear that in order for CCS to move along the innovation-development process towards and past commercialisation, there is a need to take account of the different motivations and to find a language of mutual meaning and purpose for the technologies.

From a theoretical perspective, we have seen the interest, optimism, and positivism, as well as the negativity, hesitation, and pessimism, both within and between the key stakeholder groups along the innovation-decision process. Many have expressed a keen interest in CCS but none have taken the clear leadership role towards the technologies' advancement, mainly due to unacceptable penalties, costs, and risks, which they cannot absorb alone. However, we have also seen these parties create and share information with each other, whether that is through events that increase awareness and knowledge domestically, desktop studies on CCS compatibility for China, or small-scale pilots and demonstrations that assess the innovation's competence and safety under Chinese conditions. We have also seen Chinese parties come together to seek resolution to shared problems and challenges but there is still much to be done to create a mutual understanding around the technologies, which can lead it towards wider Chinese deployment. For these reasons, I argue the existence of a hybrid model of diffusion, whereby Chinese stakeholders are passive acceptors of CCS who also create and share information along the domestic innovation-development process to reach a mutual understanding (See Table 8.5).

Stage 1 – Recognition of a Need or Problem – "The promotion of public welfare" **– Climate**	– Increase in Environmental and Climate Awareness – Rise of CO_2 Emissions and the Government's Response – International Obligations and Domestic Priorities – Political Pressures and Environmental Limits – Perceptions of Urgency and the Emergency Response
Stage 2 – Research (Basic and Applied) – "The increased production of goods for export" **– Coal**	– Coal Consumption, Energy Security and Economic Development – CCS Opposition & Pessimism – CCS Opportunities & Positivism – Realising the Realities of CCS – The Administrative Centre for China's Agenda 21 (ACCA21) – Technology Transfer and Systematic Research Failures – CCS Research Stagnation or Stabilisation – Next Steps: Energy Systems Modelling Research
Stage 3 – Development – "Maintenance of low prices for urban consumers" **– Energy**	– Policy and Regulatory Anticipation leading to Technological Readiness – The Achievements, Merits, Difficulties and Challenges of Demonstrating CCS in China – The CCS Energy Penalty – CO_2 Storage, Risk, Leakage and Safety – CCS Governance and Multi-stakeholder Management – CO_2 Classification, Utilisation and Transformation – Reducing Uncertainty and Building Assurances
Stage 4 – Commercialization – "Increased profits for society's elites and industrialists" **– Profit**	– Technological Enthusiasm and Policy Apprehension – Government and Industry's Policy-Technology Loop – The National Development and Reform Commission (NDRC): Technology Neutrality – The Role of Government in CCS Commercialisation – Capture Ready: Bringing CCS to the Power Plants and Provinces – Cost and Profit: Who should pay for CCS in China? – Technologies Competition: CCS as Part of a Suite of Technologies

Figure 8.5. The Chinese Domestic Innovation-Development Process

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Chapter Nine: Removing CCS Uncertainties throughout the 'Innovation-Decision Process' – Decision making is shared between technically-expert officials near the top of the diffusion system and with those who may or may not wish to adopt

As the final thematic chapter of this thesis, this discussion will focus on the innovation-decision process and the hierarchy of communication effects, as well as their relation to removing Chinese uncertainties around CCS adoption. This will lead the way for the concluding chapter on increasing the rate of adoption through a hybrid diffusion model.

Researching the international diffusion of CCS within the power sectors of various countries, including China, Vallentin (2007) focuses almost exclusively on harder policy and regulatory instruments, such as stringent carbon reduction targets and cap-and-trade CO_2 markets, and their influence on the technologies' adoption. Concluding that the immense uncertainties around CCS makes it hard for the technologies to be diffused on a broad scale, both internationally and domestically, he stresses the need for a global framework, or initiatives and mechanisms, that include developed and developing countries with intensive international cooperation and collaboration around the learning and sharing from CCS demonstrations.

In a somewhat related study, Lai *et al.* (2012) analyses the structure of China's CCS efforts from a Technological Innovation System (TIS) perspective, providing recommendations to avoid the valley-of-death scenario between R&D and large-scale commercial deployment. Interestingly, Lai found that the traditional theoretical understandings of a typically linear TIS, with its push-and-market-pull economic model, do not fully capture the trajectory of innovation diffusion. As such, Lai calls for alternative innovation-diffusion frameworks that acknowledge the social and communicative flow of knowledge around technology through social networks and the interactions between actors within the innovation-development process.

Although appearing to be quite different, these studies are enormously relevant to this research. Responding to the former, this chapter complements Vallentin's (2007) international CCS diffusion study by focusing on the soft governance diffusion, as opposed to the harder governance, to better understand how these functions can contribute to a global CCS diffusion framework for collaboration, learning, and information sharing. Responding to the latter, this study complements the Lai *et al.* (2012) study on Chinese CCS development by focusing not on the push-and-market-pull economic model but an alternative innovation diffusion framework that acknowledges the flow of knowledge through social networks and interaction of actors in the innovation process.

Theoretical Framework

As the penultimate chapter, here we will focus on the ‘innovation-decision process’ and the ‘hierarchy of communication effects,’ as well as whether or not decision-making is shared by technically-expert officials near the top of the diffusion system and with those who may or may not wish to adopt (Figure 9.1).

Research Questions	Conceptual Components	Centralised Diffusion	Decentralised Diffusion	Hybrid Model of Diffusion
7. How can international entities employ various types of communications channels to diffuse different kinds of CCS-related information that may influence Chinese decision-making processes?	**Innovation-Decision Process**	Key decisions are made by technically-expert officials near the top of the diffusion system	Diffusion and decisions are often shared with those who may or may not adopt	**Decision making is shared between technically-expert officials near the top of the diffusion system and with those who may or may not wish to adopt**
	Hierarchy of Communication Effects			
8. Are key decisions are made by technically-expert officials near the top of the diffusion system (a centralised system) or if such decisions about diffusion should be made shared with this who may or may not wish to adopt (a decentralised system)?	**Rate of Adoption**			
	Hybrid Model of Diffusion			

Figure 9.1. International CCS Community as the ‘More Knowledgeable and Experienced Parties’

Importantly, this will lead us toward the concluding chapter that will focus on the ‘rate of adoption’ and a presentation of my model for a ‘hybrid model of innovation diffusion,’ which holds the potential to be used for the diffusion of other technological innovations within similar social systems. However, before I do so, I would like to take you back to the very beginning with a discussion around ‘perceived newness.’

Perceived Newness

According to Rogers (2003:5-6,12,14,168,171-2), an innovation is an “idea, practice, or object that is perceived as new by an individual or other unit of adoption” and diffusion is considered “a special type of communication in which the messages are concerned with new ideas.” He says, it is this “perceived newness” that often gives the diffusion process its special character. For this reason, the perceived newness of CCS is critical to this study.

In Chapter Five, we learned that 86 percent of Chinese respondents said CCS was new to some degree (Figure 5.28) and when asked during interviews, some found it “completely new” (G02) or “quite new” (A30), while others saw it as “familiar” (R06) and even “natural” (A38). Many had come across the individual elements of scientific or biological processes within academic studies or industrial activities, most common was the separation of nitrogen dioxide (NO_X) and sulphur oxide (SO_X) for pollution control and EOR. (R23;A39;A07;G02;R20;R06;A08;A31;A29;A28;A11;I13;A17;A32;A26;R01;I18,A25;R35).

At the same time, the combination of CO_2 capture technologies with integrated underground sequestration for the purposes of climate change mitigation was seen as a new concept for most (G02;R06;R23;R20;A39;A07;A31,A30;A03;G27;R16;A19), which one saw as coming from western-industrialised countries (R16). A number of interview respondents said they had only to be introduced to this concept at international meetings and conferences (A08;A31;A29;A28;A32). Therefore, CCS can be considered as valid for this discussion on the international diffusion of CCS within this Chinese social system.

Adding to his definition, Rogers (2003:20-21,168) says that perceived newness can often lead to a degree of inherent uncertainty when potential adopters first evaluate an innovation and when they deliberate whether or not to adopt it as a new alternative and/or to incorporate it into an ongoing practice. Describing it as essentially an information-seeking and information-processing activity, he sees the innovation-decision process is a kind of cognitive and persuasive process to remove the uncertainties around the innovation, through which potential adopters (particularly apathetic or resistant adopters) can receive a positive (or indeed negative) re-orientations towards accepting (or rejecting) a particular innovation. We will look at this process in much more detail here.

Innovation Decision Process & Hierarchy of Communication Effects

Rogers (2003:20-21,168) defines the innovation-decision process as “the process through which an individual (or other decision-making unit) passes from gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision.”

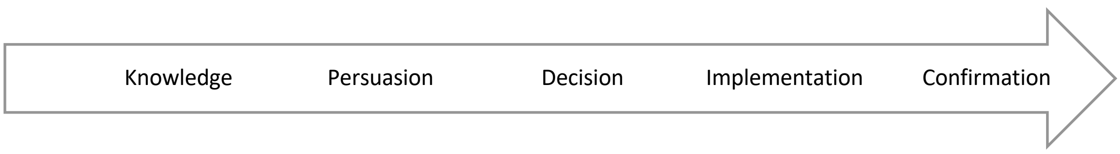

Figure 9.2. The Chinese CCS Innovation-Decision Process

Forming a sequential process with five stages (Figure 9.2), this innovation-decision process is not always a linear sequence of events, as the decision stage could occur before persuasion, for example. Additionally, as we saw in earlier chapters on the CCS innovation-development process within China, we should not expect to see sharp distinctions between these stages. Rogers (2003:20-21,168) tells us that, within this complex reality, it is often difficult for the adopter to identify when one stage ends and another begins, therefore, it is often difficult for the researcher to provide empirical evidence of their existence. He urges us to avoid mixing time and process research with the stages of decision making.

In order to help us study these stages, we can look at the communications channels and their effects, which we have seen in previous chapters. Known as the 'hierarchy of communication effects,' the process between first gaining 'knowledge' until actual behavioural change can follow this cumulative sequence of innovation-decision stages, with different communication channels playing different roles in causing different effects, with mass media considered more effective at the knowledge stages and interpersonal channels considered more effective for persuasion. However, it is possible to use the same sources or channels at each stage of the adoption process, it can also be possible to receive information about an innovation from different channels and sources at different stages in the process (Rogers, 2003:168-9,178,195-8,205,990).

At this stage, it is important to note that potential adopters typically receive three different types of information about an innovation. Firstly, "awareness-knowledge" information about its existence, which may motivate further information seeking and different types of knowledge. Secondly, "how-to knowledge" information on how to trial and use the innovation correctly, which can often be substantial for complicated or complex innovations and crucial for successful adoption to avoid rejections and/or to prevent discontinuance. Finally, "principles-knowledge" information, which deals with the underlying principles of why and what is the capacity of the innovation to meet the needs of the adopter(s) (Rogers, 2003:21,171-4,378). This will be important for later discussions.

Stage One – Knowledge (Awareness)

Rogers (2003:20,169) states that "knowledge occurs when an individual (or other decision-making unit) is exposed to an innovation's existence and gains an understanding of how it functions." An adopter's need (and whether necessity precedes knowledge or knowledge of the innovation preceded necessity) is also very important at this stage. So too is whether or not an innovation was introduced by a change agent, who might have created that need within the adopter (Rogers, 2003:168-9,178,195-8,205,990).

During the Communications Survey, I asked participants when they had first heard about CCS, from which sources/mediums, and the level of their necessity, at that time (Q.5.1. to Q.5.4). From their responses, the first reported 'knowledge' of CCS within China took place in 1995, but as a social system this really peaked at various intervals between 2005 and 2012 (depending on individuals or organisations), which was very much based on sector and geographical location (Figures 5.24, 5.26 and 5.27). This was very much consistent with the period under investigation and in line with what we have seen within the chapters focusing on international entities and CCS-related communications. When asked from where they first heard of CCS (Q.5.2.), there was an almost equal split between interpersonal connections (38 percent), engagement activities (34 percent), and mass media channels (28 percent) (Figure 5.25.). This directly contradicts Rogers' earlier claim that mass media communications campaigns are more effective at the knowledge stages and interpersonal more effective at persuasion (Rogers, 2003:168-9,178,195-8,205,990).

When asked during interviews to provide more information on their knowledge experience (Q.5.2.1.), respondents provided a broad mixture of responses. A few said they had learned from international academic journals and periodicals, such as Welly and Sprinkle's database, Science, Nature, Bio Geoscience, Natural Science, Chemical Engineering Science, Chemical, and Rocks Series Publication (A03;A28;R14;A31). Other channels were more two-way/convergent, with meetings arounds multilateral agreements (such as the IPCC Special Report working groups and the development of marine CCS management guidelines for the London Protocol) and international conferences (such as International Conference on Carbon Dioxide Utilisation) that also offered interactive meetings and site visits (R23;G27;A08;A31;A29;A28;A32;A11).

The International CCS Community had a strong influence on the Chinese interviewees, with many spending time in industrialised countries learning from their academic supervisors and research partners (such as the University of Nottingham, Imperial University, Stiftelsen for Industriell og Teknisk Forskning (SINTEF), Heriot-Watt University, Berkeley Lab, University of Saskatchewan, Geological Survey of Japan, and Fluor) and participating in foreign-led pilot and demonstration projects in their host countries (such as Weyburn and NZEC) (I05;R06;A07;I37;A30;A33;A39). Many carried the concept of CCS back to China and created more localised learning networks (such as the UK-China (Guangdong) CCUS Centre), which sowed the seeds for small-scale domestic Chinese pilot projects (I18;A19;A17;A26;R36;R35;A38;R23;R04;R22;A28;R01;A19).

As we seen earlier, many Chinese parties had increasingly expressed a keen interest in CCS and were actively creating and sharing information with each other to create a mutual understanding around the technologies, with CCS research emerging within Chinese journals and within the Chinese Academy of Sciences and Key State National Laboratories (A11;A03;A28;R14;A31;R01). Leading the way in creating knowledge about CCS, the Chinese Government's promotion of CCS within key programmes (such as MOST's National Science and Technology Research Programme) and its openness to collaborating with international partners, particularly the activity surrounding the EU-China MoU on Clean Coal (2005), which was seen as instrumental in creating knowledge (A39;G02;R16;R04;A19;R23;A11;A28;A03).

As we saw in the previous discussion on Chinese motivations for CCS adoption, the first knowledge of an innovation is intrinsically linked to need and/or finding the solution to a problem. Rogers (2003:20,169) states that knowledge and awareness could occur passively "by accident" but often takes place through "selective exposure," where potential adopters actively initiate communications that expose them to ideas that are consistent with their interests and experiences. Also mentioned earlier, Hassinger (1959) argues that there is a form of "selective perception," whereby potential adopters would "seldom expose themselves to messages about an innovation unless they first feel a need for the innovation" and if there was no prior need then any exposure would have limited effect.

When I asked my Communications Survey participants about the circumstances they first learned of CCS (Q.5.5.), only 17 percent said they actively sought a solution to a problem, with 79 percent saying they were approached by others or learnt about it passively through other activities (Figure 5.31). When I asked what the likelihood was that CCS would succeed in resolving their problems (Q.5.6.), 84 percent said it was likely to some degree, while only 7 percent said it was unlikely (Figure 5.32.). At the organisational level, they had much more of an active need (67 percent) and less involvement from second parties (21 percent). From this, we can be sure that CCS as a concept was not only new and needed but that it was introduced to almost passive Chinese participants through both selective perception and selective exposure, which is consistent with my theoretical arguments in earlier chapters.

When I asked interviewees to provide more information on their necessity for CCS, the majority spoke of climate change and the technologies' potential for mitigation, particularly given the rise of China's emissions and the need to make large reductions by 2030 (I13;A11;R14;A25;A26;A39;A03;R36;I05;I10;A21;R01;I37;I34), although there was also a large degree of scepticism about anthropogenic climate change and the abilities of CCS over other technologies (R20;R35;A19;A03;I13;R36;A30;I10). However, as mentioned previously, these views were not fixed and the awareness of climate change grew and the levels of necessity for CCS changed as confidence in the technologies fluctuated over time (A19;R06;A30;I40). Other pressing necessities were the urgency to reconcile China's coal consumption and the coal-fired power generation (R01;I37;I13;I34), the links between national planning, economic development, increased Industrialisation, coal production, energy consumption, and CO_2 emissions (R14;I05;R06;A11;A17;R36;R22;R24;R04;A03). Additionally, there was the need to keep abreast of the latest emerging technological and future lucrative commercial opportunities, such as the CDM and future CO_2 cap and trading possibilities (A11;A08;A19;R22;I34;R04;I10;I18;G02;R01;I40;A07;R06).

A small minority saw CCS as not necessary and a distraction from other cleaner technologies and renewable energy sources (R16;A17). Some, particularly in academia, felt it necessary to work on CCS as a priority research area and in order to keep up with universities in Canada, US, and UK (A07;R01;A19;A11;A08). Ultimately, many saw their necessity set by external pressures, which would be decided by others, mainly the Government, when the time was right (G12;R16;G02;A03;R04;A11;A30). As seen in Chapter Eight, the Chinese Government is the ultimate 'gatekeeper' within the innovation-development and decision processes, through its provision of CCS-related policies and funding. Unfortunately, for the proponents of CCS, many felt the Government didn't see CCS as an urgent technological priority and that it hadn't provided what is necessary to move CCS to where it needed to be (G27;R04;A17;I37;R23;R09).

Stage Two – Persuasion (Opinion/Attitude Formation)

Rogers (2003:169) tells us that the persuasion stage usually occurs when "an individual (or other decision-making unit) forms a favourable or an unfavourable attitude towards the innovation." Holding a degree of inherent newness and uncertainty, the innovation's advantages and disadvantages are not always known or fully understood by potential adopters, this is because their initial feelings are often more important than their cognitive processes and they become more psychologically involved with the innovation. During this time the potential adopter seeks more information as a way to reduce this uncertainty, interpreting the information to suit their own situation, applying these assumptions to their real-life circumstances, and deciding which messages are credible or not. He says that often the potential adopter performs this evaluation taking their real-life circumstances into consideration, with input via expert opinion and/or subjective evaluations from peer networks and interpersonal communications. Considering mass media messages to be too general, he believes potential adopters often seek specific details to confirm their beliefs and expected consequences, as a means of social reinforcement. Usually seeking objective scientific advantages and disadvantages, they hope to identify if the innovation is a viable option to existing practices or superior to a range of alternatives and to completely understand any likely consequences. He goes on to say that at the persuasion and decision stages, near-peer network channels and interpersonal communications are usually more common, providing opinion and/or subjective evaluations based on their own personal experiences. Given potential adopters often rely on the experiences of others to substitute their own, they can be more easily accessible and convincing at this early stage (Rogers, 2003:14).

When I asked the Communications Survey respondents when they first formed (positive or negative) opinion or attitude towards CCS (Q.5.8.), the earliest date was 2000 but the majority were in 2006, 2008, and 2010 (Figure 5.35), which is consistent with the peaks of international events and activity with China that we saw in previous chapters. Asked whether these opinions were positive or negative at that time (Q.5.9.), the responses were overwhelmingly positive with only some neutral and somewhat negative (Figure 5.36.). When I asked respondents to tell me more about this during interviews, I received mixed responses. One interview said it took about one year to form a neutral opinion on CCS. After gathering more information from academic journals (such as *Applied Energy, Energy Policy, Energy)* their opinion frequently fluctuated between neutral and positive but they never felt negative towards the technologies (G02). Others agreed, saying they didn't feel CCS was positive but didn't feel it was negative either, as they took a very analytical (cost-benefit) approach to the technologies' hypothetical deployment in China and were not making any commitments or investment (A03;A30;R04;A19). Others felt they had quickly formed a positive opinion of CCS but as they gradually learnt more about the high capital costs, the efficiency impacts (energy penalties) on the operation of a power plant, and the risks of long-term storage, their attitude towards the technologies became neutral or negative (I05;R22;I13;R01;G02;A17;A03;R04;R14;R06;R20;R35;R36;R22;A25;I10;A29;R24).

Some respondents said they knew little about CCS at the beginning but the more they learned about its advantages, the more confident and more positive, particularly knowing that the challenges could be overcome (R06;R01;R22;A07;R14). Conversely, the more others learnt the more negative they became about the technologies and pessimistic about its future (A21). Others were positive and supportive of current CCS technological research but felt more negative about its actual future application (large-scale demonstration and wide-scale deployment), as China had already done a lot of work but there were still large challenges around technological maturity, economics, and public acceptance (I13;A21;I10;R06). There was also reference to the opinions of others who feel CCS is not an appropriate and/or realistic option, which can affect the attitudes of others (I05;G12;R06;A03). Although some said they ignored the claims CCS was risky or had no future and remained positive (R24;R20). A number of parties stated that, around 2009-2010, the activities of a number of international parties had directly influenced Chinese opinions to be more positive about CCS, such as the UNFCCC Conference of Parties, the IEA Road Map, CSLF and GCCSI reports (I18;R06;G02;R01;A03).

As we saw in Chapter Five, when I asked the Communications Survey respondents' opinion around possible superior alternatives to achieving their objectives (Q.5.7), 42 percent said there are, and 14 percent said there aren't, but interestingly 44 percent of respondents were unsure (Figure 5.33). By sector, government appeared to be the most convinced that there are superior alternatives, while the others all appear to have similar views (Figure 5.34.). When asked to tell me more about alternatives during interviews, some seen the Chinese Government as showing support for CCS but on the other hand only providing policies and offering tariffs, subsidies and concessions to use wind, solar, hydro, geothermal, biomass, and nuclear (A03;A17;A07;R04;I05;R24).

Energy efficiency was seen as an important option (G02;A17;I05;R04;I37) but some felt the potential for further efficiencies in the energy sector was limited and also costly (R01;A07;A38). Fuel switching to renewables, and in some cases nuclear, was seen as the second most favourable option and although it was thought that CCS might not be needed by 2030. It was acknowledged that it still needed time to develop, occupy the market, become reliable, and to become cheap enough to replace fossil fuels. It was thought that if that happens then there will be no need for CCS at all, making the technology option redundant (A17;I15;R16;R14;R01;R06;A07;A11;R04;I05;I37;A03;I10;R24;A38;R22).

After renewables, nuclear was also considered the third option but, although not costly, it was considered risky and tightly regulated, particularly after the 2011 Fukushima Daiichi nuclear disaster (A07;R20;R22;R06;A21). The final option for many was CCS, despite its potential for large amounts of rapid reductions in a short period of time (A07;A39;A19;R04;I05;A11;A17;R22;I18;A33;I13;G12). Biological carbon sequestration was considered a more natural possibility but not sufficient enough to store the sheer volume of industrial emissions (R16;R14;R20;A25). Overall, a few thought other options were suitable for European countries, but that CCS was the best option for China at that time (R01;R20;A21;A19;R23). Although it was also recognised that other options were suitable for different areas of the country (R06;R22;R23;R24;A26).

Stages Three – Decision

Rogers (2003:20-21,169,177) tells us that the decision stage takes place when "an individual (or other decision-making unit) engages in activities that lead to a choice to adopt or reject an innovation." Given the possibility of rejection at any time along the innovation-decision process, after adoption there is a choice between continued adoption (perhaps at a later date) or complete discontinuance (either through dissatisfaction and/or replacement). However, depending on the innovation, it is often difficult for individuals to change a prior decision to adopt or reject, as activities may already have commenced, opportunities might have been lost, and/or significant funds or resources might have already been earmarked or invested. Therefore, adopters often seek to prevent dissonance by seeking only information that they expect will support or confirm the decision already made (selective exposure) (Rogers, 2003:22,217).

When I asked the Communications Survey respondents when they had decided to engage with CCS in a meaningful way (Q.5.10.), there was a similar pattern of peaks (2006, 2008, 2010) that we had identified in previous questions (Figure 5.38.). When asked during interviews, many parties said they had started with CCS-related desktop studies for publication and used laboratory-sized experiments, small-scale pilots and demonstrations to prove their assumptions and to provide evidence for scaled-up research (A21;A31;I18;R14;A33;I34). As we saw earlier (Q.5.10.), 86 percent of respondents said their decision to engage in CCS-related activities had been influenced by examples, trials, or demonstrations given by other parties (Figure 5.39.). There didn't seem to be any substantial difference in the influence by sector, although we should note that industry was slightly more influenced, then government and research, followed closely by academia (Figure 5.40.). Overall, just over 50 percent of these saw demonstrations as positive and 20 percent saw them as negative, with 25 percent seeing them as neutral (Figure 5.41.). By sector, academia was the most positive, industry the most neutral/unsure, and the government the most positive/neutral (Figure 5.42). When I asked respondents to tell me more about this during interviews, I was told that, in theory, CCS was considered viable but in practical terms it was recognized that proof would be needed to build trust around the technologies (I40). This trust would only come by building confidence in the technologies through real-life trials and first-hand implementation. Whether it is an optimal, collective, authority, and/or contingent decision is also important.

Given the overwhelming focus within diffusion studies on the individual as the unit of analysis, it is often those individuals' decisions which are under investigation, without paying closer attention to their network relations at the institutional, community, or even national level (Rogers, 2003:22,125,278). For this reason, diffusion scholars have increasingly drawn attention to examine social and communication structures, as well as other variables, and to identify who exactly makes diffusion decisions. Rogers (2003:28-30,221,125-6,403) asks us to consider four possible types of innovation decisions. The first being the 'optimal decision,' where the potential adopter has almost the entire responsibility for the decision, with complete independence from others in the social system. Although such decisions are often made much faster, they are usually not free from social norms and/or communication channels. Second is the 'collective decision,' where a consensus is found among members of the social system, with conformity expected after the decision has been made. Thirdly, the 'authority decision,' where the decision is made by a few select individuals who hold status, power and or technical expertise and is the most rapid means of decision making. However, with the adopter having little or no influence in decision making, there the authority may be circumvented during implementation. Lastly, 'contingency decision,' where a sequential combination of two or more decisions (of any of the previous three types) have been made in tandem. One possible option to speed up the rate of adoption is to alter the unit of decision, so that fewer individuals are involved.

During the Communications Survey, I was keen to tease out who the real decision makers might be, whether that be the central, provincial, or local-levels of government, or down to managerial levels within the organisation and colleagues. Therefore, I asked who (or at what level) decided that the respondents would engage in CCS-related activities (Q.4.1.). Unsurprisingly, the respondents themselves came out on top by quite a distance, with higher managerial levels, but the central Chinese Government came in third (Figure 5.21.). I asked when the decision was made that they should be involved in CCS activities (Q.4.2.) and again saw the familiar pattern of 2006, 2008, 2010, and 2012 emerge (Figure 5.22). When I asked if the decision was made by others and if they were consulted at any point in the process (Q.4.3.), 81 percent responded positively and 13 percent negatively, with 6 percent responding unsure (Figure 5.23.). When asked on what date did the decision turn into action (Q.5.12.), there were similar peaks of 2006, 2008, and 2010 (Figure 5.43.).

Rogers (2003:185) tells us that the main outcome of the persuasion and decision stages is the formation of a favourable or unfavourable attitude or opinion towards the innovation but this alone cannot determine overt behavioural change towards adoption or rejection. One way to get around the uncertainty of the implementation stage is to test or trial the innovation on a partial, limited or probationary basis under specific circumstances or certain conditions. This can also be substituted by the trial of a close peer, which can also have the possibility to speed up the diffusion and adoption-decision making processes. This will be the focus of the next sections on implementation and confirmation.

Stage Four – Implementation (Innovation Use)

Rogers (2003:179) tells us that individual adoption can be relatively easy but the implementation and use of an innovation can be much less so, particularly at the organisational levels, and especially when the decision makers are often different to the implementers. Continuing for a substantial period of time, the implementation stage can be a period of institutionalisation whereby the innovation becomes a "regularised part of an adopter's ongoing operations," whereby it loses its "distinctive quality as the separate identity of the new idea disappears." Still holding a substantial degree of uncertainty over the innovation's use and the expected consequences, technical operational and problem-solving communications often take place with change agents. At least some implementation problems are likely to be created by individuals and/or organisations, so adopters of an innovation almost always attempt to make changes in the original innovation to fit their situation better.

Particularly likely to take place at the implementation stage, there are opportunities for adopters to learn more about the innovation and to customise it to fit their unique situation, thus making it more likely to suit their needs (Rogers, 2003:17,20,169,185). Often taking the form of a simplified version or through misunderstanding of its use, potential adopters might also have alternative applications to meet their true needs, thereby giving it a new meaning. There is also the potential to rename the innovation (without any fundamental changes being made in the innovation itself), perhaps in order to make it more acceptable to the local system. Additionally, reinvention may occur because a change agency influences its clients to actively modify or adapt an innovation (Rogers, 2003:186-8).

Asked during the Communications Survey if their company, organisation or institution had carried out any feasibility studies, research activities, tests or trials (or other such activities) related to CCS (Q.2.3.), 73 percent responded positively (Figure 5.12.). Furthermore, asked if they had made positive contributions which may lead to the advancement in the progress of CCS development and deployment nationally (Q.2.4.), 83 percent responded positively (Figure 5.13.). When I asked if any significant modifications, adjustments, redesigning, and/or alterations to the technologies were made (Q.2.5.), 71 percent said yes, while 23 percent said they were unsure (Figure 5.14). Those that responded positively were then asked what the reasons were for such modifications (Q.2.6.) and the majority said 'customisations to meet local needs,' 'alteration to be used for other purposes' (i.e., EOR, EGR, EBCM, or EWR), or 'changed for commercialisation and gaining profit' (Figure 5.16.).

Early CCS implementation in China took the form of pilot experiments with small amounts of funding from government-funded organisations like the National Science Foundation and CAS for frontier studies, such as the project in the Tong Liao basin, and transportable facilities like that of Huaneng (R35;R20;I05;R14). Initially, there were no domestic projects and few funding sources available for implementation through demonstration in China (A07;R35;A31). However, after some time, industry partners like Huaneng, PetroChina, Shenhua, Sinopec, CNOOC, and Shenneng, invited Chinese stakeholders the opportunity to participate in projects by offering them use of their facilities for experimental testing purposes on a slightly larger scale (RO1;A33). Although the size of these were small and the cost of large-scale demonstration much too great (A03;G27).

Much later, the Chinese government begin to provide funding to industry and began to encourage others in research and academia to collaborate on integrated experimental research at larger demonstrations projects (such as Such as the GreenGen plant, the Huaneng Gaobeidian PCC Plant, the Shenhua Ordos Project, Sinopec Shengli Oil Field, Yuhuan, and the Yancheng Oil Field, Jilin Oil fields), which provided valuable technical data for both positive and negative results and operational experiences to supported continued decision making and policy formulation and regulatory development. By acting as a coordinating body to bring Chinese stakeholders together around CCS demonstrations, arrange meetings and on-site visits, and issuing communications, there was an attempt by parties (both Government and business) to build confidence in the technologies and to construct a domestic Chinese CCS community, which we discussed in the previous chapter (R01;R06;A03;R35;I10;A26;RO4;G02;A19;A07;G27;A07;G12;R16;A21;I40;I37;A32;R22;A3).

Some said that when you know more details about the demonstrations you realise more difficulties of scaling up towards deployment and then you become less optimistic (R24;I15), while others warned against developing too many small projects or being unprepared technologically as a waste of government resources and/or having a negative demonstration effect (R01;I05;A11;A17;A19). Some felt it might be better to have one large integrated project, which might be more convincing (I40;A17;R09;A11;R16). As we had seen in the previous chapters, the technological learnings needed from the scaling up of demonstration is challenging and effective policy support and the levels and amounts of funding appeared to be a significant issue, although providing the appropriate incentives, or just those that others get, was seen as key to moving forward (R35;I05;A07;A31;R06;G15;R16; A17;I40;A11;A39;R09;I18).

With incremental technical improvements and potential cost reductions hindered by the need to test in a larger and more integrated way, many said that there needs to be effective ways to provide the evidence needed to convince others to invest and to assure the public at large that there is no risk. However, for this to happen, there needs to be an exchange of technical data and sharing of project experiences, which involves commercial sensitivities (A32;A30;I10;R16;A07;R06;R04;R22;A26;I13;R2). International cooperation was seen as crucial, although while information was available on global technical examples of demonstrations and onsite visits, not all were seen as positive and commercially potential (G02;A39;A30;A32;R35;I34;A38;R22;G27;R09;I05;A26;A07;A19;I13;A17). The EU-China COACH project was reported to provide small-scale funding for a project at Tsinghua, while CSIRO-supported Huaneng's pilot at the Gaobeidian Power plant in Beijing, which led to the slightly Shidongkou project in Shanghai. Besides Huaneng's involvement in FutureGen, there was very little opportunity to have meaningful access to international demonstrations (I05;R35;A11;R06;A21). Since 2012, similar to the situation internationally, demonstrations appeared to be slowing down or paused (I13;R09;A11;I10;R23;I18), others said they had ambitions for demonstrations in the coming few years (I10;A38;R35;A33;G27;R23;R24; I13;G12;R06;A03;G02).

Stage Five – Confirmation (Discontinuance)

Although the implementation stage might signify the end of the innovation-decision processes for many adopters, for those who have continued uncertainties it is not. At this point, individuals might seek reinforcement of an innovation-decision that has already been made, with many wanting supportive messages that will prevent dissonance from occurring. Nevertheless, some information reaches the individual that leads to questioning the previously made adoption versus rejection decision during the innovation-decision process, with some now hoping to reverse their decision (Rogers, 2003:20,169,180,189).

To test this, I asked the Communication Survey respondents if, after a period of working on CCS, they felt they'd made the right decision (Q.5.13.). Overall, 81 percent believed it to be the right decision, while 15 percent were "unsure," and four percent said "no." (Figure 5.44.). Some felt it was the right decision to begin working on CCS, particularly as they had found solutions to many of the challenges identified earlier and seen value in continuing this work (R04;R01;A03;R16;R20;R22;I13;R14;I10;A30). Others felt nothing had been proven yet, so seen less potential in the technologies' future, and their role in its advancement (A17;R01;A19). Although some said they had left CCS twice, only to return to the work on it again at a later date (R06). One thing is clear from this research, China still has some way to go before we can say it has confirmed the adoption of CCS.

Summary, Analysis and Conclusion

As the final thematic chapter of this thesis, this discussion focused on the innovation-decision process and the hierarchy of communication effects, as well as their relation to removing Chinese uncertainties around CCS adoption. It will also lead the way to the concluding chapter on increasing the rate of adoption through a hybrid model of innovation diffusion, looking specifically at the potential to accelerate the diffusion of CCS within the People's Republic of China.

Key to any diffusion study is the perceived newness of the innovation under investigation and we saw quite clearly that CCS was, to a large extent, considered new within China. Although it was not considered new to the extent that it would negatively affect its potential adoption, it was seen as a Western invention being introduced into China through international conferences and domestic events. However, as with any degree of perceived newness of an innovation, there exists a certain degree of inherent uncertainty around CCS that would require further evaluation and deliberation, which we saw taking place within the cognitive and persuasive innovation-decision process. Cognisant of the conflict between the theoretical stages of the innovation-decision process and the non-linear reality of decision making, I learned from Rogers to investigate the hierarchy of communications channels and the different types of CCS information, as well as their possible effects on adoption.

Beginning with the Chinese social system's initial knowledge/awareness of CCS, it was important to look both at the need for the innovation and whether or not that need was created by an external change agent. We learned from the Communications Survey that knowledge of CCS was most prominent between 2005 and 2012, which aligned with my findings from the secondary-sourced publications and the peak of CCS-related literature within the social sciences. Contrary to Rogers' assumption that mass media communications campaigns are more effective at the knowledge stages and interpersonal more effective at for persuasion, we saw an almost equal split between interpersonal connections (academic supervisors and research partners), engagement activities (multilateral agreements and international conferences with interactive meetings and site visits), and mass media channels (international academic journals and periodicals). Recognising that many of these channels included elements of both one-way/linear and two-way/convergent communications, that many respondents carried the concept of CCS back to China to create localised/horizontal learning networks, and that Chinese parties were actively creating and sharing information with each other to create a mutual understanding around the technologies, these are all consistent with my overall research proposition for the existence of a hybrid model of diffusion.

In terms of necessity for CCS, Rogers (2003:20,169) said that knowledge and awareness could occur passively by accident and there was clear evidence of that from the Communications Survey, as almost four fifths of respondents said they were approached by others or learnt about it passively through other activities. Although, to be fair, after they had gained knowledge, the vast majority said CCS was likely to succeed in resolving their problem. Interestingly, the active need for CCS was much higher and the involvement by second parties much lower at the institutional/organisational level, which tells me that change agents might want to first focus on passive individuals. As seen in the previous chapter, CCS was primarily viewed as a tool for climate change mitigation, while also important for reasons of Chinese energy security, economic productively, technological development, and commercial opportunity, which undoubtedly assisted its development and diffusion. However, continued competition with superior alternatives and a lack of concrete government support by policies and financing did little to speed diffusion and further work was needed to persuade Chinese parties to fully adopt.

In terms of persuasion, it appears that there was a period of around one year between the knowledge stage and when respondents first formed an opinion of CCS, which again aligned with the flurry of international activity within China. Almost always initially forming positive opinions, these could rarely be described as static and quite often fluctuate based on new information. Some respondents quickly became more negative or neutral towards CCS as they received more evidence of the barriers towards the technologies' application and others who became more positive and confident when they found ways to overcome the challenges through further analysis and engagement. It appears that the opinions of other influential domestic stakeholders were critical in providing support and securing funding but some see these parties are unfamiliar with CCS and needing to better understand its potential. International parties were seen as equally important to persuading potential adopters to progress. Crucially, as we saw in the previous chapter, CCS does not exist within a vacuum and a majority saw alternatives to achieving their objectives or were uncertain of the technologies' superiority. Although much of this seemed to be based on the Chinese Government lack of signally concrete support through policies and subsidies, which might put CCS on a level playing field with other low-carbon energy technologies.

Given the Government's crucial role in the Chinese adoption of CCS, it was important to look at their influence within the domestic innovation-decision process. It was clear from the Communication Survey responses that almost all respondents had a role in deciding whether they would engage in CCS-related activities, with four fifths saying they had been involved in the decision-making process. However, with higher managerial levels and the central Chinese Government prominent too, this makes the 'contingency decision' (a sequential combination of two or more decisions) most common. During the decision stage, it appears that many respondents had started almost immediately to begin by engaging in CCS-related desktop studies, laboratory experiments, small-scale pilots, and demonstrations with the objective of proving their assumptions and providing evidence for scaled-up research. However, a huge number confirmed that their decision to engage in these activities had been influenced by examples, trials, or demonstrations given by other parties, with around half seeing these as positive, a quarter as negative, and the rest as neutral. Significantly, the key message that emerged from interviews was the need to look beyond the theoretical understandings of CCS and to build trust and confidence around the technologies through real-life trials and first-hand implementation in China.

With regard to implementation, almost three quarters of Communication Survey respondents said their company, organisation or institution had carried out some kind of feasibility study, research activity, test or trial related to CCS, with a vast majority saying they have made positive contributions to the advancement of CCS development and deployment within China. Importantly, almost three quarters said they have made significant modifications, adjustments, redesigning, and/or alterations to CCS, most frequently to customise the technologies to meet local needs or alter them for commercialisation and to gain profit. This is consistent with what we have learned in previous chapters about China's focus on utilisation and provides further insights into the motivations of the early adopters, particularly those we previously described within the innovation-development process R&D stage. It appears to have been lead users, such as Huaneng, PetroChina, Shenhua, Sinopec, CNOOC, and Shenneng, that had invited Chinese parties to participate in domestic projects, offering them use of their facilities for experimental testing purposes on a slightly larger scale.

Similarly, although not yet offering comprehensive policies or funding, the Chinese Government appeared to have encouraged stakeholder groups to congregate and collaborate around integrated-experimental research at many demonstrations, intended to provide the data and experience needed to reduce technical uncertainties, costs, and risk over time, while providing opportunities for operational experience to build the confidence in CCS and attract investors in due course. However, one thing was clear, that there was still a need for China and the International CCS Community to learn from each other. Therefore, it is important for us to recognise that decision making is indeed shared by technically-expert officials near the top of the diffusion system with those who may or may not wish to adopt, again demonstrating the existence of a hybrid model of diffusion.

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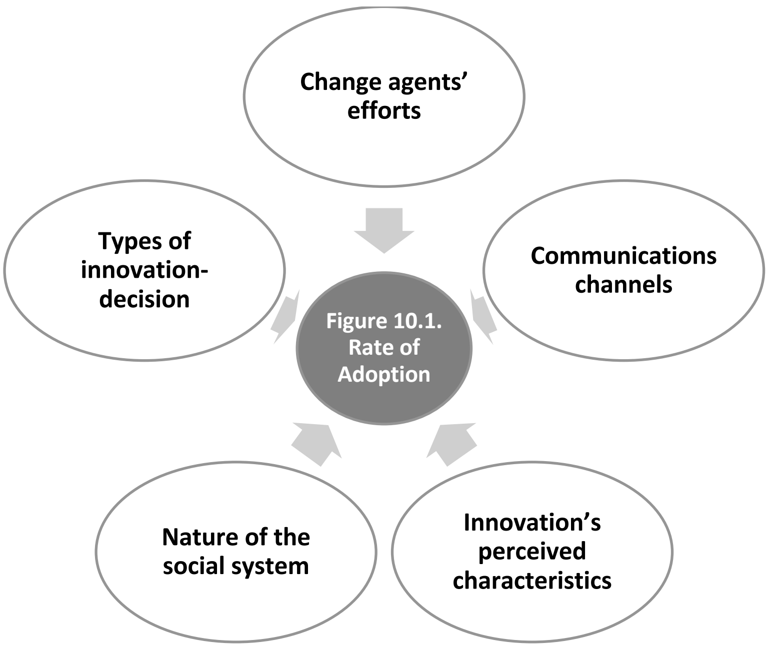
Chapter Ten: Conclusion – Increasing the 'Rate of Adoption' through a 'Hybrid Model of Innovation Diffusion' – Accelerating the deployment of CCS within the People's Republic of China

Drawing on many of the concepts and findings from previous chapters, this final concluding chapter focuses on increasing the rate of adoption through a hybrid model of innovation diffusion, looking specifically at the potential to accelerate the deployment of CCS within the People's Republic of China. Presenting my hybrid model of innovation diffusion for CCS, this holds the potential to be used for the diffusion of other technological innovations within China and may be applied to other similar social systems.

Rate of Adoption

According to Rogers (2003:20,213-5), the 'innovation-decision period' is the length of time it takes for an adopter to pass through the innovation-decision process, from first knowledge, to decision, to adopt/reject, which could last days, months, or even years. He tells us that this may continue as far as seeking confirmation from others that their decision to use an innovation was the right decision. Although measuring this is often impractical, if not impossible, as it might continue over an extended period of time. Intrinsic to their role, most change agents seek to speed up this process by introducing the innovation to the greatest number at the earliest point in time or by shortening the period of time within and between the stages of the innovation decision process. Typically measured by the number of adopters over a given time frame, the rate of adoption within a social system can then be assessed through five key variables (Figure 10.1.).



Having already discussed these five key variables in previous chapters, the focus of this last and final chapter will be to integrate these five elements in a discussion of how international entities (the change agents) have employed various types of soft governance (communications channels) to diffuse different kinds of CCS-related information (the perceived characteristics) that have influenced Chinese adoption of CCS (the social system's decision-making processes). Importantly, I argue the existence of a hybrid model of diffusion (Figure 10.2.), which would allow all parties to find a common language and to communicate around the technologies that would provide the potential of quickening technological development, demonstration, and deployment. As mentioned at the beginning of this chapter, this holds the potential to be used for the diffusion of other technological innovations, perhaps within China or other similar client social systems. Following the same structure as this thesis, I begin with international change agents.

Change Agents' Efforts

In Chapter Six, I built on the work of prominent scholars in this field, such as Meadowcroft and Langhelle (2009), de Coninck and Bäckstrand (2011), and Stephens and Liu (2012), to further understand the International CCS Community's structure, functions, and communications, as well as its influence on international policy processes.

I learnt from Torvangerm and Meadowcroft (2011) that national governments seek to find the most timely and cost-effective pathway towards GHG emission reductions but face great uncertainties on which technologies to dedicate their limited resources. From this, there is an undeniable need for enhanced global governance, multilateral cooperation, and bilateral collaboration, with increased learning and information sharing to speed the advancement of CCS towards deployment globally. Previously recognised by de Coninck and Bäckstrand (2011), the growing diversity, overlap, and fragmentation within the international CCS community meant that different parties could intervene to provide different governance functions at different periods of time. Around the same time, Hagemann *et al.* (2011) also noted the over-reliance on soft governance functions as opposed to financial support, while also presuming China to be a willing adopter of larger-scale demonstration. However, this was an area that had yet to be studied, until now.

Through the combination of primary-source survey and interview data, which was complemented with secondary-sources to develop case studies (Annex), I identified the structure of the International CCS Community (Figure 6.5), which has now been integrated into my "Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of CCS within the People's Republic of China (PRC)" (Figure 10.2). As identified by de Coninck and Bäckstrand (2011), many of the international organisations played unique but complementary roles in the diffusion within China. For example, the IPCC's work had contributed to gradual normative shifts towards a greater acceptance of CCS in the global south and my research saw strong evidence of this in China. Similarly, the IEA's strategies and targets for demonstration reverberated throughout political summits and technical and policy publications at all levels, which sought to significantly increase engagement with non-OECD developing countries in an effort to influence national policies and plans.

From the outset, this research saw CCS emerging from the motivated expert sources in the industrialised western contexts, with a necessity to engage with emerging economies and developing countries through more localised horizontal networks in order to maximise opportunities for global learning and information sharing, particularly towards demonstration. At the same time, we saw the same group of western industrialised nations and organisations create a multitude of international mechanisms, which I have identified as diffusion networks. Providing opportunities for more frequent and effective interactions between the developed and the developing countries, these homophilous partnerships have been successful in building trust and increasing credibility, while providing opportunities to change the opinions of potential adopters. As distinct opportunities, all of these CCS-related diffusion networks had the common goal to obtain learnings and share lessons, as well as creating the conditions for global demonstrations.

At the same time as undertaking multilateral and multi-national activities through diffusion networks, there is clear evidence that at least six western-industrialised nations have displayed clear change agent behaviours with an overt desire to influence Chinese parties' adoption of CCS. Most notably these country's established information exchange relationships through bilateral programmes and projects (Figure 7.2), which were innovatively designed to create an equal partnership and a level-playing-field with China. Although much progress had been made through these bilateral activities, many appeared to hit limitations when it came to the reality of the costs of constructing and operating a large-scale commercial demonstration. Quite often leading or participating in bilateral initiatives or projects, some paraprofessional aides supported China's early pilot and demonstration activities and even acted as a model for how to organise partnerships domestically. From what we see here, we can confidently say that the messages regarding CCS have originated from motivated expert sources, while also being diffused through localised sources along horizontal networks, thus demonstrating the existence of a hybrid model of diffusion, validating my proposition for a hybrid diffusion model (Figure 10.2).

Communications Channels

In Chapter Seven, I responded to the call from Bäckstrand *et al.* (2011:277) and Stephens and Liu (2012:146-148) to move beyond communications studies related to public perception and to investigate the multitude of new communication mechanisms within the CCS community. By delving deeper into the CCS-related soft governance activities to better understand how international parties cooperate, collaborate, and communicate to influence Chinese decision-making processes, I first focused on the change agents' communications campaigns that sought to bring about behavioural change and to produce identifiable outcomes. Although one-way/linear communications were present and played a positive re-energizing role, so too were two-way convergent channels, most commonly in the form of bilateral meetings, symposiums, and workshops, which had the ability to identify joint objectives and reach consensus on the way forward. Joint working group action plans, policy assessments, small pilot projects, and road-mapping exercises, were all centred around the exchange of information and experience sharing towards removing technical uncertainties and policy hesitations and creating the Chinese conditions and confidence for a CCS demonstration. Importantly, we saw clear evidence that increased contact and communications forged closed interpersonal connections and triggered interpersonal networks that have lasted for some time.

Already mentioned earlier, de Coninck and Bäckstrand (2011) had recognised that different parties could intervene to provide different soft governance functions at various intervals to suit their intended objectives, which we have seen clearly during this research. Similarly, Hagemann *et al.* (2011) had also noted the International CCS Community's special interest in China and the focus on setting technical directions, facilitating information exchange, and building networked partnerships, although he didn't look at this in any great detail. With both scholars, perhaps seeing the overreliance on soft governance as the international community's strategic weakness to strategize and a failure to make an impact, we should not forget the advice from Vallentin's (2007) to pay more attention to the international cooperation and collaboration around the learning and sharing and Lai *et al.* (2012) to look at the flow of knowledge through social networks and interaction of actors in the innovation process.

Identifying 205 cosmopolite communication channels, I had categorised these into eight different types of mass media, linear, and knowledge channels (Figure 7.7) and eleven types of interpersonal, convergent, persuasion channels (Figure 7.9), each having different impacts and levels of influence on the Chinese CCS decision-making process. As we saw through the previous chapters and the case studies (Annex), the volume and intensity of interactions and the multiple influences on Chinese decision makers at all levels have clearly had an impact on decision making. Targeted and tailored, these communications hold the potential to foster legitimacy, to gain group consensus more widely, to mobilise the vital resources needed to increase the chances of the technologies' long-term acceptance. These have now been integrated into my "Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of CCS within the People's Republic of China (PRC)," again validating my proposition for a hybrid model of diffusion (Figure 10.2).

Innovation's Perceived Attributes

Chapter Seven also looked at the perceived characteristics of CCS and we have discussed how the technologies have been received by the Chinese social system through both the innovation-development and innovation-decision processes, within the final two chapters. Having a huge impact on the rate of adoption, it would be beneficial for the proponents of CCS to ensure their messaging around CCS is consistent with their objectives. Although not a structured study of CCS discourse, I used my analysis of the supplementary literature and secondary-source case studies to identify the key messages around the technologies' relative advantage, compatibility, complexity, trialability, and observe-ability (Figure 7.20). This has now been integrated into my "Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of CCS within the People's Republic of China (PRC)" (Figure 10.2). Needless to say, it would not be beneficial to further elaborate on these messages at this late stage but for those who might want to diffuse CCS, I would encourage them to consider using these messages, or similar, when they engage with potential adopters. Similarly, I would urge them to avoid messages and communications which might unintentionally lead to the categorisation of CCS as a preventive innovation, thus reducing its relative advantage and limiting its ability to be rapidly diffused. From what we have seen in previous chapters, CCS is highly compatible with Chinese conditions and there is an unquestionable need. Therefore, I would encourage change agents to use only those storylines that demonstrate the rationality of adoption.

Nature of the Social System

As we learned in Chapter Eight, CCS presents many opportunities for China and we saw in the earlier chapters that Chinese parties have been actively engaging with international partners around the technologies. However, as eloquently put by Jaccard and Tu (2011:411), we should recognise that China has been "showing enthusiasm but not too much," which has caused confusion and frustration for those seeking to diffuse the technologies within the country. Providing a comprehensive qualitative assessment of China's appetite for CCS and Chinese parties' motivations for engaging with the technologies, we discussed the prospects for future domestic demonstration and deployment. However, although we can describe the Chinese CCS community as a social system engaged in collective learning, it became clear that it lacks a common and mutual goal, which presents a challenge for the CCS as the innovative solution to everyone's problem. Crucially, for the technologies to progress along the innovation-development process, there is a need for to bring the various stakeholder groups together, which is to create and share information along the domestic innovation-development process in order to create a mutual understanding of CCS, and to find a way to come together to take the technologies towards demonstration and deployment.

As we have seen previously, it appeared that Chinese stakeholders had initially characterised CCS as a preventative innovation, making its motivations for adoption somewhat weaker and its potential diffusion both slower and more difficult, perhaps even impossible. Fortunately, for the technologies' advancement, we also saw signs of Chinese parties linking CCS to more current domestic problems, such as fuel consumption and energy production, which demonstrated how the technologies can be part of the solution to problems today. Quite positively, some saw CCS as the ultimate solution to resolve challenges related to China's coal consumption and national security, having a bright future that would allow China to continue to use fossil fuels in a secure and sustainable way, which for them made adopting the technologies completely necessary. It was at this point that I further realised that when seeking to diffuse CCS within the Chinese CCS Community as a social system, proponents of the technologies should not only emphasise their ability to 'promote public welfare' but should simultaneously appeal to Bordenave's (1976) other motivations for adoption (Table 8.4). Contradicting Rogers' (2003:67,23-4) assumption that an innovation seeks to solve "one common problem" or reach a "mutual goal" which binds the social system together, we need to bear in mind that CCS responds to many different but interrelated problems as it moves through the Chinese CCS innovation-development process and find a solution if the technologies are going to make their way through to commercialisation and widespread deployment.

Despite the indignation from senior Chinese figures, it seems they weren't able to hold back the wave of Chinese interest in CCS technologies, and there was a plethora of both international cooperation and domestic collaboration, which we saw in previous chapters. There were many examples of researchers and academics working together with industry to create and share information about CCS and early signs of the formation of the Chinese CCS Community. However, we also saw systematic research failures, inadequacies and inefficiencies that affected the move of CCS technologies from the R&D stage to commercialisation. There were also particular challenges around demonstrations, with the need to urgently scale up the trialability and observability of CCS under real-life conditions through large-scale fully-integrated and commercially-viable projects. However, for this the Chinese CCS Community would need Government support.

Although the Chinese Government played an important bridging role at the international level and coordinating at the domestic level, the lack of an overarching authoritative institution made it difficult for Chinese parties and for CCS to move forward. Additionally, despite promoting CCS demonstration at the strategic level, there was a clear position of neutrality when it came to supporting the technologies with policy formulation and funds. Many saw it as the responsibility of Government and industry to pay the cost for mitigating climate change but were realistic that the initial high costs and few immediate returns made this both challenging and unlikely. As we saw, this highlighted the need for policy interventions to bring these aspects into alignment, one that would be equally as acceptable to all the stakeholders involved, which would emphasise the relative advantages of CCS over its competitors. From what we had seen, it was clear that different behaviours within the Chinese CCS Community, as a social system, were important in either facilitating or impeding the development and diffusion of CCS within China. Importantly, for CCS to move along the innovation-development process towards and past commercialisation, there is a need to take account of the different motivations and to find a common language of mutual meaning and purpose for the technologies. This has now been integrated into my "Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of CCS within the People's Republic of China (PRC)" (Figure 10.2).

Types of innovation-decision

Finally, the innovation-decision process has taught us a lot about the Chinese parties' adoption experiences and we learned that CCS was perceived as new, although not so new that it would be difficult to be adopted. Described as a foreign concept, imported via international conferences and domestic events, it was the interpersonal connections that appeared to have the biggest role in knowledge and awareness, despite Rogers' assumptions on the role of mass media channels. Once introduced by international parties, it was clearly more localised/horizontal within China, as Chinese parties began actively creating and sharing information with each other. Despite being viewed as necessary, the majority of respondents were approached by others or learnt about it passively through other activities and it failed to shine amongst its superior alternatives. It appeared as if those who engaged with it became either more positive or negative and opinions fluctuated over time, mainly due to the messages they were receiving from mass media sources and signals from the Central Government, or lack thereof.

In terms of decision making, it was clear that respondents had a key role in the decision making, particularly when it affected their participation in CCS activities. However, there was also a decision-making role for their higher managerial levels and the central Chinese Government too. Deciding almost immediately to engage in CCS-related desktop studies, laboratory experiments, small-scale pilots, and demonstrations, many had confirmed that their decision had also been influenced by examples, trials, or demonstrations by others. With the vast majority saying they have made positive contributions to the advancement of CCS development and deployment within China, many also claimed to have made significant modifications, adjustments, redesigning, and/or alterations to CCS.

Significantly, many felt they had made the right to engage in CCS activities, either because they had resolved their uncertainties or they still saw hope in removing their hesitations.

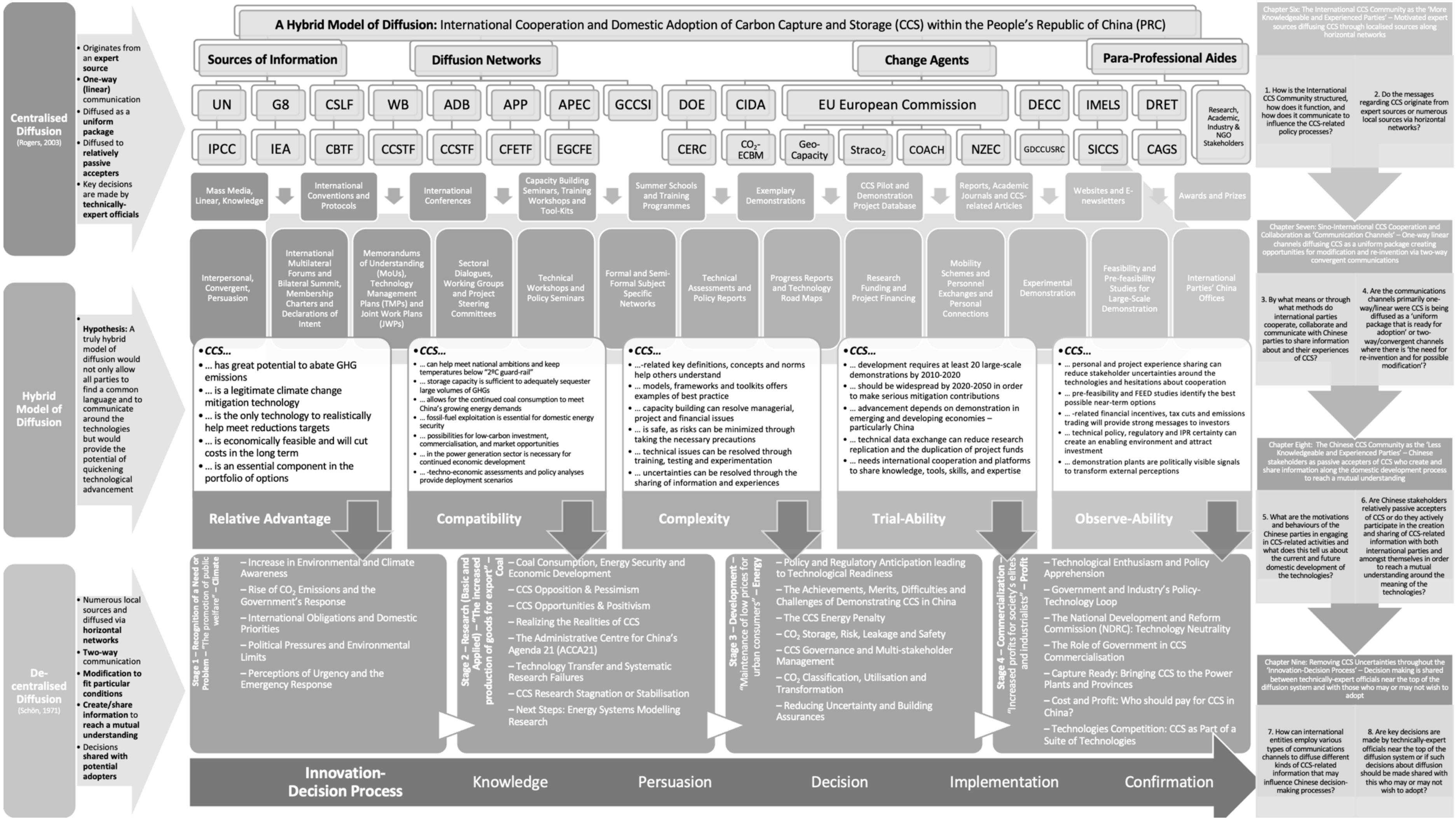


Figure 10.2. A Hybrid Model of Diffusion: International Cooperation and Domestic Adoption of CCS within the People's Republic of China (PRC)

Hybrid Model of Diffusion

The ultimate theoretical objective of this research was to apply Rogers' DOI theory (2003) in the context of international CCS cooperation with China and to adapt and develop the DOI paradigm to demonstrate the existence of a truly hybrid model of innovation diffusion.

Earlier scholars, such as Blaut (1987) and McMaster and Wastell (2005) criticised Rogers and diffusionism as a form of elitist colonialism where linear channels are used to communicate pseudo-scientific arguments in order to influence a subject community. Roger's (2003) thinking is that diffusion is centralised, with expert sources using one-way (linear) models of communication, to diffuse an innovation as a uniform package to relatively passive acceptors, with decisions made by technically-expert officials near the top of the diffusion system. Conversely, Schön's (1971) thinking is that innovations emerge from numerous local sources and evolve as they are diffused via horizontal networks. This involves two-way convergent models of communications with a degree of reinvention occurring as the innovation is modified to fit particular circumstances. This also involves the creation and sharing of information and for decisions to be shared by those who may or may not adopt.

Going against their thinking, this study found that a truly hybrid model of diffusion *does* exist and that it has the potential to hasten the speed of adoption, if employed appropriately. The idea of a 'hybrid diffusion system' directly challenges Rogers' assumption of linear, western, and elitist propositions of innovations. Importantly for the advancement of CCS, a truly hybrid model of diffusion can allow all parties to find a common language and to communicate around the technologies more effectively, thus holding the potential to remove any uncertainties and hesitations they might have. This has the very real-world potential of quickening technological development, demonstration, and deployment.

Separating my research areas into four theoretical themes (Figure 3.2.), my goal was to adapt the DOI theory and apply a range of its concepts to the international diffusion and domestic development in China. Key to this, however, was to investigate both Rogers (centralised) and Schön's (decentralised) ideas around diffusion models.

Looking firstly at the 'more knowledgeable and experienced parties' (the International CCS Community). When investigating whether CCS had emerged from expert sources (a centralised diffusion system) or numerous local sources and diffused via horizontal networks (a decentralised diffusion system), it should be recognised that it was the UK who first raised the political profile of CCS through the G8 and called for other OECD countries to work together for its development. However, it should also be recognized that the IEA and others determined that significant numbers of demonstrations would be needed in emerging economies, such as China. Failure to convince developing countries within the climate negotiations of the value of including CCS within the CDM, the UNFCCC was no longer seen as a viable forum to advance CCS. This led to western parties stepping outside to create initiatives with like-minded countries in order to further their own or mutual interests, which created diffusion networks to work on issues related to CCS. Quite often these initiatives included both more developed-country partners (who faced challenges advancing CCS demonstration within their own borders) and developing country partners (who held the conditions and potential to demonstrate themselves).

Although being homophilous in many ways (such as with fuel production, energy consumption, GHG emissions, and/or geographical conditions), the more-knowledgeable western-industrialised countries were able to offer China CCS-related technical information and policy experiences, as well as small amounts of funding, which is what made them more heterophilous. In return, it appears the primary motivations of most of these countries and their networks were to persuade China to undertake actions and activities that would lead towards domestic CCS demonstration and to develop trusted relationships that would offer them the possibility to gain near-term technical learnings from these large and expensive experimental platforms, while also laying the groundwork for potential technology transfer and/or commercial opportunities in the future. Taking the complexities of this heterophilous relationship and co-existing homophilous partnership into consideration, it is fair to consider this to be a hybrid model of diffusion.

Exploring the second theoretical theme of 'communications' and applying the concepts of 'campaigns,' 'channels,' 'exemplary and experimental demonstrations,' as well as 'perceived characteristics,' the goal was to uncover whether or not international CCS engagement with China demonstrates a centralised (one-way/linear models were the innovation is being diffused as a uniform package), decentralised (a two-way/convergent model where there is a degree of reinvention occurring as the innovation is modified by users to fit their particular conditions), or a truly hybrid model of diffusion. It is clear that the change agents (and their diffusion networks) identified have been engaging in interventions with coherent objectives in an attempt to bring about behavioural change in order to produce identifiable outcomes. Although it can be argued that they do not follow the conventional appearance of a 'communications campaign,' they definitely are sets of organised activities and messages with the intent to have specific effects on the part of a relatively large number of individuals within a specified period of time and through an organised set of communication activities. From the examples presented, we see a series of one-way/linear communications that promote CCS as a uniform package that is ready for adoption, which represents a centralised system of diffusion. Alongside these, we also see examples of 'two-way/convergent channels of communications' whereby international and Chinese partners are proactively seeking solutions to problems and actively looking for ways to reinvention and possibly modify the innovation, which are elements of a decentralised diffusion system. What both systems have in common is that they both seek to speed up the diffusion, development, and deployment of an innovation. Therefore, a truly hybrid model of diffusion does exist in emerging economies like China.

When investigating the Chinese CCS community, the opportunities and challenges for CCS development within China, it is important to explore whether Chinese stakeholders are relatively passive acceptors of CCS (a centralised diffusion system) or whether they actively participate in the creation and sharing of CCS-related information with both international parties and domestic stakeholders to reach a mutual understanding around the meaning of technologies (a decentralised diffusion system). By employing Roger's theoretical theme of the 'less knowledgeable and experienced parties' and by looking in-depth at the Chinese CCS community as a 'social system,' I explored a "Chinese CCS innovation-development process' and 'instrumental actions and motivations,' in an attempt to better understand the real-world opportunities and challenges for CCS within the country through the experiences of those I have interviewed. Crucially, it is important to go back to reconsider Rogers' (2003:67,23-4) idea of the "collective learning" social system that cooperates at least to the extent of seeking to solve a common problem or reach a mutual goal, which binds them together. Through this study, we have learned that different stakeholders and motivations are more prominent at different stages of the innovation-development process, which has caused considerable communicative issues and has impeded the diffusion of CCS within China. Key to this, however, is the fact that there are varied instrumental actions of CCS for different stakeholders including a preventive climate change response for some, a key tool to protect national interests, a means to keep the lights on, or a profitable business opportunity for others. Ultimately, as gatekeepers, it is up to the Central Government (through governance, finances, policies or project management) to define the meaning and purpose of CCS for these relatively passive acceptors and to maintain their interest long enough to facilitate the technologies' development and diffusion in China. However, for this, they might also need to be convinced, perhaps through more targeted innovation-decision process interventions.

With regards to CCS-related decision making, when considering whether 'key decisions are made by technically-expert officials near the top of the diffusion system' (a centralised system) or if 'diffusion and decisions are shared with those who may or may not wish to adopt' (a decentralised system), it is safe to say there is the potential for a truly hybrid model of diffusion, but does not seem to be functioning well at this time. With the new concept produced from external forces, the desire to adopt CCS appeared to be greater at the organisational levels with the potential for top-down decision making. However, there were also very high levels of engagement at the individual level and consultation over adoption. Unfortunately, despite their very central role in the development and decision-making process, the Government's overall neutrality towards CCS seems to have prevented parties finding a common language, ultimately slowing the diffusion process.

In conclusion, there are definitely signs that CCS is being diffused from outside of China, while the international CCS community has been engaging with Chinese parties through horizontal diffusion networks and bilateral communications campaigns. Chinese stakeholders have reported the influence of international one-way linear forms of communications on their decision making, while also working closely with foreign partners to unlock the challenges of CCS development and explore new uses for the technologies. When it comes to whether or not the Chinese CCS community are passive acceptors, they certainly do have hesitations but generally they are positive and active in their CCS activities, although they face huge challenges with regards to policy support. With diffusion decisions made on a contingent basis, there is a need for the Central Government to be decisive about CCS and supportive if they are serious about employing CCS to reduce the country's carbon emissions.

To conclude, a truly hybrid model of diffusion would not only allow all parties to find a common language and to communicate around the technologies, but also provide the potential of quickening technological development, demonstration, and deployment.

Research Limitations and Opportunities for Further Investigation

While I feel I have taken the right approach through this research, looking retrospectively, there are a number of things I might have changed. Taking an overly ambitious approach by looking at international diffusion from the perspective of 40 potential Chinese adopters, I might have started with focusing on only one change agency and with those they had collaborated and communicated. Although this would not have provided such rich research data and significant findings, it might have provided a more nuanced understanding of the impact of an organisation's influence and their impact on individual adoption. Such a contained and narrow analysis might be the focus of future studies, now that I have collected my data. As mentioned earlier, going well beyond the boundary of this investigation, this was not a study of CCS discourse analysis, although there is potential to carry out further investigations into the provision of CCS-related messages and their true impact on technological adoption. Having looked at the diffusion of CCS within China, it would be interesting to further investigate what international parties have gained from their efforts and whether any lessons learned in the Chinese context have impacted their own domestic activities. At the time of investigating international cooperation, there were still no significant developments in China. Although, as Chinese parties move closer towards demonstrations and deployment, there might be interesting areas to study. In particular, there is a huge potential to further investigate the processes around Chinese demonstration and how global learning and information sharing can accelerate the global deployment of CCS. Finally, now that I have identified the existence of a hybrid model of diffusion, a particular area of further study could be if the model is adopted in the diffusion of other technological innovations within similar social systems.

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Annex: Case Studies

These case studies are centred around the key international entities that emerged as prevalent within my interviews and thus highly relevant to investigate further. Information from these more comprehensive case studies were used to inform the analytical and concluding chapters, particularly Chapters Six and Seven, as well as the conclusion.

Case Study I – Intergovernmental Panel on Climate Change (IPCC)

Established by the World Meteorological Organisation (WMO) and UN Environment Programme (UNEP) to "provide policymakers with regular assessments of the scientific basis of climate change, its impacts and future risks, and options for adaptation and mitigation," participation in the IPCC is open to all member countries for participation (IPCC, 2013). As each country nominates experts to comprise the IPCC Bureau, it is essentially a large transnational network with hundreds of scientists and knowledge-brokers, many of which already had prior contact and communications and held scientific authenticity and/or political authority (de Coninck *et al.*, 2011:370-371). Although being appointe, they volunteer their time and expertise to provide "comprehensive and objective and produced in an open and transparent way," while undergoing "multiple rounds of drafting and review" (IPCC, 2013). The knowledge, experts and networks are often drawn from other organisations. Seen as a possible technocracy (whereby decision-making is heavily informed by a wider range of technical experts, scientists, modellers, and specialists, that play a key role in formulating policy by providing assessments, evaluations and identifying options), some believe the pressing challenge of anthropogenic climate change is just too big to be left in the hands of interest-driven politicians and potentially uninformed policy makers (Markusson, 2012:256-257).

Although the IPCC had already carried out an assessment of CCS within the "Second Assessment Report" (1995), this didn't fully endorse the technologies as a viable option for mitigation and the IPCC had expressed reservations over technical and environmental uncertainties (Winskel, 2012:209). During the preparation of the "Third Assessment Report" (2001), the IPCC's confidence in the technologies' viability appeared to be growing, which led to the calls by the Subsidiary Body for Scientific and Technological Advice (SBSTA) during the 'Seventh Conference of Parties (COP7)' for further and more thorough investigations into the technologies' potential. With a 2002 Regina workshop serving as a review of the research to date and concluding that more needs to be done, this then kick-started the process that would eventually produce the 2005 "IPCC Special Report on CCS" (IPCC SR) which would elevate the technologies as a "focal issue in international climate diplomacy and energy collaboration," and bring them into the energy and climate policy mainstream (Meadowcroft *et al.*, 2009:5-7, Langhelle, 2009:241; Van Alphen, 2011:82; Vergragt, 2009:201). Additionally, the activities surrounding the report's writing also created national collectives and networks of scientists and researchers, with the US participants having both a direct and indirect influence on the national agendas and research funding (Stephens *et al.*, 2009:38).

Strikingly, de Coninck *et al.* (2011:370-371) see the writing of the IPCC SR as “the first capacity-building effort on CCS because its authorship group contained many researchers from developing countries” who benefited from participation in the lead author meetings and writing process. Noting that the IPCC SR has been a prime example of constructivist discursive approach that has created a gradual normative shift towards greater acceptance of CCS as a low-carbon option, states, governments, industry, organisations and other stakeholders were believed to have shaped their preferences for CCS (de Coninck *et al.*, 2011:368-376). However, despite the IPCC SR being “welcomed” at COP11 and subsequently doing much to increase support for CCS, the IPCC still maintains that its assessments are “policy-relevant but not policy-prescriptive” (IPCC, 2013). Leaving CCS-related discussions in 2006, the IPCC remains in the conversation but most of its role is now considered to be being performed by the IEA (de Coninck *et al.*, 2011:375-377).

Findings:

- Besides its obvious attributes as a source of technical information for the Chinese stakeholders (who had a technical interest and queries around the workings of the innovation), the IPCC SR also provided China-specific information on the need and feasibility of CCS within the country (A03;I37;I05).

- Seen as a catalyst for not only introducing people to CCS, it also moved peoples’ interest around the technologies as a viable third option for emissions abatement (the others being energy efficiency and new or renewable energy sources) (R24;A11;R04).

- However, the influence of the IPCC SR on China’s adoption of CCS had already begun before its publication. Some time prior to the writing of the report, six key Chinese experts in fields relevant to CCS were selected by senior Chinese officials to take part in the report writing process, with an additional four Chinese experts reviewing its content. While not all of these appointed experts went on to continue to work in the area of CCS after the report was published (with one reportedly not even remaining until it was completed). For some Chinese experts, this early engagement in the IPCC SR writing process led to a long and dedicated career towards CCS research and their efforts to see domestic development and deployment of CCS within China. Learning from and building long-standing relationships with other leading international experts from international organisations, these parties continued to provide technical assistance for China-specific studies and Chinese domestic CCS projects. Perhaps unexpectedly, one key outcome of their involvement with the IPCC SR has been their own role in actively promoting CCS within China and in positively activating domestic Chinese networks around the technologies (R24;R23).

Case Study II – United Nations Framework Convention on Climate Change (UNFCCC)

Despite no single UN institution governing CCS, there have been many UN agencies, UN conventions, and UN protocols, as well as mechanisms, that have either directly impacted or have had implications for the technologies' global advancement. None have played an active role in promoting CCS and all have remained formally neutral towards the technologies, their development, and their future deployment possibilities. However, as the all-important forum where national states come together for collective action on climate change, the UNFCCC was seen as the most legitimate, efficient, and cost-effective forum for CCS to emerge (de Coninck, 2011:375). Unfortunately, although awareness of CCS and recognition of its capabilities had been growing within the UNFCCC (IEA, 2016:38), gaining political support for the technologies within the international climate change negotiations had not been easy (de Coninck, 2011:370-375).

Emerging during COP7 (2001), when the SBSTA invited the IPCC to investigate the technologies' potential (IPCC, 2002:3), the IPCC SR (2005) was "welcomed" under the UNFCCC and formally included as a legitimate mitigation option at COP11 (Meadowcroft *et al.*, 2009:5-6; Ward, 2011:18-20). However, there were also calls for greater technical certainty and regulatory clarity before CCS could be included with the CDM. This was due to significant hesitation and even opposition from those outside the OECD countries, despite the best efforts by interested fossil fuel entities (such as Saudi Arabia), which only caused increased suspicion (de Coninck, 2011:376, Zakkour *et al.,* 2014:6949). During COP14, Australia and the IEA led a coalition of countries calling to permit CDM Certified Emissions Reductions (CERs) to be earned through CCS projects, although a collective of emerging economies and developing countries (led by Brazil) blocked such moves by calling for a more cautious review of the environment and health implications of CCS, while was also partially politically and economically motivated.

A primary reason for this stalling was the belief that CCS within the CDM would divert efforts away from promoting a truly low-carbon economy towards creating further subsidies to enhance fossil fuel production (Evar *et al.,* 2012:29). With the widely recognised failure to generate a strong commitment for global carbon mitigation and technology transfer at the COP15 (2009), the climate change negotiations were then believed to be entering a period of chaos (Duan *et al.,* 2013:2-3), with the hostility towards including CCS within the CDM continuing (Shackley *et al.,* 2012:149, 60). However, during COP16 (2010), CCS was given conditional approval for CDM registration but was not immediately eligible for project activities, as this was contingent upon all outstanding technical issues and procedural requirements being addressed (Ward, 2011:18-20, World Bank, 2012:40-42), with a final decision expected during COP17 (2011). This was somewhat of a turning point for CCS and we could assume that the developing hesitations and political barriers within the UNFCCC may have fuelled western-industrial nations' more direct approach to diffusing CCS along more multi-partner and bilateral routes.

Ultimately, the UNFCCC, its COPs, the Kyoto Protocol, and the CDM, had not provided any direct incentives for CCS to advance within the multilateral climate negotiations and the technologies' advancement within this system was considered to be "something of a failure" (Zakkour *et al.,* 2014:6948-9). However, some organisations, such as the IEA, recognised that some progress had been made and they remained positively optimistic in future efforts (IEA, 2016:38). At the same time, coalitions of countries had already started to step outside the UNFCCC system to launch their own multilateral initiatives (which included both developed and developing countries) and bilateral cooperation (particularly with countries like China and India). Allowing them to set their own agendas and activities without challenge or criticism from other nations, de Coninck (2011:368-76) describes this as a "weakening of multilateral climate diplomacy" and the "rise of a new geopolitics of climate change."

Findings:

- According to some of the Chinese interviewees, the UNFCCC was thought to be a key multilateral opportunity, with COP15 in Copenhagen (2009) seen as an important milestone in the development of CCS within China. COP15 had the effect of increasing the profile of CCS domestically and enhancing the technologies' perceived prospects in the eyes of its potential Chinese adopters and this was particularly the case for those earlier adopters who were on the verge of abandoning their CCS activities due to experiencing many set-backs and challenges in recent years. Some Chinese adopters described the pre-COP15 period as a time of great uncertainty, the rise of climate and CCS-related content within the mainstream media, television and newspapers, seemed to lead to enhanced support for the technologies from the "higher levels" and this subsequently led to increased funding available for CCS-related research and project activities (R35;R06).

- According to Chinese interviewees, along with the increased support and funding for CCS came somewhat unrealistic aspirations for significant policy development and for ambitions towards demonstration projects in China. Such hopes were subsequently dashed in the following year at COP16, in Cancún, when CCS then failed to be included within the CDM. Faced with the fact that the international climate negotiations were not going as well as anticipated and coupled with the sense that international funding for CCS was drying up in the wake of the 2008 international financial crisis, the prospects of stable policy support and reliable funding for CCS demonstration seemed as far away as ever (I18;R06;R24).

- With these interviews taking place in early 2015, some had placed high hopes on the outcomes of the COP21, in Paris, which was planned for December that same year (A38).

Case Study III – International Energy Agency (IEA)

Originally appearing as an emergency response during the 1974 OPEC oil embargo crisis, the IEA had become the *de facto* global energy advisor that had provided a platform for Western countries to secure stable energy supplies within the orbit of the OECD (Lesage, 2009:261; IEA/CSLF, 2010:27; de Coninck, 2011:371). During the 1990s, it had avoided making links between fossil fuels and climate change but this position began to shift slightly within their "Uncertainties in Relation to CO_2 Capture and Sequestration – Preliminary Results (2003)" report, when they "appeared almost grudging in their references to climate change," while also providing results but no clear endorsement of the technologies (Meadowcroft, 2009:5,267-8). However, with the dominance of coal featuring heavily within their energy scenario analysis for 2004, CCS began to appear more frequently within most future IEA modelling and analysis (Drahos, 2009:124, de Coninck, 2011:37).

The IEA's publications, particularly its annual "Energy Technology Perspectives" (ETP) (2006-2016) series and its 'Blue Map Scenario' section, have been a key means of getting its messages out. In 2008, its ETP projected global energy emissions increasing by 130 percent by 2050 and it recommended that more than 2.5Gt CO_2 emissions be avoided annually, calling for a "energy technology revolution" which necessitated CCS to abate 19 percent of these emissions. Routinely cited by governments, industries, researchers, and academics, these statistics and predictions further cement the 'storyline' that fossil fuels will continue to have a role for many decades and that CCS is "eminently reasonable," thus restricting the possibilities to break the existing deeply-embedded societal practices and systems that inhibit more radical change (Meadowcroft, 2009:273-4). Writing on this subject, Hansson (2012:77-8) sees such storylines of fossil-fuel dependency "inevitable-ness" and "a potential smoother transition [to decarbonisation] offered through CCS" as leaving few other options than for the technologies' to be deployed and calls for political support and financial resources to be provided.

Conversely, by publishing its "Cost and Performance of Carbon Dioxide Capture from Power Generation" (2011), the IEA only really highlighted the challenges of gaining accurate estimates and created greater uncertainty around the true costs of CCS (World Bank, 2012:10; Almendra, 2011:21), with its more recent estimates being much lower than those from industry (Hansson, 2012:77-8). In 2012, the IEA's "World Energy Outlook (WEO)" warned that without CCS the prospects of staying within the '2ºC guard-rail' becomes increasing more unlikely and ever costlier (Kapetaki, 2016:13) and the ETP's 'Blue Map Scenario' suggested that abatement costs without CCS could be as much as 70 percent higher, warning that are frequently shared when calling for more CCS policies and projects (de Coninck, 2009:2162). Given its internationally-respected analysis providing what appears to be an agreed consensus that CCS should be an integral part of any energy mix and mitigation portfolio, many developing countries use the IEA's analysis as the basis for their national climate strategies and policies (Yang, 2016:3, World Bank, 2012:70).

Discussed in more detail later, the IEA accepted the G8's 2005 'Gleneagles Summit' invitation to investigate CCS development and ways to accelerate its deployment. Subsequently, in 2007, the IEA then held workshops in Calgary and Oslo, which ultimately led to its recommendations for 20 demonstrations. Later creating a dedicated CCS Unit, the IEA is considered the most significant "pioneering" organisation and an important provider of publications and workshops in this field (Almendra, 2011:10; Drahos, 2009:130; de Coninck, 2011:369-71, Hagemann, 2011:5703). Although having limited capabilities to fund CCS demonstrations, it does play a coordinating role, providing technical direction, and sharing policy/project developments globally, and had published the first global status reports "Carbon Capture and Storage: Progress and Next Steps" and "CCS: Full Scale Demonstration Progress Update" in 2010 (de Coninck, 2009:2163; Hagemann, 2011:5700; IEA/CSLF, 2010:5; IEA/CSLF, 2010:9; Ashworth, 2010:426).

Undoubtedly, the IEA's most important CCS-related publication and the organisation's first-of-a-kind report for any technology, is the "CCS Technology Road Map (TRM)" (2009) and its later "CCS Technology Road Map" (2013), which laid out five key challenges (technology, financing projects, legal and regulatory framework, public engagement and education, and international cooperation) to meet the G8's goals, and set out the long-term plans, key milestones, and immediate actions, in order to increase coordination and maximise the effectiveness towards deployment. Offering positive signs that between US$26.6 and US$36.1 billion had been allocated for (19-43) large-scale demonstrations in OECD countries, the IEA sought to see 100 projects globally by 2020, although its aspirations didn't always reflect reality and it failed to reach its ambitions (IEA/CSLF 2010; World Bank, 2012:84; de Coninck, 2011:371, 375; IEA, 2009:3,6-7; World Bank, 2012:141; Fischer, 2015:9,25; de Coninck, 2014:261).

The IEA CCS Unit acknowledged that challenges do still remain. It also stressed that a concerted effort is needed by all parties with "continued political leadership remaining absolutely essential" (Lipponen *et al.,* 2010:5752). However, this would require significant deployment by 2030 and over 3,400 projects by 2050, which it estimated would need around US$4b annually between 2010 and 2020, with a total investment of US$5.8 trillion by 2050 (IEA, 2009; Shackley and Evar, 2012:155; Evar, 2012:18-9). As much as 65 percent of projects need to be in the developing world by 2030, so this would require engagement with countries outside the OECD and funding of around US$17.3b by 2020, perhaps rising to almost US$40b annually in 2030 (IEA, 2009, IEA/CSLF, 2010:6; Seligsohn, 2010:2; Van Alphen, 2011:17-8; Almendra, 2011:2,11; Minchener, 2012:7; World Bank, 2012:68).

As one of many of its platforms, the IEA also created the 'International CCS Regulators' Network' as a way for policy makers to interact with peers and for stakeholders to work objectively with others towards drafting CCS-related policies within a supporting but neutral forum (World Bank, 2012:109). By collating the OECD's CCS policy developments and providing regulatory frameworks, which was aimed towards helping developing countries adopt these models or to formulate their own bespoke versions, these were often shared through IEA "enabling activities," such as roundtables and workshops (Evar, 2012:30; IEA, 2010; APEC, 2-12:145-6; de Coninck, 2011:375; World Bank, 2012:83; Hagemann, 2011:5705). Through these CCS guidance publications and activities, it is thought that the IEA aims to influence policy and regulation formulation in the developing world (Van Alphen, 2011:107; Meadowcroft, 2009:6-7).

By taking a two-strand approach to extending its reach into the non-OECD world, the IEA had continued to work with others to strongly advocate for the inclusion of CCS within the CDM, both inside and outside the formal negotiations (STRACO_2, 2009:44,79; Torvange, 2011:305). Not unique to CCS, one way in which the IEA reaches out to these non-OECD parties is through its implementing agreements (such as the IEAGHG and IEACCC), which are created as cost-effective ways to create knowledge, disseminate information, define concepts and share best practices and development regulatory frameworks, as well as facilitating networking and collaboration (Fischer, 2015:8; Lesage, 2009:270-271).

Although China is not an OECD/IEA member, since the signing of a 1996 MoU, the IEA's energy-related engagement with the country has only intensified, particularly as coal became an increasingly important issue and a mutual priority for both in 2006. With the IEA and Chinese parties working closely on the China-related sections of its "CCS Technology Road Map (2009)" and later collaborating together on the Chinese MOST-sponsored "CCS R&D Map for China," a key recommendation put forward during this time was for 8-10 large-scale CCS projects in China by 2030 (Drahos, 2009:126). As a number of Chinese parties demonstrated either hesitation and/or opposition to such plans, the IEA held a number of China-based workshops throughout this period to better understand domestic trends, opportunities and challenges, while also benefiting greatly from local expertise in the publication of its 2012 "Facing China's Coal Future: Prospects and Challenges for CCS" (Best, 2012:3-6).

Leading to a series of engagement events over recent years, these parties have continued to deepen this close relationship, with China becoming an IEA 'Associate Member,' in 2015, and the IEA taking further steps to engage with non-OECD countries (IEA, 2017). Establishing the Beijing-based IEA-China Energy Cooperation Centre, in 2016, and announcing an expansion of cooperation with the Chinese Government, in 2017, the focus of the 2017 WEO was primarily on China. With the IEA 'CCS Technologies & Policies Specialist' later recognising that China plays a crucial role in launching the new batch of large-scale demonstrations globally, they stressed the importance of this in renewing the momentum towards CCS internationally (IEA, 2017).

Findings:

- Publishing the first "IEA CCS Technology Road Map (TRM)" in 2009, with an updated version in 2013, Chinese governmental parties were heavily involved in the drafting process of the China-related parts of these publications, which helped them to learn of and familiarise themselves with CCS technologies.

- Through the provision of positive information and reassuring messages at regular working meetings in China and by assisting Chinese parties in undertaking their own CCS-related feasibility activities, the IEA also made the prospects of CCS appealing and made the possibility of development and deployment seem achievable in the face of great adversary (G02;R01).

- The IEA reports, websites, and newsletters, were also considered an important source of written information for many Chinese parties (R04;I13;G02;A29;R35;R24;A17;R06) and the organisation's frequent seminars and workshops in China also helped share its knowledge and to disseminate key studies and findings by and within the Chinese CCS Community (G02;R01;G12;R04).

Seen as the first international organisation to focus on CCS, the IEA Greenhouse Gas R&D Programme (IEAGHG) presented itself as an informed source of impartial information on GHG mitigation options (Meadowcroft, 2009:5; Evar, 2012:20; Tamura, 2012:57; de Coninck, 2011:371). Tasked with initiating research, performing evaluations, stimulating networks, and maintaining information sharing platforms, its activities fall short of funding large-scale demonstrations due to its limited budget (Smouse, 2007:21; World Bank, 2012:109; de Coninck, 2009:2163). Publishing technical reports, policy papers, and articles since the early 1990s, the IEAGHG has seen the shift from CO_2 disposal towards CO_2 utilisation in the 2000s, and has been one of the key organisations to close the gap between development and demonstration, as well as to bridge those in government, research/academia, and industry (de Coninck, 2011:371; de Coninck, 2014:256; Vallentin, 2007:59,78). An early example of this was through the 2001 IEAGHG 'Weyburn-Midale CO_2 Monitoring & Storage Project,' which brought together over 30 government, industry and research institutes (from Canada, Denmark, Italy, the UK and the US) to produce monitoring tools that would be shared through the IEA's international subject-specific research networks (Vallentin, 2007:59; APP, 2006h:49; Van Alphen, 2009:4594; Van Alphen, 2011:160). Meeting periodically through workshops and seminars, these networks and their activities are often useful to optimise knowledge-sharing and technical learnings. The IPCC drew heavily on these networks for the IPCC SR (Stephens *et al.,* 2012:136; Meadowcroft, 2009:6).

Bringing a wide variety of parties together through its biennial "International Greenhouse Gas Control Technologies Conference (GHGT)" conference series, the number of international attendees has increased steadily since 1992, providing what is considered a critical community-developing function (de Coninck, 2011:371). With its changing participation over time often reflecting the shifting patterns of the technologies' development and geographical spread (Stephens *et al.*, 2012:131-6), this has been demonstrated in the investigations, studies and articles presented and published within its "International Journal of Greenhouse Gas Control Technology" (Bradbury, 2012:47).

Recognising the real lack of CCS-related peer-reviewed journals and articles, this journal has acted as a prominent repository for the growing technical and policy research from government and industry, making it a truly CCS community publication (Shackley, 2012:118-9; Stephens, 2011:383; Stephens *et al.,* 2012:136). Likewise, the IEAGHG's 'Project Database & Interactive Map' has been used to gauge the level of activity regionally, to measure progress nationally, and to record the levels of funding and investment globally (Reiner, 2008:24; Klass *et al.*, 2008:107; Van Alphen, 2011:33).

At a lower level, the IEAGHG's annual 'International Interdisciplinary CCS Summer School' is seen as "necessary to broaden the knowledge base in industrialised and developing countries, particularly at an academic level" by "supporting and accelerating the dissemination of knowledge on the potential for CCS to students around the world" (IEAGHG, 2016:4). Taking place in both OECD and non-OECD countries, since 2007, it has targeted students with diverse backgrounds and a broad understanding of the issues surrounding the technologies and provided week-long programmes of presentations and discussions, as well as group works. Covering most technical and policy related aspects along the CCS chain, it often includes visits to notable CCS pilot facilities and demonstration projects (IEAGHG, 2016:5; de Coninck, 2011:371; Stephens *et al.,* 2012:136). The 2012 course was hosted by Tsinghua University in Beijing, during which a field trip was arranged to the China Huaneng Group's Beijing Gaobeidian Power Plant. Additionally, since 2006, the IEAGHG has produced a quarterly "Greenhouse News" and a weekly email newsletter with an estimated readership of over 7000 (Reiner, 2008:45; Stephens, 2011:383; Stephens *et al.,* 2012:136).

Findings:

- The IEAGHG has had significant involvement with Chinese parties on CCS. Inviting key members of the Chinese CCS Community to chair and present at the GHGT conferences, it has also been attended by senior Chinese CCS figures and remains a key resource of CCS-related information and networking opportunity with the wider international CCS community (A39;R35;R24;R22;I18;A17).

- The GHGT conference proceedings, published within the IEAGHG's "International Journal for Greenhouse Gas Control," has been identified as a key information source for CCS within China (A30;A19;A17;R14;R01;R35).

- Significant is the involvement of the IEAGHG in CCS learning at the lower levels. Through holding its annual "International Interdisciplinary CCS Summer School," the organisation is sure to invite a handful of Chinese students every year, even holding the 2012 programme at Tsinghua University in Beijing. One key characteristic of the summer school is that it often includes visits to CCS pilot or demonstration projects as part of the training (R35;A21;R04;A26;A11;R16).

- Some members of the Chinese CCS community told of their frustration that after applying for the summer school opportunity several times, they were unsuccessful in gaining a place on the training programme. One such interviewee commented that "if there are more encouraging messages from the global messages for us, [then] we can pay something by ourselves, to do it, to learn, that is no problem, but in [the] current situation, if we are studying, we invest money on it, we do not find any more things we can do to contribute" (A07;I40).

- IEAGHG also hosted more specific network meetings within China on technical areas, such as oxy-fuel combustion (A38).

As the second IEA implementing agreement with a connection to CCS, the IEA Clean Coal Centre (IEACCC) focuses on a much broader range of technologies and claims to be "the world's foremost provider of information on the clean and efficient use of coal worldwide, particularly clean coal technologies," while providing this "in a balanced and objective way, without political or commercial bias" (IEACCC Website).

Findings:

- Holding a long-standing relationship with a number of the earlier Chinese adopters of CCS technologies that hold senior positions in academia (A11;A21;R24;R22), the IEACCC held a number of CCS-related workshops and activities in China and has dedicated section of its website to China, which has been translated to the Chinese language. However, many of these Sino-international interactions stemmed from their CEO's involvement in international cooperation activities with China.

Case Study IV – Group of Eight (G8)

During the mid-2000s, the G8 seemed to have "stepped in to fill a void" that existed within a fragmented yet overcrowded landscape of energy and climate-related governance (Lesage, 2009:259-272). Led by Tony Blair, as the UK Prime Minister holding the G8 Presidency, he had placed climate mitigation at the top of the global political agenda and raised the profile of CCS through referencing the technologies as a mitigation option within the "Gleneagles Plan of Action (2005)" (Shackley *et al.,* 2012:154; Buhr, 2011:336). This then committed G8 countries to work towards accelerating the development and commercialisation of CCS, and charged the IEA along with the newly formed Carbon Sequestration Leadership Forum (CSLF), as the international mechanism for monitoring G8 countries' progress, while as the same time hoping peer/societal pressure would hold them accountable (Webb *et al.,* 2007:2; Tjernshaugen, 2008:1-2; Bachu, 2009:4720; Ashworth, 2010:426; Lesage, 2009:263). Shortly afterwards and discussed again later, the

G8 supported and attended the IEA/CSLF "Global Assessments" workshop in Oslo, produced the "Near-Term Opportunities for CCS" report in an effort to share lessons and experiences across countries (de Coninck *et al.,* 2011:373).

G8 summits and workshops provided opportunities to engage with developing countries, particularly those large emitters. For example, during the June 2008 Aomori Ministers Meeting the G8 energy ministers were joined by China, India, and South Korea, when both the OECD and non-OECD countries released a joint statement. In anticipation of the July 2008 G8 Tōyako Summit, this was a demonstration of re-committed to the "Gleneagles Plan of Action" and was seen as "a good indication of governmental faith in CCS" (Vergragt *et al.,* 2011). Reemphasised by a statement that stressed the "critical role of CCS in tackling the global challenges of climate change and energy security," these Ministers stated they "strongly support the [IEA and CSLF] recommendation that 20 large-scale CCS demonstration projects need to be launched globally by 2010." Acknowledging different national circumstances, they stated the need for financial support, capacity building, and information sharing to accelerate progress towards CCS demonstration and deployment.

Although reiterated again at the 2009 L'Aquila Summit, the IEA's "CCS: Full-Scale Demonstration Progress Update" (2009) showed that these non-legally binding commitments and the soft targets of 20 projects by 2010 would not be met, partly due the 2008 global financial crisis (Lesage, 2009:264). The report did show that several of its members (Australia, Canada, the EU, and the US) had already set national targets and had started to earmark funding for their own domestic projects (de Coninck *et al.,* 2011: 369,375). Despite this lack of progress, during the 2010 "Muskoka Summit," the IEA/CSLF (and now the GCCSI) released the "CCS: Progress and Next Steps" (2010), which called for around one hundred CCS projects within both developed and developing countries by 2020. With 18 needed by 2015, and around 3,400 needed by 2050, Condor *et al.* (2011:6125) had calculated that around 35 percent of these would be needed in non-OECD countries, which would require significant international financing. This would require the need for increased engagement with emerging economies, particularly the coal-based countries like India and China (Liu, 2009:3883). Unfortunately, the direct impact on my respondents seemed limited but one quite key figure received the important message below.

Findings:

- It was hard to quantify the possible influence of the G8 on Chinese parties' attitudes towards and experiences of CCS. However, one (very senior and key) research figure saw the 34th G8 Summit, held in Tōyako, as "a very important event that demonstrated the huge market potential for CCS in China" (R06).

Case Study V – Carbon Sequestration Leadership Forum (CSLF)

Launched by George W. Bush, with the involvement of the US Department of State, US Department of Energy (DoE), and the National Energy Technologies Laboratory (NETL), the CSLF was seen as a demonstration of the US desire to share CCS-related knowledge, to benefit from coordinated international activities, in terms of collecting technical data and gathering project-based learning for the NETL Global project database (de Coninck *et al.,* 2009:2136; Best *et al.*, 2011:6145; Stephens, 2006:7; Bäckstrand, 2008:92-3; Langhelle *et al.,* 2009:236; Stephens, 2009:42). Involving 13 country members in 2003, this grew to 21 in 2008, and 24 in 2010, accounting for more than 75 percent of global emissions and constituting the "loci of major CCUS activity" (Bachu, 2009:4721; Stephens *et al.,* 2012:137; de Coninck *et al.,* 2011:72,372). Criticised for involving only a few emerging economies and developing countries and with a lack of actual engagement with their domestic stakeholders, Bäckstrand (2008:92-3) described the CSLF as a "mini-lateral island," were technological cooperation and voluntary unquantifiable efforts are used as a response to the climate threat, yet another expression of U.S. unilateralism. de Coninck *et al.* (2011: 375) sees the establishment of such organisations by a hegemon, with a coalition of willing states, as serving their own interests by promoting the availability of CCS as a technological solution, as a means to negate commitment and to legitimise the use of fossil fuels. Given the CSLF's fossil fuel dependent membership and its positive stance towards CCS, this was thought to "undermine the credibility of the organisation and its claims to provide neutral and independent information on CCS" (de Coninck *et al.,* 2011:373). However, perhaps to counter such distrust, the CSLF brought together international political and industrial representatives, as well as researchers and academics, to produce a number of highly-detailed road maps, which are somewhat less ambitious that others, but this might reflect the reluctant to see actual CCS deployment (Vallentin, 2006:11; Meadowcroft *et al.*, 2009:6; Drahos, 2009:126-130).

CSLF Capacity Building Task Force (CBTF)

Established in 2003, the ministerial-level CSLF is defined as a knowledge-sharing platform that aims to facilitate the development and deployment of CCS technologies via collaborative efforts that address key technical, economic, and environmental obstacles. Facilitating engagement at the highest levels through its biennial CSLF Ministerial Meetings, the GCCSI (2014:3) claimed that the 2003 Fifth CSLF Ministerial Meeting had the effect of "re-energising the global momentum for the deployment of CCS." Potentially bring positive attention back to the importance of CCS, motivating members to carry out the tasks agreed and creating wider enthusiasm around the technologies' potential. At a lower level, the CSLF also supports peer networking opportunities that facilitate policy, technical and financial information exchanges, collaborative research and networking opportunities, which allows shared learning of cumulative experiences from different projects and regions (Asia Society, 2009:50; de Coninck *et al.*, 2011:372).

Although praising the CSLF for bringing together policy makers, industry representatives and other influential actors and for providing "global coordination, transparency, cost-sharing and sound communication" in the "urgent challenge of improving understanding of CCS," de Coninck *et al.* (2012) criticised the initiative for failing to involve a much broader range of stakeholders to provide what was needed the most "global learning in full-scale demonstration" (2009:2135-6). Considering the rapid growth of emissions, Vallentin (2006:59) warned that for international CCS diffusion to be successful, technology-specific capacity building in the developing work is an important prerequisite. Likewise, examining the CSLF's Capacity Building Task Force (CBTF) activities in seven economies, Bachu (2009:4719-4726) warns that in order for CCS to be advanced globally, there is a need to provide the right information, tools, skills, expertise and institutions within these countries.

Dependent on buy-in from the host governments, the Chinese MOST had joined the CSLF in 2003, as an effort to increase its technological advancement and had welcomed this opportunity for international cooperation (Li *et al.,* 2016:3; Webb *et al.,* 2007:9; Chen *et al.,* 2010:2129; Gu, 2013:16-17; Best *et al.*, 2011:6145; Minchener, 2011:44). Hosting the 4th CSLF Ministerial Meeting in September 2011, a series of events was held over five days with Chinese governmental departments, key experts and academics in attendance. At the announcement of funding for 12 capacity-building projects that would be offered through the World Bank Capacity Building CCS Trust Fund, China was allocated US$1.8 million for CCS capacity building and projects, which included workshops on sharing experience of CCS-related research and demonstration and specific issues, such as structuring legal and regulatory frameworks (Gu, 2013:16-17). At the time, China was the Vice-Chair of the Policy Group Secretariat and the Lead for the Working Committee on Large-Scale Demonstration, along with the US.

By playing an important role in the endorsement of collaborative research activities and its recognition of pilot and demonstration projects, 20 international projects had been recognised by 2011, with affirmations around their relevance. However, CSLF activities were concentrated on its members within North America, the EU, and Australia (Wilson *et al.*, 2011:328; van Alphen, 2011:133; van Alphen *et al.*, 2010:980) and there was a lack effective collaboration between the developed and developing worlds, despite experts calling for a complementary set of demonstrations globally, particularly in coal-based economies like India and China (Stephens, 2006:7; Stephens, 2009:42). Related to this, the CSLF Global Achievement Award is one tool it has to reinforce the importance of CCS, first won by the Norwegian Sleipner CCS Project in 2011 (IEA, 2016:22; Van Alphen, 2011: 133,202).

Findings:

- One Chinese governmental interviewee acknowledged that the CSLF provided an abundance of ambitious and positive information related to CCS, which inspired seeking solutions to CCS problems (G02).

- Others stated that such information was nothing new and that the real motivation for Chinese involvement in such activities was not the prospects of learning additional CCS-related information but the possibility of gaining additional funding for their own domestic CCS projects (R09).

- Another significant advantage is that it has the possibility to connect international industry with Chinese parties (A21).

Case Study VI – World Bank (WB)

The role of the World Bank (WB) in the energy, climate, and GHG technologies space grew following the G8's Gleneagles "Plan of Action" call for Multilateral Development Banks (MDBs) to increase its dialogue on these issues, to develop a framework for engagement, and to accelerate the adoption of these technologies. Seen as the G8 using its institutional power to envelop other western-dominated organisations to undertake its own energy-related work, the WB is considered its "second important institutional partner" (after the IEA) and took on this challenge by outlining US$3b worth funding for projects within its 2007 "Action Plan" (Lesage (2009:271-4). As a prime example of nation states exerting their influence over MDBs, de Coninck (2011:369,375-6) sees this as the promotion of shared problem solving in order to maintain global stability, while actually legitimising and serving the national interests of hegemonic countries (such as the US).

In terms of funding towards CCS, the WB established the US$6.1b 'Climate Investment Funds (CIFs)' in 2008, which was seen as a possible avenue to secure public and private financing for CCS projects in emerging and developing countries, such as China (Best, 2012:38). However, although requiring recipient nations to develop "Country Investment Plans" that would set them on a low-carbon pathway, there was significant opposition from some against supporting coal-related projects. As the UK provided GB£800m to the CIFs for the broader package of low-carbon and climate resilience projects, it recognised the role of the MDBs in supporting CCS as a critical transformative technology and for demonstration in the developing world, and channelled GB£25m and GB£35m through the WB and ADB, respectively, to support other CCS-related projects, regional analyses, and capacity building activities in Africa, China, Indonesia, Mexico and South Africa (Littlecott, 2015), which will be discussed in more detail later.

World Bank CCS Capacity Building Trust Fund (WBCCSTF)

In September 2009, the WB 'CCS Capacity Building in Developing Countries Workshop' was held in Washington DC and brought together governments, industry, and others for the creation of the World Bank 'CCS Capacity Building Trust Fund' (CCSTF). Aiming to support developing countries to integrate CCS within the national strategies and low-carbon policies, the CCSTF was seen as a milestone event for CCS-related capacity building and allowed the WB to gain agency within the CCS agenda. Although lending credibility to CCS within the developing world by being considered a provider of independent, neutral, and legitimate information, the CCSTF's £11m GBP funding actually came from Norway and the GCCSI and the majority of its technical assistance a provided by the IEA, the CSLF, and other entities with fossil fuel legacies and interests (Zechter *et al.,* 2009:2-4; Hart *et al.*, 2010:117-8; de Coninck, 2011:373-5; Ward, 2011:14).

At the country level, the WB's CCSTF aimed to provide US$6.9m worth of tailored technical assistance and capacity building to nine countries, which included US$1.8m for technology road maps, geological storage capacity assessments, and training workshops for China. The intention was to enhance CCS-related strategies, policies, regulatory framework, and financial mechanisms, as well as managerial skills and experience (Zechter *et al.,* 2009:6-9). At the analytical level, the WB's CCSTF looked at cross-cutting issues in different regions, using case studies as examples, as a way to address these issues at a more strategic level. Intended to inform but not prescribe policy, the 2011 "CCS in Developing Countries: A Perspective on Barriers to Deployment," sought to emphasis the (G8/IEA) need for 50 large-scale CCS projects (70 percent) in developing countries by 2020, while giving consideration to the associated costs and possible CCS project financing models at the local scale (Zechter *et al.,* 2009:9,11).

In 2007, the WB released a similar report entitled "Cost of Pollution in China," which monetised the health, environmental, and developmental impacts of pollution and estimated the cost to GDP as three percent in 2010, rising to 13 percent by 2020. With much of this focused on industrialised pollutants arising from the combustion of coal, there has been a growth in environmental awareness and calls for climate action in China, even if this impacted economic development (Chen, 2010:2125; Jaccard, 2011:411). Accounting for the resources of the China Development Bank (CDB) and considering China's domestics capabilities, as well as the interest to collaborate with foreign partners, it was recognized that with significant political will there could be great possibilities for the development of CCS (Duan, 2010:4-5; Malone *et al.,* 2010:422; Best, 2012:6, 35). However, given the uncertainties around costs and risks, China strongly believes that developed nations should take the lead with CCS demonstration, while providing strong incentives for developing country involvement (Condor, 2011:6129; Ward, 2011:14).

Often a prerequisite to investments that involves both great cost and risk, there is an expectation of both policy development and a willingness to build the capabilities needed to assure project success (Seligsohn *et al.,* 2010:8; Best, 2011:6145; Best, 2012:36-8). Through the WB's provision of US$1.8m (mentioned earlier), a key focus was to bring together expert teams, to develop Chinese power sector expertise, and to strengthen the institutional capacity of one of the big five SOE power-generation companies, China Power Investment (CPI) and its plans for four CCS-related projects in China. Analysing the outcomes of a WB's CCSTF-supported CCS-related activities and evaluating their effect on Chinese parties, Cumming *et al.* (2014:4918-24) seen technical assessments informing decisions for CCS throughout China, while China-based capacity building workshops and visits to US-based projects, not only good opportunities for Chinese stakeholders to engage with other parties, but gave them the ability to take the next steps in their CCS-related work.

Findings:

- Releasing a report entitled "CCS in Developing Countries: A Perspective on Barriers to Deployment" (2010), the WB was seen as a source of techno-economic analysis and legal and regulatory assessment for countries that have less CCS activity but hold the potential (R01;R06;G12).

- The WB supported Chinese parties in the development of a CCS road map and smaller CCS-related feasibility studies. Access to these expert sources was considered both much needed and eagerly sought by Chinese parties (R01;R06;G12).

- Acting as a source of information for members of the Chinese CCS community, the WB supported Chinese parties in the development of a CCS road map and smaller CCS-related feasibility studies. Access to these expert sources was considered both much needed and eagerly sought by Chinese parties (R01;R06;G12).

Case Study VII – Asian Development Bank (ADB)

The Asian Development Bank (ADB) has steadily increased its investment in low-carbon and clean-energy technology projects and has made significant efforts to fill the gaps in its developing member countries' (DMCs) knowledge and capacity. Increasing climate financing to DMCs, from US$668m to US$1.7b between 2007 and 2008, the ADB provided US$3b annually between 2011 and 2014 and had committed to increase this to US$6b per year by 2020 (Zhao, 2010). Calling for its members to step up efforts to employ clean and low-carbon technologies, the ADB has been a proponent of CCS as "the only near-commercial technology available that can cut up to 90 percent of emissions from coal-fired plants" that has the potential for "propelling countries in the region toward more sustainable economic growth," while emphasising the potential mitigation costs for China if the country doesn't invest in large-scale demonstration (Groff, 2016).

Playing a crucial role of providing construction funds and investment certainty in the short-term (Ward, 2011:12), the ADB (and other MDBs) are perfectly placed to provide building capacity activities to combat technical, as well as non-technical gaps, and plug potential policy holes, thus providing assurances to international and domestic investors (Seligsohn, 2010:8). However, although financing of early projects is key, a survey by Lai *et al.* (2012:643) showed a longer-term over-reliance within the Chinese CCS innovation system on international (and state) constructing CCS projects. Although unwillingness by commercial partners for operating costs may be down to uncertainty around technical and economic issues, this can also be attributed to the lack of an effective enabling environment (i.e., clear policy guidance or regulatory frameworks, and financial mechanisms or incentives), which allows for the scaling-up of demonstrations and attract private sector investment. Such uncertainty can also deter potential investors from undertaking expensive feasibility assessments, time-consuming storage capacity characterizations, and/or costly front-end engineering and design (FEED) studies.

ADB CCS Trust Fund (CCSTF)

In June 2009, the ADB established the CCSTF with an initial AU$21.5m contribution from the GCCSI and a further US$35m provided by the UK in 2012. Although all DMCs were eligible for support, activities in China, India, Indonesia and Vietnam were given priority (ADB, 2009; World Bank, 2012:109; Littlecott, 2015). As a DMC, the ADB provided US$35m in loans and US$84m in equity for the construction of China's US$420 for China's Tianjin GreenGen Integrated Gasification Combined Cycle (IGCC) Project, with additional grants of US$5m and US$1.25m for long-term maintenance and CCS-related technical assistance, respectively. Approved by the NDRC in 2009, GreenGen was included in the 'Chinese National 11th Five Year Plan (2006-2010)' and identified as key national scientific research (MOST 863 Program). Led by China's Huaneng Group, the largest power generation company in the country, it was to promote coal-fired power generation with CCS. It was hoped that these investments would enhance China's local technical capabilities and increase ambitions for the planned scaling up of the project in coming years (NDRC, 2010:28,47; Minchener, 2011:33-34,52; Esken, 2012:30,168-9; Hart *et al.,* 2010:10-9,116-7; Best, 2012:19,28,38; GCCSI, 2009:10; Ward, 2011:15).

In November 2011, NDRC requested the ADB provide a programme of policy and technical assistance in China, which involved a series of parallel activities to fast-track development and demonstration, and included road map studies, scenario developments, technology assessments and demonstration selection (GCCSI, 2009:10; Minchener, 2011:33-34). Although the ADB's technical assistance activities allowed for both technical and policy-related knowledge sharing and capacity building, they also created opportunities for multilateral, bilateral, as well as domestic CCS engagement and created international and national networks around projects, technologies and policy areas (Wilson, 2011:329; Lai *et al*., 2012:639).

Importantly, the ADB supported a Chinese "Review of CCS Road Maps" (2015) which led the way for the "People's Republic of China: Road Map for CCS Demonstration and Deployment" (2015), funded through a US$2.2m grant from the CCSTF. Although several other CCS road maps and guidelines were released in China (by the IEA, MOST, ACCA21 and WRI), the ADB/NDRC version was significant as it was the first comprehensive and government-endorsed plan for deploying CCS at a national scale (Kastmann *et al.,* 2013:7,25). Following a fruitful period of technical assistance and engagement with the Chinese CCS community, the ADB had developed an extensive understanding of the challenges facing CCS in China, the most serious of which being the uncoordinated and fragmented nature of government responsibility (ADB, 2016).

Impacting the prospects for a national CCS development and demonstration strategy, the ADB proposed supporting the establishment of two ADB China CCS Research Centres, which would employ mainly Chinese nationals and occasionally short-term foreign experts in order to join forces with partner institutes throughout the region and to facilitate the creation and functioning of an international network of CCS researchers that will update technology and policy development status.

Findings:

- By providing financial assistance, supporting the creation of small research teams, and bringing together Chinese parties to develop their plans for CCS-related activities until 2050, the ADB's "CCS Road Map" was seen as a "very important document directing the future of CCS in China" (A21;R01;G12;R06;R24).
- Holding frequent communications with Chinese parties and taking regular visits to China at various intervals, the very presence of the ADB in China had the effect of reassuring Chinese parties of the international and domestic relevance of CCS and motivating them to continue with their CCS activities (A21;R01;G12;R06;R24).
- One key development was the decision by the ADB, in 2014, to support the creation of two CCS centres with the objective of pushing CCS development in eastern China – with Chinese parties jostling for position (A21;R01;G12;R06;R24).

Case Study VIII – Asia-Pacific Partnership on Clean Development and Climate (APP)

As a non-binding compact between several mainly industrialised, energy-consuming, and GHG-producing countries, the APP built on existing national initiatives and created new partnerships, in order to exchange information and share experiences. Such voluntary arrangements were often criticised for their unaccountability and lack of setting targets and there were questions around the APP's legitimacy and motivations. Contributing to the already fragmented international climate change governance structures, Bäckstrand (2008:67,91-94,97,99) sees the APP as yet another attempt at US unilateralism, by engaging with like-minded countries to institute a barrage of voluntary technology agreements to counteract the "Eurocentric" Kyoto Protocol. Claimed to be a response to the Bush Administration's dissatisfaction with the options presented by Kyoto, the APP promoted the technology-driven approach to climate mitigation which the US favoured. This made the APP a convenient home for CCS and a perfect vehicle for the US State Department to extend its reach globally by planning and implementing joint CCS projects and demonstrations internationally (Gallagher, 2009:14; Hart *et al.,* 2010:118; Stephens, 2009:42; Alphen, 2011:123,133; Tamura, 2012:59; Stephens, 2009:42; Langhelle, 2009:237).

Contrary to these criticisms, the APP's "Partnership Vision Statement" (July 2005), which was released during the 38th ASEAN Ministerial Meeting in Laos, maintains that its partnerships activities are aimed to contribute to the efforts of the UNFCCC and to complement not replace the Kyoto Protocol. Less than a year later, during the Inaugural Ministerial Meeting (January 2006) in Australia, the APP released its founding documents (the "Sydney Ministerial Communiqué," the "APP Charter," and the "Partnership Work Plan"), which were intended to "serve as tools that articulate the partner's ideas for how the initiative was intended to function," in order to "set out the parameters of their innovative collaborative effort to achieve practical results through concrete and substantial cooperation, both bilaterally and multilaterally" and to "develop sustainable solutions to shared challenges through bottom-up practical action," in order to support "agile, constructive, and productive international cooperation" (APP, 2006; APP, 2008a). Crucially, the tricky issue of intellectual property was to be "addressed on a case-by-case basis within the specific context in which they appear, bearing in mind the purposes of the Partnership" (APP, 2006b).

Holding a second Ministerial Meeting in India (October 2007), the "New Delhi Communiqué" announced Canada had joined and confirmed plans for the Asia-Pacific Energy Technology Cooperation Centre. The third, and final, ministerial meeting took place China, resulting in a "Shanghai Communiqué" (October 2009), which told of the achievements of some of the 175 endorsed (including 22 flagships) collaborative projects, and their continued contributions to climate mitigation, again reaffirming the commitment to the UNFCCC and Kyoto. However, with only one new project initiated and new initiatives emerging after COP15 (December 2009), the APP would wind down in 2010, although many of these projects and communiqués are considered to live on in various guises (Minchener, 2011:44).

APP Clean Fossil Energy Task Force (CFETF)

The US had an influential role in the APP, as it chaired its governing 'Policy and Implementation Committee (PIC),' that provided direction and monitored progress and the US State Department-based 'Administrative Support Group (ASG).' The ASG acted as the secretariat that arranged its activities and coordinated its communications with the eight sector-specific public-private task forces. Organising an April 2006 workshop in Berkeley, the PIC brought together over 300 experienced public, private and third sector parties and instructed them to develop detailed "Task Forces Action Plans" with flagship projects that would illustrate the "vision of the partnership" and to demonstrate "self-perpetuating action" (APP, 2006c; APP, 2008a). China was the Co-Chair, along with Australia, in the Clean Fossil Energy Task Force (CFETF). From this, 17 CCS-related projects were endorsed with the aim of increasing technical efficiencies and reducing cost, primarily through a series of meetings, workshops, and seminars, but also through targeted laboratory research and pilot demonstration (APP, 2017f).

The CFETF flagship project was the "Post-Combustion Capture (PCC) Technologies," a partnership between the Australian CSIRO (led by the University of Newcastle) and China's Huaneng Clean Energy Research Institute (CERI). Completed in July 2008, this was China's first PCC pilot demonstration and was expected to capture around 3,000tpa of CO_2 for utilisation in the soft drinks industry. Although with plans to scale up by 2011, it faced the same efficiency and cost challenges as other CCS projects (Liu, 2009:3881; Hart *et al.*, 2010:111; APP, 2009a). Despite its lack of commitment and limited budget, by 2016 the APP was seen as perhaps the only remaining multilateral forum that could facilitate the coordination and possibly source the necessary funds for large-scale demonstration (Best, 2012:39; de Coninck, 2009:2163). Additionally, the APP has also played a small role in the CAGS (discussed later) and the Joint Japan/Australia and CUCBM 'ECBM Initiative,' as well as the supporting the WRI and Tsinghua University in the development of China-specific CCS regulatory and liability guidelines, based on those from the US (Espie, 2011:5954; Ward, 2011:24; NZEC; Gallagher, 2009:13; Li, 2011:5349; Hart *et al.*, 2010:118; Minchener, 2011:51).

Findings:

- Holding annual APP meetings with representatives from member countries, these were important occasions for governments to develop and announce bilateral cooperation. One of these occasions was in 2007, when Australia and China met to announce a MoU to increase cooperation with regards to CCS. Although this cooperation was more of an informational knowledge-sharing and personnel exchange, and not really technical cooperation, it was instrumental in providing the know-how and convinced Chinese parties upon their return to China to work towards domestic pilot projects in Beijing in 2008 (I05).

- China was Co-Chair in the CFETF with Australia and CCS was a focus of this collaboration. There was a formal personnel exchange which reportedly led to bilateral cooperation and continued support from both the APP and Australia for one of China's earliest CCS pilot demonstrations in Beijing. This was subsequently visited by the then Australian PM Kevin Rudd prior to the 2008 Beijing Olympics. Chinese members acknowledged that these developments "would not have occurred without the relationships developed in the 2006 international exchange program" and the earlier support from the APP (I05).

Case Study IX – Asia-Pacific Economic Cooperation (APEC)

Although first showing concerns about climate change in 1993, and again in 2007, it wasn't until the 2010 APEC meeting in Japan that its members acknowledged the growth of their emissions and their national responsibilities (On, 2013:7). Considered as another example of multilateral cooperation based on mutual developed-developing country respect and non-binding commitments, APEC was seen as a gateway to lucrative (and growing) economic markets that were of interest to many western industrialised nations, particularly the US and Australia (Smouse, 2007:17; Martin, 2014:1-2; Wright, 2014:3). Motivated through the increased realisation of the shortcomings of the soon-to-be concluding Kyoto in 2012, APEC's "Fukui Declaration" (June 2010) and its subsequent US (2011) and Russia (2012) Summits placed an emphasis on enhancing energy security through phasing out fossil fuel subsidies, promoting low-carbonization, and aimed to help establish low-carbon societies though market opportunities and private sector investment in green industries. Ensuring "essential energy services" for those developing countries which require them, APEC also promoted and periodically increased its soft targets, which included the development of sectors for and assisting in the diffusion of climate-friendly, low-carbon, clean-coal technologies, such as CCS. Although criticised for being an ineffective talking shop, which provided only policy recommendations, voluntary directives, and non-binding targets, with weak monitoring, reporting and verification (MRV), and few mechanisms for regulation and/or enforcement, APEC was considered instrumental in creating an inclusive atmosphere that cultivates "a spirit of cooperation" (On, 2013:1-7).

Building on this momentum, during the 22nd Annual APEC Leaders' Meeting and CEO Summit, that took place in Beijing during November 2014, Chinese President Xi and US President Obama concluded the event by marking the 35th anniversary of US-China diplomatic relations with a highly significant statement that laid out the countries' commitment to combating climate change and their future engagement on CCS (Martin, 2014:1). Although this could be seen as the two great emitters creating the challenge to meet (and perhaps go beyond) their own pledges, some viewed this as a total breakdown of the Kyoto Protocol-style separation in climate change negotiations between countries into Annex I and non-Annex I, and a sign of China's new willingness to take on a leadership role that comes with being a great economic power (Marcu, 2014:6).

APEC Expert Group on Clean Fossil Energy (EGCFE)

APEC Energy Ministers' Meetings (EMMs) take place annually or biennially and these meetings provide political guidance and direction to the APEC Energy Working Group (EWG), which meets twice annually to implement the APEC "Action Agenda" aims. Building the capacity of its members through joint R&D, data collection and analysis, the sharing of information and learning from experiences, the EWG facilitates seminars, workshops, and people-to-people exchanges, as well as peer reviews, demonstrations, and best practice guidelines and manuals. Led by the US, IEA, Energy Charter and Renewable Energy and Energy Efficiency Partnership (REEEP), the EWG has five sub expert groups, with the Expert Group on Clean Fossil Energy (EGCFE) most relevant to this study. Chaired by the US DoE, the EGCFE has carried out technical feasibility assessments and policy studies, seminars and workshops, and provided guidelines for CCS readiness and building capacity throughout the APEC region (Hagemann, 2011:5703; Smouse, 2007:17; World Bank, 2012:110; Wright, 2014: 5-6).

In 2003, with support from the Australian, Canadian, and US governments, as well as the IEAGHG, the EGCFE began organising the multi-phase APEC CCS Capacity Building Program with a focus on emerging economies that are major energy producers, consumers and GHG emitters along the Pacific Rim. Based on two distinct but interrelated themes (studies and activities), the overall objectives were to assess the potential for CO_2 geological storage in non-industrialized APEC countries and to identify candidates for projects, while building capacity for implementation of such projects. With activities taking place across five phases (2004-2012), APEC produced a series of technical reports, developed a comprehensive training programme and materials, delivered a series of workshops, although with little-to-no adaptation to any particular country or tailoring towards different audiences. Not surprisingly, China was a focus of some of these studies and workshops, in 2006 and 2010 (Bachu, 2009:4719-23; Wright, 2014:7-17; Smouse, 2007:19-20).

Findings:

- It was noted within the Chinese CCS community that APEC's intensive focus on CCS at such a high level (with firmly established climate objectives) was considered "a clear signal" from the international community to the Chinese government and this was "big news" This provided legitimacy to the efforts of the Chinese community already working on CCS and an added impetus for continuing with their CCS-related work and for investment in domestic CCS (R09;I13;A38;R22;A26;I18).

- Chinese interviewees see APEC meetings taking place every few years as the Chinese Government refocuses its attention towards CCS. In turn, this cycle repeatedly regenerates the motivation of Chinese industry and leads to increased interest from the wider CCS community (G12;I40).

- There were concerns that APEC's objectives, such as the innovative CCS pilots with enhanced water recovery, were merely "pride projects" to show improved diplomatic relations between the two countries. As climate change was a relatively safe area for US-China collaboration, one specific announcement followed a particularly tense period following the US presence and perceived provocation in the South China Sea (R09;R24).

Case Study X – Global CCS Institute (GCCSI)

Created in response to the G8's (2008) call for demonstrations, the Australian PM Kevin Rudd announced the GCCSI's establishment in September 2008. Also perceived as a hegemonic exercise to serve its own national interests, Australia's invitation to join the GCCSI seemed to be towards the coalition of willing states present in other CCS-related initiatives (de Coninck, 2011:375). Formally launched in April 2009, with AU$100m annually for the first four years, the Australian Government had also planned to invest AU$2bn towards large-scale CCS demonstration efforts domestically. These developments and a series of other events around that time was believed to have created an atmosphere of optimism that CCS would soon be deployed at commercial scale (IEA, 2009:4; IEA/CSLF, 2010:17,127; Ashworth, 2010:430; Minchener, 2012:26; Almendra, 2011:10; Gu, 2013:16). However, this optimism was short lived, as the disappointment at COP15 in Copenhagen coupled with the 2008 global financial crisis caused a series of funding cuts, industry cutbacks, and the fall in commodity prices, leading to a cancellation in international CCS projects (GCCSI, 2015:10; IEA, 2016:50).

Despite earlier receiving high-level government endorsement and public funding for its first four years, the GCCSI found its financial support extinguished by the new Australian Labour Government's budget cuts and (following consultation with its members) resorted to becoming a member-funded (not-for-profit) organisation (GCCSI, 2015:1,10). Although open to all interested parties, there is a strong expectation that GCCCSI membership involves a legitimate interest in CCS, a commitment to the institute, and more than just an incidental involvement in CCS-related activities. Its members come from carbon-intensive economies and industries that produce and/or consume large amounts of fossil fuels, membership grew from 226 to 368 between 2010 and 2013 (de Coninck, 2011:373; IEA/CSLF, 2010:127; UK-China Guangdong, 2013:12). In response to this, the GCCSI established a decentralised organisational model across three regions (the Americas, EMEA, and Asia Pacific) with offices in Melbourne, Washington DC, Brussels, Tokyo, and Beijing, which would be tailored to the needs of its membership.

Working with a wide array of other multilateral entities and international institutions and helping to forge public-private partnerships and investment alliances, the GCCSI plays an important role in funding activities and bringing parties together globally, which has arguably led to the creation and facilitation of an increasingly interconnected International CCS Community (Stephens *et al.,* 2012:144-5; Hagemann, 2011:5705-7; GCCSI, 2015:1; IEA&CSLF, 2010:25; IEA, 2009:7). Although, the GCCSI (2015:4) sees this as a way to combine expertise, coordinate activities, and share knowledge globally, with de Coninck (2011:373) determining this forming of strategic alliances and sharing similar goals as a way to counteract the considerable fragmentation within the existing CCS governance landscape. Crucially, in more recent years, the GCCSI is now believed to be expanding its partnerships outside the CCS community in an attempt to include the technologies within mainstream energy and climate change discussions (GCCSI, 2015:4). Claiming advocacy as one of its primary functions, the GCCSI (2015:1) seeks to create the positive image that CCS is "safe and clean" and ready to use, however given its origins and membership, such optimistic messages are often viewed with suspicion. Often lacking real criticism of the technologies within their publications and communications, de Coninck (2011:372-7) sees this as another case of enthusiastic storylines without effective scepticism of their potential.

Despite losing its public funding, the GCCSI's annual budget of AU$50m remained one of the most well-resourced CCS-related organisations and perhaps the only to have the potential for CCS demonstration. Following its involvement in writing the IEA-CSLF "CCS: Progress and Next Steps," the GCCSI has continued to be involved in a wide range of technical and policy-related publications. However, following on from earlier efforts, since 2009, the organisation has developed and maintained a list of publicly-declared large-scale integrated projects (LSIPs), making these available through its online interactive map and in its annual flagship "Global Status of CCS" publication, as well as a series of multilingual "Strategic Analysis of the Global Status of CCS – Country Studies" (de Coninck, 2011:372-3; Almendra, 2011:10; Hagemann, 2011:5705; Best, 2012:39). Although useful tools to demonstrate progress, the number of projects failing to reach the investment stage also leads to great concern. Drawing on the knowledge and experience of its wider and varied membership, the GCCSI has positioning itself as the "global broker" of CCS-related information and a central repository for data on global CCS developments. Also coordinating a number of subject-area networks, the GCCSI hosts seminars in different countries and workshops on specific issues, as well as organising online webinars which span continents and time zones, which eases its diffusion (World Bank, 2012:109; GCCSI, 2015:5). Although supportive of non-OECD capacity building activities, the GCCSI efforts in this area were usually undertaken in collaboration with other organisations, such as the IEA, CSLF and WB (de Coninck, 2011:372; ADB, 2012:144).

The GCCSI's engagement with China began through a series of workshops in Beijing during 2009, which highlighted the importance of EOR both globally and particularly for China (de Coninck, 2011:372). Recognising the importance of this cooperation for both sides, MOST became a member in 2010, and NDRC signed a MoU to strengthen technical cooperation and advance demonstration and deployment in 2012, while the Huaneng Group became the Chinese power industry representative and the China Steel Corporation its non-power CCS applications representative (Minchener, 2011:44, Minchener, 2012:26; Gu, 2013:16). Working with UK entities for regional activities in Guangdong Province since 2010, the GCCSI then established a physical office in Beijing in 2013, which led the Australian Minister for Resources and Energy, Martin Ferguson, to say "the lessons learnt and shared by the Institute through its work in China will help governments and project proponents from around the world, including Australia, to accelerate the deployment of CCS technologies" (UK-China Guangdong, 2013:12). Unfortunately, although the GCCSI has been tracking the progress of Chinese large-scale CCS demonstrations and other notable projects, there has been limited GCCSI funding towards the direct financing of demonstration projects in China – despite its potential to provide assistance (ADB, 2015:23). However, one significant outcome of the GCCSI/NDRC partnership was the 2015 ADB-supported "Road Map for CCS Demonstration and Deployment in the People's Republic of China" (ADB, 2012:144; ADB, 2015:vii).

Findings:

- Invited to send a delegation to attend the GCCSI preparation meeting in London in 2009, the Chinese Government enlisted the support of one interviewee (a leading Chinese researcher) to attend. Going on to sit on the GCCSI's 'International Advisory Panel' and to provide strategic advice, policy guidance and progress updates on local CCS developments, this party also acted as a bridge with the CCS community and assisted in establishing a physical office in China dedicated to CCS-related issues (R09).

- One of the key functions of the GCCSI is to hold CCS-related conferences, seminars and workshops globally, including within China and to publish technical reports, and online information and email communications. With many organisations providing similar activities (that have been criticised for offering the same speakers and information), there are questions as to how much influence such activities have on Chinese parties' attitude towards CCS and their adoption of the technologies. (R01;R09;R16;R23;I05;R06;R24;G02;A07;A29;A39;R04).

- Chinese governmental stakeholders stated that while they welcome such international cooperative activities for the purposes of collecting information and that they do allow them to feel more positive towards CCS, it does little to change their actual position on the technologies and that the provision of funds for CCS projects might be more persuasive in swaying their opinion and initiating action (G12;G02).

- A few individuals reported small amounts of funds from GCCSI but there was a feeling that the organisation was beginning to show less enthusiasm towards China in recent years (R06;R24;R23).

Case Study XI – US Department of Energy (DoE)

The US DOE's Office of Fossil Energy had played a critical role in promoting domestic CCS activities, both by providing large sums of funding and through coordinating national and regional-level programmes, as well as facilitated pilot efforts and demonstration projects (Stephens, 2009:33; NETL, 2011:10-11). Most prominently, the US FutureGen Alliance project was once seen as the cornerstone of the Bush Administration (Drahos, 2009:127-8). However, its costs had escalated to unacceptable levels and the partners failed to raise the capital needed, resulting in a loss of governmental support (de Coninck *et al.*, 2014:258). Despite significant domestic technological advances and managerial lessons, the DoE was falling short of its goal to successfully demonstrate reliable, safe, and cost-effective CCS, by its target date of 2012, and it was looking unlikely it would achieve its ambitions of widespread deployment and market penetration by 2020. Seeking to increase its project experience beyond its own borders, it began to initiate, support, and become involved in international initiatives and projects (Klara *et al.*, 2002: 248,252-3, Wilson *et al.*, 2007:5945; van Alphen *et al.*, 2010:972-982; Stephens, 2010:2026; Pollak *et al.*, 2011:316; Wilson *et al.*, 2011:328).

Around the same time, positive US-China bilateral relations had been intensifying, with joint affirmations of support for continued clean-energy technology cooperation, firstly in Washington D.C. (February 2013) and then the Netherlands (March 2014). Resulting in the two Presidents (Obama and Xi) announcing a series of joint agreements to reduce emissions alongside submitting their Intended Nationally Determined Contributions (INDCs) for Post-2020 climate targets in November 2014, this sent a powerful message internationally ahead of COP21 in Paris the next year (CERC, 2014b; CERC, 2015:14; Lewis, 2015:2). However, as outlined by the US-China Climate Change Working Group (CCWG), the key to achieving these targets would be building on the work of the US-China Clean Energy Research Centre (CERC), which had been a successful vehicle to partner on research, projects, pilots, and demonstrations in China (Marlay and Cai, 2014:2,40; CERC, 2014:22,40; Marlay and Cai, 2015; CERC, 2015:14; Yang, 2016:3-4).

By way of providing some background, the US Asia Society's "Roadmap for US-China Cooperation on Energy and Climate Change" (January 2009) outlined the "unparalleled opportunity for a new [US-China] strategic partnership." This was followed with, what would become called, the US-China Strategic and Economic Dialogue (July 2009), which resulted in the signing of an MoU that established the CERC (Drahos, 2009:126; Asia Society, 2009b:15. CERC, 2014:ii). Providing a mechanism to support their respective national climate commitments, the CERC was designed to encourage bilateral clean technology-related collaboration, while also striving to achieve the G8's ambitions for demonstrations (Asia Society, 2009a:6-8,13,45). Historically, the US-China cooperation had lacked commitment, coordination, and funding, as well as effective management of intellectual property, so the CERC was seen as a new paradigm for technological innovation, clean-energy sector deployment and the way bilateral partnerships are structured and financed (Asia Society, 2009a:27; CERC, 2011: vii,2-3,23; CERC, 2014b, CERC, 2016:1; Gallagher, 2009:10,14; Lewis, 2014:546-7).

US-China Clean Energy Research Centre (CERC)

Set out in the "CERC Protocol (2009)," the bilateral partnership was to be governed by a high-level ministerial council that included the DoE and three Chinese ministries (Asia Society, 2009a:12,45,48; CERC, 2009:5; CERC, 2011:33; Lewis, 2014:549). Seeking to benefit commercially from the accelerated development and deployment of technologies, while avoiding duplicative research costs, the "CERC Protocol (Annex I)" also sought to "banish the ghosts of past ideological debates over intellectual property," which had been a persistent problem for both countries' cooperation (Drahos, 2009:125). Stipulating that each CERC consortia should include bilingual Intellectual Property (IP) provisions within their "Technology Management Plans (TMP)," as a prerequisite to their "Joint Work Plans (JWP)" (Marlay, 2012:20; Yu and Baird, 2014:3), these were considered novel test-bed arrangements, which took many months to agree. In order to remove any uncertainties or hesitations that could restrict collaboration, an 'IP Experts Working Group' was established and five IP-related workshops were held to increase the clarity and confidence of those with less experience navigating complex IP requirements (Asia Society, 2009a:30-31, CERC, 2011:7-8,17-18; Marlay, 2012:20; CERC, 2013:16-19; CERC, 2014:58-62; Yu and Baird, 2014:8-14; Lewis, 2014:546,549,552-3; Lewis, 2015:7-13; Yang, 2016:5). However, Chinese partners are reported to have seen the focus on IP as time-consuming and bothersome, with some seeking clever workarounds, which limited the instances of joint CERC-related IP creation (Lewis, 2014:552-3).

Taking six months and 28 drafts for both sides to agree the Advanced Coal Technology Consortia's (ACTC) TMP, the US Secretary of Energy, Steven Chu, commended those involved in the process for "freeing our researchers to offer their best ideas and encouraging innovative thinking," commenting that he seen joint US-China IP as the ideal outcome (CERC, 2011: viii, 8-9). At the working-level, the CERC ACTC built on their partners' expertise and experience and set out nine critical research themes to "accelerate the development and deployment of clean coal technologies, including CCS within both countries" (CERC, 2013:B1, CERC, 2014b:11-12; DoE, 2011b; Lewis, 2014:550; Yang, 2016:12-17). Key to this was the experimenting, piloting, demonstrating, and optimising processes to provide learnings for technological efficiencies, cost savings, and to create commercial conditions (CERC, 2015:24). Performed through exchanging information and sharing experiences at consortia meetings, site visits, platforms and other communications, annual meetings were also opportunities to share progress and achievements and to allow leadership to review and to set the strategic direction (CERC, 2011:12,54; CERC, 2012:53-56).

Although originally hoped to be a new paradigm for the way bilateral partnerships are structured and financed, the CERC did not wholly resolve the historical issues in US-Chinese cooperation identified earlier. On commitment, despite continually welcoming new (mainly Chinese) members, the CERC documents show that US membership declined significantly, reportedly due to the original industrial partners leaving due to IP concerns, funding hesitations, or weighing up the costs/benefits of participation (CERC, 2014b:11-12; Marlay and Liu, 2013:11; Lewis, 2014: 549,552; Yang, 2016:7; CERC, 2015:2). Regarding coordination, the three participating Chinese ministries with overlapping jurisdictions often caused challenges logistically and with reaching consensus (Asia Society, 2009a:12,45,48; CERC, 2009:5; CERC, 2011:33; Lewis, 2014:549). Additionally, the different national approaches to selecting leading partners was seen as seen to have stifled effective collaboration, and potentially resulted in missed opportunities (CERC, 2011:5; Yang, 2016:5, 12-17; Lewis, 2014:549). Regarding funding, uniquely the CERC required equal funding from both sides, with expectations that both public and private, as well as non-profit, sector partners would make contributions. However, China didn't fully embrace that 50/50 and public-private model, which was believed to have had implications for matching teams and tracking contributions (Yang, 2016:3,12-17).

On intellectual property, despite funding over 240 researchers by 2016, the ACTC contributed to only around 20 commercial technologies and software projects, and the patents were only filed and registered in one of the two jurisdictions (Lewis, 2014:9-10,552-3; Yang, 2016:12-17). In fact, Yang (2016:7-9) found that with no truly jointly-funded ACTC projects, most of the information exchanged between partners was already publicly available, in the form of over 400 journal articles and more than 80 conference papers. For the US, the real value of the CERC was to access the learnings from "big experimental platforms" (Yang, 2016:12-17; Marlay and Cai, 2014:14; Lewis, 2014:9-10,553; Asia Society, 2009a:30; CERC, 2014b:11-12; Ward, 2011:15; CERC, 2011:2). However, the CERC was criticised for having too many small, scattered, or rebranded projects with too many projects lacking partners from the US and less engagement by Chinese industry (Marlay and Cai, 2015:11; CERC, 2013:v; Lewis, 2014:549). At the same time, the Chinese National Center for Science & Technology Evaluation (NCSTE) independently reviewed the CERC and found it to be "a milestone initiative with a win-win approach" that "enables a new kind of relationship, built on mutual trust, understanding, and friendship."

Surprisingly, at the 2014 CERC Steering Committee Meeting, Ministers discussed the potential "Phase II (2016-2020)," with aspirations to address those criticisms by focusing resources on a smaller number of larger projects that had the potential to truly disrupt existing markets and deliver powerful clean energy solutions (CERC, 2013:21; CERC, 2014:1,22,40; CERC, 2014c; CERC, 2014d; Marlay and Cai, 2015:12; Friedmann, Zheng and Wood, 2014; CERC, 2015:22,37; Yang, 2016:2; Marlay and Liu, 2013:12; Lewis, 2014:549).

Findings:

- Providing online information of current CCS developments and project news, the DoE's website proved to be an important resource for Chinese parties (RO1;A32).

- Another effective form of communication was the regularly organised seminars and workshops in China, which were often facilitated through Chinese government departments or private companies. While influential in bringing together international and Chinese experts to discuss the latest development of CCS both at home and abroad, the DoE also helped to organise Chinese delegation visits to international organisations and projects of interest (A21;I18;I40).

- Face-to-face Interpersonal communications between DoE personnel and Chinese individuals have also been important, with one particularly high-ranking individual speaking at international CCS-related events and attending meetings in China. Referring to the recent international success of technical CCS scale-up, this individual is reported to have said “"without CCS projects, there will be no CCS" (I40) and "we are ready to pilot, we are seeking partners and looking for possibilities" (R09).

- Reporting that a DoE team was on the ground in China meeting with and assessing potential candidates, there were reports that the US was to support two China-based CCS projects. Leading to members of the Chinese CCS Community jostling for position to collaborate. One project was known to focus on the demonstration of CCS with enhanced water recovery, while the other was believed to be for supporting feasibility studies for another more conventional CCS project. All these activities were believed to have sent strong messages to those within the Chinese CCS Community that the US has been actively watching the Chinese CCS Community and is assessing the competency of various individuals, organisations and projects with the possible intention to provide support (A21;R24;G02).

- As a platform for bringing together international and Chinese parties and to provide a push towards large-scale CCS commercialisation, CERC was seen as a great opportunity by a number of Chinese governmental stakeholders (G02;G12).

- Many of the US parties identified by the Chinese interviewees have been involved in CERC activities, including Alstom, Aramco Services, Dow Chemicals, Duke Energy,

Energy Foundation, GE, ICF International, the Berkeley Lab, LLNL, LANL, MIT, NETL, NDRC, Peabody Energy, UofK, WVU, UWy, Washington University in St. Louis, and WRI (A07;A03;A11;R01; R14;A21;R06;A39;G02;R35;R16;A29;A28;A17).

- There were reports that CERC was dominated by certain parties, who had good relations with old project partners that held both influence and the finances, often excluding others (A07).

- One key Chinese figure involved within CERC showed concern that in recent years the support from these international industrial parties had appeared to dwindle, with several leaving the consortia and others halting their own investment in CCUS, giving the impression that CCS had a "not so bright future" (A11).

- Another interesting aspect of the US-China relationship is the creation of a DoE "Award of Distinction" for outstanding contributions to CCS in China (R24).

Case Study XII – Canadian International Development Agency (CIDA)

Considered to be climate ambitious, Canada had recognised the exponential growth in its petroleum industries and the unprecedented rise in heavy GHG-emitting oil sands production, mostly in its provinces spanning its Western Sedimentary Basin. Seeking not to antagonise those autonomous states by halting their activities and causing a loss in profit and revenue, the Canadian Federal Government needed to find a solution to curb the emissions of Saskatchewan and Alberta, which if allowed to grown unchecked, would be greater than 600 megatons per year by 2050, comparable to Canada's current total emissions of 750 (Jaccard, 2011: 75-95).

Fortunately, the country already held many of the natural characteristics, industrial attributes, and commercial abilities needed to successfully develop, demonstrate, and deploy CCS. Featuring the technologies as a critical component within its 'National Climate Change Strategy' since 1999, Canada's public and private sector partners worked together on "Canada's CO_2 Capture and Storage Technology Roadmap" (2006) and "Canada's Fossil Fuel Energy Future: The Way Forward on Carbon Capture and Storage" (2008). Alongside government policy, the federal and provincial governments had invested over CA$3b through the Clean Energy Fund and the ecoENERGY Technology Initiative, and planned to launch seven large-scale fully-integrated CCS demonstration projects by 2015. Alberta and Saskatchewan also launched their own pilot projects and programmes for sharing information, most famously the Weyburn-Midale project (one of the earliest large-scale demonstration projects) and more recently the SaskPower Boundary Dam (the first and largest fully-integrated, commercial-scale CCS project) (Mitrović *et al.,* 2011: 5685-91).

More relevant to its cooperation with China, Canada had been a leader in coal-bed methane (CBM) production, although its volumes of production and investment levels had been falling for some time. Appearing to grow exponentially just across the border in the US, Canada had recognised CO_2-enhanced coal-bed methane (CO_2-ECBM) (one form of CCS) as a transitional technology towards a more reliable and affordable energy supply (IEAGHG, 1999; Natural Resources Canada and CANMET Energy Technology Centre, 2008). Meanwhile, China had been venting CBM into its atmosphere since the 1950s, only later realising that this hazardous pollution was also a valuable economic resource. Holding an estimated one third of global CBM resources, China had also begun to notice the US industrial success in this area and its decision makers recognised the opportunities for promoting domestic industrial development and encouraging international cooperation. Creating the state-owned China United Coalbed Methane Corporation (CUCBM), the first Chinese investment promotion event "Prospects for Enhanced Recovery of Methane from Deep Beds of Unmineable Coal (1991)" attracted significant attention from foreign partners which lead to many joint ventures and pilot projects, including with Canada (Stevens, 1999; IEAGHG, 1999:83-4; Sun, 2000; IEAGHG, 2000:36; Ye, 2007:2; CUCBM, 2009:5,10; Sloss, 2015:31, Wu, 2015:3-5).

Emerging from relations built during the 1991 event, an Alberta Research Council-led Canadian-CUCBM consortium submitted a successful proposal to CIDA's 'Canadian Climate Change Fund.' Following the signing of the 'China CBM Technology Development Agreement' with China's Ministry of Commerce (MOFCOM) in December 1999, a CIDA-CUCBM agreement created the China-Canada CO_2-ECBM Project, which was seen as the most significant Sino-Canadian CCS-related initiative of its time (He, 2011). Funded by equal CA$5m contributions from both governments, the project was launched in 2000 and sought to transfer Canadian technologies to China and to demonstrate the viability of injecting and storing CO_2 in deep unmineable coal. Taking place over two phases, the work was broken down into 'work breakdown structures' that would identify micro-piloting sites for the demonstration and evaluation of Canadian technologies in China. Seen by Canadian partners as a successful transfer of Canadian technologies and the building the capabilities of Chinese colleagues, the possibilities for new commercial opportunities in China led to Chinese partners calling for full-scale demonstrations (Ye, 2007:6,34,40; Wu, 2015:8; Sloss, 2015:32-3; GCCSI, 2017). Despite supporting conceptual designs, the Chinese and Canadian Government didn't provide funding and the prospects for a larger semi-commercial scale pilot appeared to fizzle out, although the ARC did continue to support Chinese companies undertaking feasibility studies under 2010 (Sloss, 2015:29-33).

Findings:

- A number of Chinese parties interviewed had participated in the 'China-Canada CO_2-ECBM Project' training exercises and/or had contributed to its associated tasks. They believed these early activities to have demonstrated the great commercial potential of CO_2 sequestration and utilisation to produce methane by-products in China's vast coal beds (A03;R14;A07).

- The Weyburn-Midale Project was seen by some Chinese parties as having a promising commercial model, mainly due to its inclusion of EOR, and they were impressed by the project's achievements and spurred on by the prospects of adapting such models to the Chinese context (A19;R06;R01;A07). However, with support from the Canadian Government to facilitate the selling and buying of CO_2 as a resource, Chinese parties reported experiencing difficulties in replicating such activities in China, reportedly due to the lack of government support and limited successful domestic EOR projects (R01).

- Seen as a landmark event in the development of CCS internationally, the SaskPower Boundary Dam project has been viewed by Chinese parties as a technical success but financially unviable in the long-term. Seeing an acceptable (but still expensive) cost of capture as US$30-50 per ton, the cost at the SaskPower project was estimated to be much more than that, thus undoing any positivity of any technical successes achieved (I05;R09;A07;I40).

- Although Chinese parties had also met with the project team and visited the Sask Power demonstration in September 2013, after hearing that the investment costs were nearly ten times the cost of a power plant in China (without CCS), their enthusiasm for the technologies were dampened considerably. Considering the level of Canadian government support, high electricity prices, low fuel costs, availability of CO_2 and prospects of EOR from Weyburn, there appeared to be little possibility that such conditions could be replicated in China. Despite SaskPower receiving both positive and negative evaluations from international experts and the media, Chinese parties feared taking any such chances in demonstration, while the domestic Chinese conditions were not compatible (I05;R01).

Case Study XIII – European Commission (EC)

The EU and China have had economic relations since the 1970s, firstly on trade, then development aid, and then foreign direct investment, with climate change being a more recent area of joint strategic interest. At the core of this bilateral relationship is the periodic 'EU-China Summits,' with the 'Joint EU-China Partnership on Climate Change' forming a central component of that dialogue in recent years. Released during the Eighth EU-China Summit (2005), its "Joint Declaration on Climate Change" saw concrete plans for CCS development and demonstration in China (by 2020) emerge as a key bilateral priority. Establishing a Bilateral Consultation Mechanism (BCM) and creating a "Rolling Work Plan" the following year, the EU-China relationship appeared to strengthen, even during the onset of the global financial crisis, as both signed nine cooperative agreements, leading to the establishment of the Europe-China Clean Energy Centre (EC2) (Romano, 2010:3-4; DECC, 2009; Gu, 2013:17; DECC, 2009).

Released during the Twelfth EU-China Summit in 2009, the "Demonstrating CCS in Emerging Economies and Developing Countries: Financing the EU-China NZEC Plant Project" saw the EC pledge EUR50m towards a collaborative project that was to be "a concrete and politically visible demonstration plant on a scale large enough to catalyse change at the national level and to transform external perceptions of China" and to reach commercialisation by 2020 (EC, 2009; Romano, 2010:4-8). Throughout this period, the EC's Framework Programme (FP) had also offered funding opportunities for CCS-related research, pilots, and small-scale demonstration, with China receiving an estimated EUR46m for 200 projects during FP6 alone (De Matteis, 2010:470). Importantly, the EC's CCS-related objectives, activities and funding, were primarily channelled through several interconnected initiatives, namely EU GeoCapacity Project, STRACO$_2$, and COACH, and as well as NZEC, all of which will be discussed a little later (Zhongyang, 2009:3915; Taylor, 2009:2-3). Followed by another EU-China MoU later that year, this also led to the China-UK-led NZEC (II), also discussed later, which aimed to attract possible public and MDB donors, as well as active and passive equity investors (Senior *et al.*, 2011:5956-7).

Findings:

- There had been strong cooperation between the EC and China's MOST on many aspects of science and technology and a number of Chinese interviewees mentioned having direct contact and interactions through a number of EU-China bilateral CCS-related projects (R04;G02;R01).

- Quoting 2006 as the key date for when Chinese governmental parties were introduced to (and started to pay close attention to) the concept of CCS, the EC was believed to have played an important key role in this process (G02;R16).

- There were earlier EC supported CCS projects (in the 1990s) that involved Chinese parties that were not directly focused on China, which allowed them to initially learn of and become engaged in CCS-related activities (R09;A28;A33).

- There was a feeling that the "golden era" of EU-China CCS cooperation (2006–2013) has been declining for some time now, although Chinese parties were still attentively watching the EU's own commitment towards CCS carefully (such as the financial offering by EU by way of the "New Entrants Reserve (NER 900) Programme" for innovative commercial CCS and renewable energy technologies demonstrations) (R01;A11;I18).

Setting aside the high-level pledges and funding opportunities, it is the official-level dialogues, meetings, and feedback that provide opportunities for the EC to shape China's domestic climate policy development processes, while also avoiding the stormy waters at the diplomatic and political levels (De Matteis, 2010:450-7,467,472-3). A number of the key CCS-related dialogues are presented below:

EU GeoCapacity

Taking place between 2006 and 2008, this 26-partner/21-country consortium primarily focused on assessing the CO_2 geological storage potential across Europe, however its 'Work Package Six (WP6): International Cooperation' had a focus on technology transfer and building partnerships with China. Successful in developing an inventory of CO_2 emissions point sources in Hebei Province and assessing the storage capacity in China's Bohai Basin, GeoCapacity partners brought this data together to produce a CO_2 source-sink resource for Chinese partners. However, Chinese Government regulations around the provision and sharing of data relating to its domestic infrastructure and subsurface geology meant there were restrictions around EU partners' technology, so China-specific technology needed to be developed domestically. Focused on providing the scientific rationale and documented proof for the legitimacy and cost efficiency of the concept of CO_2 geological storage and its contributions to climate change, GeoCapacity sought to provide a basis for influencing policy makers, industry leaders, and in developing a potential supply chain in China. Alongside this technical cooperation, there were frequent formal meetings, thematic seminars, and basin-related workshops, as well as training – which fed into the other EU projects in China discussed below (EU GeoCapacity, 2009:4-10,29-31,37; EU GeoCapacity, 2010:3,10,54-61; Vangkilde-Pedersen *et al.,* 2011:6; Vangkilde-Pedersen et al., 2009:48; Bellona, 2009; GCCSI, 2009:8; Liu, 2009:3880; Vangkilde-Pederse *et al.*, 2009:2670).

Findings:

- GeoCapacity Project was believed to have ignited wider local interest in the concept of CCS and the possibilities for various stakeholder groups in this field, leading to what is thought to have been one of the earliest stakeholder meetings (supported by the CAS in Beijing in 2006) (R09;R04;I18;R06;A21;A39;R16;A19).

- GeoCapacity also provided opportunities for not only direct interaction with the EC, but also member states and other countries (such as Norway, Australia and Russia) to collaborate with China (A17;A32;A29).

Support to Regulatory Activities for Carbon Capture and Storage ($STRACO_2$)

Taking place between 2008 and 2009, the EC's FP7-funded $STRACO_2$ project was to support the development of an EU regulatory framework for CCS by investigating incentivisation schemes, financial mechanisms, international trade, and technology transfer, as well as socio-economic issues. Seeing China as a gateway for the international adoption of CCS, $STRACO_2$ placed great emphasis on creating dialogues, and joined with Chinese regulatory authorities ($STRACO_2$, 2009:9; EC, 2009; EC, 2017). Meeting in Brussels and Beijing, the six European and three Chinese partners came together to agree on priority research areas and ways of working, as well as an effective means to communicate (EC, 2009). However, despite plans and efforts to work closely, the EU and China held separate Expert Working Group (EWG) meetings (reported with very little cross-over), only coming together at the Consolidation Meeting in Beijing, where they presented their research and discussed the format of the final report. Despite this, $STRACO_2$ was considered successful in providing lessons on the policy and regulatory developments in each jurisdiction and its work package-level findings and final synthesis reports where shared at the $STRACO_2$ "International Conferences on CCS Regulation in the EU and China" in Brussels and through subsequent workshops in China ($STRACO_2$, 2009:10,60-167; EC, 2009).

Findings:

- Many of the European institutions referenced earlier were also involved in $STRACO_2$, which allows us to begin to recognise how the EU has been influential in building early connections between European nation states and Chinese institutions (R01;R04;R06).

- Some policy-focused parties commented that their organisational interests in CCS coincided with the beginning of the project (as only a number of people in China were thought to know of CCS before that time), so the project provided opportunities for early "learning-by-doing" (R16).

Cooperation Action with CCS China-EU (COACH)

Launched in November 2006, the three-year, 20-partner, multi-sectoral consortium was aimed at creating strong and durable EU-China cooperation on clean near-zero emissions coal. Led by both European and Chinese partners, the six individual work packages (WP) were intended to provide design recommendations for possible large-scale CCS demonstrations in China between 2015-2020, perhaps using European technologies. WP1 focused on 'Knowledge Sharing and Capacity Building' through bilateral workshops and training (which helped to intensify the dialogues and share information), mobility schemes (which allowed Chinese personnel exchange to European partners), and two (one-week) "COACH Schools" in China (which allowed a "cross-fertilization" of early career researchers and professionals). WP2 'Capture Technologies' and WP3 'Geological Storage and Large-Scale Use of CO_2' identified the most viable technologies for China's flagship Huaneng GreenGen Project and provided the geological assessments and point-source mapping, as well as the first ever analysis of CO_2 transportation options for China. Although economic/cost considerations remained to be the key challenge making progress, the bilateral partnership again suffered from Chinese Government regulations around the provision and sharing of data. WP4 'Recommendations and Guidelines for Implementation' sought to bridge the technical recommendations with recommendations on legal, regulatory, financial/economic, and social considerations. The last two, WP5 'Project Management' and WP6 'Overview, Monitoring and Reporting of Chinese-European MoU Activities,' were more related to coordination, administration, and reporting (Kalaydjian, 2006:6-9; COACH, 2008; Poulsen, 2009:6-18; EU GeoCapacity, 2009b:6; Le Nindra, 2009:6; EC, 2009; EC, 2010; EC, 2011:5-11; Kalaydjian *et al.,* 2011:6022-6028; EC, 2012).

Findings:

- COACH seminars, workshops and training courses were seen as a very good way to push CCS forward, especially for those that had only just learnt about CCS, to allow them to understand more about the technologies, and how they can be beneficial to China, all in a very short period of time. Such platforms were also seen as a very useful method of bringing together young people around the technologies, to build friendships and to further train the next generation of CCS professionals, some of which have until today have played significant roles within the Chinese CCS community. These activities were also useful for more seasoned academics and professionals (whom may have already been working on CCS-related areas) as an opportunity for them to brush up on their CCS-related knowledge and expertise, while also allowing them to take their research in new directions and to network with international experts and other Chinese professionals. A number of Chinese parties also recalled the research support provided during COACH, which allowed them to carryout desktop investigations, laboratory tests, and very small-scale pilot projects, that produced valuable data and significant results, which was subsequently shared with other Chinese stakeholders (R01;A39;A19;I18;A08).

China-EU Near-Zero Emissions Coal (NZEC)

NZEC built on previous EC (and UK) MoUs and their overarching objectives to identify the right CCS technologies, design a Chinese demonstration, and support its construction and operation, ultimately to build confidence around the technologies in China. The EC had welcomed EU member states' involvement and the strong UK leadership was obvious. It was launched by UK Deputy Ambassador to China Barbara Woodward and the Chinese Vice-Minister Liu Yanhua in November 2007.

Designed to absorb the outcomes from the other EU-China collaborations (GeoCapacity, $STRACO_2$ and COACH), the NZEC initiative was intended to be the centrepiece of the EU's CCS cooperation with China. However, we have seen very similar structures and functions for cooperation, with five distinct but interrelated work packages that had strong linkages to the activities of the other EU-China initiatives. For example, there was WP1. 'Knowledge Sharing & Capacity Building' (which focused on meetings, workshops, training, and as well as study tours to visit key stakeholders and pilot/demonstration projects internationally) and WP2. 'Future Energy Technology Perspectives,' WP3. 'Case Studies for Carbon Dioxide Capture,' and WP4. 'Carbon Dioxide Storage Potential,' which were all intended to develop the skills and enhance the experience of partners. WP5. 'Policy Assessment and Roadmap' brought together the technical WP papers with non-technical matters that might influence CCS adoption in China, and produced the "NZEC Phase One Final Report" (2009), which was targeted towards Chinese policy makers and business leaders with little CCS knowledge.

Concluding in 2009, NZEC was seen as being successful in narrowing down the best technological options for a Chinese demonstration, while building the skills of Chinese partners. Subsequently, the need to move towards more practical experience with scaled-up demonstration led to the establishment of the 'China-EU Co-operation Leading Group,' which would form the basis of NZEC II (2010-12). However, despite an EC commitment to provide EUR50 in 2009 and EUR in 2013 towards the construction and operation of the joint EU-China NZEC large-scale first-of-a-kind 400MW demonstration project in China, this fell around EUR300-500m short of the estimated EU730-980m needed over the project over its 25-year lifetime. Given the substantial savings of demonstrating in an non-OCED country, it was hoped that NZEC II could leverage additional donors, public-private partnerships, or equity investors, although that is still to be realised (Webb, 2007:12; Zhongyang, 2009:3909-14; UK Parliament, 2009; $STRACO_2$, 2009:108,110; DECC, 2009; Taylor, 2009:7-22; Haydock, 2009:4,11; Le Nindra, 2009:6; Romano, 2010:18-19; Chen, 2010:2129-2130; Duan, 2010:5281; NZEC, 2009:4,43; EU GeoCapacity, 2009:29; NDRC, 2010:24-25,36,39-41; Senior *et al.*, 2011:5958-5963; Le Nindre, 2011:6045; Kalaydjian *et al.*, 2011:6021-6022; Hagemann, 2011:5701; Minchener, 2011:46-48; UK-China Guangdong, 2013:104; Gu, 2013:6; Best, 2012:37; Zeng, 2013:3; Haydock, 2009:7-11).

Findings:

- NZEC made a significant impact on China's adoption of CCS technologies, as MOST's ACCA21 established a dedicated NZEC project management office (G02;R04;R16).

- Similar to COACH, NZEC was seen as a past (and potential future) source of funding for CCS in China, although most funded activities were very small desktop investigations or laboratory research (R01;G27;A39;R35).

- Having concluded NZEC I and NZEC II, interviewees commented that NZEC III was still to show signs of initiation. However, it was anticipated that at some time joint collaborations will begin on associated political, economic, environmental and social issues, such as policy, regulation, cost, risk and public perception/acceptance (R04).

Case Study XIV – UK Department of Energy & Climate Change (DECC)

The UK had been a leader for CCS in Europe but the country's own ambitious plans for demonstration had been thwarted due to the cancellation of the Government's £1bn GBP commercialisation programme. Faced with these significant challenges at home, the UK has seen strategic opportunities for joint learning through cooperation with China, particularly in the South-East province of Guangdong, given its very similar conditions of good off-shore storage and industrial facilities close to the coast. For Guangdong, its rapid growing population, enhanced economic development, increasing energy demand, and need to expand its coal-fired energy fleet, as well as its status as one of China's seven pilot low-carbon provinces and the second largest Emissions Trading Scheme (ETS) scheme globally, made it a suitable and willing partner (Liang, 2014:3). However, for both sides the UK was also considered a lucrative potential market for CCS technologies (perhaps £1.5bn GBP annually by 2020), so there was a recognition by the Deputy Director of Guangdong Development and Reform Commission (DRC) that before the technologies could be widely deployed further work needed to be done on all technical and policy-related aspects of CCS. For all of these reasons, UK-China partnership and cooperation was considered very important, which led the establishment of the UK-China (Guangdong) CCUS Centre (GDCCUSC).

UK-China (Guangdong) CCUS Centre (GDCCUSC)

Using one of its key diplomatic tools for closer collaborate with China's central ministries and provincial governments, the UK Foreign & Commonwealth Office's (FCO) 'Strategic Prosperity Fund (SPF)' provided around £444k GBP for a Tsinghua University-led CCS-related techno-economic feasibility in 2009. Intended to generate governmental motivation to develop a China CCS strategy and to increase industrial interest in the deployment of CCS, it was particularly focused on the coal-fired power generation sector. Some months later in March 2010, an SPF-supported "Feasibility Study of Developing CCUS-Readiness in Guangdong Province (GDCCUSR)" was launched at an event in Guangzhou by the UK, Central Chinese, and Guangdong Provincial Governments, at a well-attended event that was widely reported by major Chinese newspapers and local media. Kick-starting a three-year process of cooperation, the UK and Chinese partners co-authored five separate but interlocking reports on CO_2 point sources, CO_2 storage, mitigation costs, commercialisation, and capacity building/public awareness, which concluded with a sixth and final report “CCUS Development Roadmap Study for Guangdong” that outlined the demand, benefits, challenges, and likely timings for CCS demonstration and deployment in Guangdong by 2030 (Liang, 2015:4).

Importantly, report number five “CCS Capacity Building and Public Awareness in Guangdong” recommended the need to create platforms and share information, tools, skills, and expertise, so the GDCCUSR Team set about establishing bodies, organising meetings, facilitating on-site visits, and forging a network of stakeholders, in order to create a source of local expertise. Taking these recommendations on board, the GDCCUSR Team scheduled quarterly bilateral meetings that focused on thematic areas, often inviting influential and interested regional stakeholders to spark or gauge their interest in CCS. These were often complemented with more open workshops during the UK Low-Carbon Weeks in China, that would share the progress and findings with national and international parties. The GDCCUSR Team also facilitated at least ten visits to power plant sites in China and visits to existing Chinese demonstrations and facilities abroad (such as Shenhua Ordos and the Scottish CCS Centre), which provided opportunities to speak with engineers and management, to promote the concept of CCS (particularly ‘capture ready’), and to assist them in their questions and/or planning. In September 2010, they launched the China Low-Carbon Energy Action Network (CLEAN) as China’s first formal CCS partnership, gaining 86 members from 55 institutions by 2013, and creating a multi-sectoral platform for domestic cooperation and becoming a hub for communications (Minchener, 2011:50).

Following the completion of the “Feasibility Study of Developing CCUS-Readiness in Guangdong Province (GDCCUSR)” in September 2013, the UK Minister and Guangdong Governor signed the ten-year “MoU of CCUS Industry and Academic Communication Promotion.” This would lead to the establishment of the UK-China (Guangdong) CCUS Centre (GDCCUSC) the same year, as a registered Chinese non-profit with a physical office in Guangzhou that would bring together technical experts and policy specialists from industry and academia to recommend the best commercial models and technology options for a Guangdong-based demonstration. Building on this work, during the 2nd Guangdong International CCUS Expert Workshop (2014), a series of speakers offered recommendations for a proposed large-scale demonstration project in South China, which was followed by a Chinese Government-endorsed announcement of the Provincial DRC plans for the first CCUS-ready demonstration project for Guangdong at the newly-constructed China Resources Power (CRP) Haifeng Power Plant, while also mentioning the possibility of a UK-China Joint CCUS Testing Centre. It is worth mentioning that in 2012 CRP had sought permission from the Provincial DRC to expand its operations, with CCS (or capture-readiness) forming the basis for the approvals (GDCCUS, 2016; Zhu, 2014:4-18; Liang, 2014:6,11-15; Liang, 2015:5; Li and Liang, 2017:9-12).

Based on the earlier (six interlocking) GDCCUSR reports, the "CRP Haifeng Plant CCR [prefeasibility] Report" was completed and expertly reviewed, in March 2015, and one year later the "CRP Haifeng Testing Platform Engineering Study" was completed, with both reports published during the annual UK-China (Guangdong) Low-Carbon Weeks. Intended to support the final investment decisions for a large-scale demonstration, the UK put forward £25m GBP for an integrated demonstration project in South China, with the hope to attract other investors. A few months later, the China and the UK, along with the US, signed an "MOU for a Teaming Relationship" for a trilateral demonstration that would be led and coordinated by GDCCUSC, operated by CRP and CNOOC, and with assistance from other industry, academic and non-profit partners (Zhu, 2014:16-17; Liang, 2014:12-13; GDCCUS, 2016; SCCS, 2016).

While focusing on the technical, policy, and financial issues, the GDCCURC didn't ignore the need to prioritise public communications and acceptance, by holding communications workshops throughout 2014, and producing the "Developing the Public Engagement Strategy for the Guangdong CCUS Demonstration Program" (2015). Supported by the GCCSI, it also carried out public surveys to better understand and implement CCS communications throughout the lifecycle of the Haifeng Project (Ashworth *et al.,* 2015; ADB, 2015:112; GDCCUSR, 2016).

Findings:

- Perhaps the most active of the EU member states, the UK maintained a strong interest in cooperating with China on CCS. There were reports that DECC had brought top CCS-related experts to China to provide technical and policy advice, which even today remains a significant source of CCS-related information for Chinese parties. Leading to the Chinese parties visiting the UK and signing cooperative agreements in 2013, this was significant motivation for Chinese parties, particularly those in Southern China (R01;R24;A39;R22).

- With support from the British Embassy and its Consulates in China, Chinese parties also reported receiving small amounts of funding to undertake CCS-related feasibility analysis and provincial road mapping studies and to create the UK-China CCS website named "Capture Ready" (R06;R22;R24;R23).

- The SPF was believed by Chinese stakeholders to be for altruistic purposes of climate mitigation, although they were under no illusion that the UK's primary interest was technological development and mutual interest in learning more about the potential for off-shore CO_2 storage, due to the similarity of conditions and aspirations between the two regions (R22;R24;R23).

- The British Embassy and Consulates were also seen as a pathway to connect Chinese parties with international investors and lucrative foreign markets that were considered more attractive and contractually secure than their Chinese counterparts (I35).

- It was one of the UK Government's workshop activities that led to the wider knowledge of CCS and its possible effects as a climate mitigation technology in Guangdong Province, which was key to convincing the government and policy makers. Through the provision of funding and expert assistance to a range of stakeholders, these governmental departments were also able to motivate other local stakeholders, to encourage a Southern China CCS community and to initiate domestic feasibility studies, as well as inspire ambitions for off-shore CCS demonstration projects in China (R22).

- Although the majority of early Sino-international cooperation efforts concentrated in Northern China, the support from the British Consulate in Guangzhou brought together international and domestic CCS experts and academics which led to the regional promotion of CCS with the southern provincial government and industry. Admittedly, informal UK-China CCS connections were already established during the drafting of the IPCC SR (2005) and academic collaborations but the Consulate's "direct and extremely close contact with Chinese parties in the region," as well as the constant provision of positive CCS-related information and support, helped to cement these (R22).

- Holding one of the earliest Guangdong CCS-related workshops at, most unusually, at the Guangdong Provincial Political Consultative Committee, Chinese parties determined this to be "very, very important," especially at the beginning and they stated that "without this driver it would be impossible, it was important... very important... I believe... especially for Guangdong, [as] without the UK's support there is nothing... we cannot go to this point" (R24;R23;R22).

- Seen as a key source of information, technical assistance, and financial support (through the SPF), communications with key UK-based experts and academics introduced key concepts (such as CCS Ready) which were laid out on a new bi-lingual website, disseminated via periodical reports and regular newsletters to the wider CCS community (R06;A30).

- It was reported that without the UK's support in holding an early CCS-related workshops and creating this regional subsystem, it would not be possible to have CCS activity and developments in Guangdong province, with one project even entitled "Implementing CCS from the UK to China, a Comparative Analysis with a Focus on Guangdong Province." Such support has also proved to be highly influential in creating a higher profile for CCS, promoting the technologies utility with the provincial government, particularly the Guangdong Province Low-Carbon Funds, issued by the Provincial DRC (R24;R22;R23).

Case Study XV – Italian Ministry of Environment, Land, and Sea (IMELS)

In May 2008, China's MOST and the IMELS signed the "Cooperation on Clean Coal Technologies, including CCS Technology and Ultra-Supercritical Thermal Power Technologies," as a mechanism for constructive dialogue and a means to transfer technologies (Ping, 2014:8116-8122). Involving Italy's Enel, this national power company had been developing CCS technologies within coal-fired power plants in Italy since 2006 and was pursuing a number of pilot projects testing CCS capture options (Benelli, 2013:3-25). Gaining approval from IMELS for the construction of its EUR2.5bn large-scale integrated Zero Emission Porto Tolle (ZEPT)'demonstration and receiving EUR100m from the European Energy Programme for Recovery (EEPR), there was also the potential for additional funding from the EU New Entrant Reserve Program (NER 300). However, despite winning formal permissions at the local levels, strong opposition from politicians, trade bodies and tourism associations, as well as protests from environmental groups, led to the Italian State Council deciding to suspend the project. Now faced with significant setbacks to its Clean Coal Programme, Enel was then left with no option but to abandon its CCS-related plans in Italy and to reluctantly pursue opportunities for investment in other countries. Already involved in over 90 collaborations and having a network of contacts in China though the 1999 Sino-Italian Cooperation Program for Environmental Protection (SICP), ENEL had invested in 47 registered CDM projects within China which was its main motivation for engagement at that time (Benelli, 2013:16; Enel, 2014:4; Financial Times, 2011; Platts, 2012; Enel, 2014:4). Enel SpA,2014: 1).

Sino-Italy Cooperation on Application of CCS to Coal Fired Power Plants (SICCS)

Beginning with the December 2008 Sino-Italian Symposium on Clean Coal Technologies and CCS Cooperation, in Beijing, this first event focused on the exchange of technical information related to state-of-the-art technologies, as well as to agree a preliminary consensus on cooperation. In April 2009, MOST had arranged for the Chinese partners (ACCA21, CERI, CAS-ITE and Tsinghua University) to travel to Enel's Rome HQs for the Clean Coal, CCS and USC Power Plant Technologies workshop and to visit and learn from Italian CCS-related research centres, labs, and pilot/demonstration projects, which further defined the scope for cooperation. Reaching a consensus on a "Final Work Plan" in July 2010, this involved included three distinct work packages (WP), each dependent on the successful completion of the previous, with a project "Kick-Off" meeting taking place in Xi'an in October 2010 (Benelli *et al.,* 2012:3).

Taking the form of technical seminars, workshops and personnel exchange over an 18-month period, the purpose of WP1 (‘Research, Information Exchange and Sharing on CO_2 Capture in Coal-Fired Power Plants’) was to share technical information, research findings and project experiences on CO_2 post-combustion capture pilot tests performed both in Italy and in China. Taking place in either China or Italy, these included more than 60 participants from parliament, ministries, industry, academia, and CCS organisations, and often included on-site visits to demonstration projects, such as Huaneng’s Shidongkou and Enel’s Brindisi pilot and R&D centre (Ping, 2014:8116,8122-3; Benelli *et al*., 2012:4; Enel SpA, 2014:1; Enel, 2014:23).

Following the completion of WP1 in June 2012, the WP2 (‘Preliminary Feasibility Study of the Application of CCS Technology in China’) would identify the design options and operational specifics for a large-scale, full-chain demonstration in China, with the relatively newly-constructed Huaneng Tongchuan Power Station (which is a similar size and scope at ENEL’s Porto Tolle) selected as the reference plant. Concluding that CCS could be transferred and installed without issue (although the issues around energy efficiencies and cost effectiveness still remained), it was recommended that an international framework that allowed for the sharing of information, facilities and experiences could be the best remedy (Ping, 2014:8116,8122-5; Benelli *et al*., 2012:4; Enel SpA, 2014:1).

Based on the outcomes and recommendations from WP1 and WP2, both sides agreed an activity plan and project budget for WP3 (‘Cooperation Scheme for the Future Joint Feasibility Study’). As this required a new agreement to allow for a feasibility study and plant construction as well as CCS demonstration, Enel and CERI signed a new MoU in March 2012. Marking ten years of energy-related cooperation between MOST and IMELS, this new framework strengthened the energy and CCS dialogue and engagement between the two countries (Ping, 2014:8122-3). Unfortunately, while Italy’s cooperation with China had led to a good example of research and development collaboration, it has not developed beyond the limited CCS pre-feasibility study, with future progress dependent on the development of more structured public-private partnerships (Enel SpA, 2014:2)

Findings:

- With challenges for demonstration at home and the potential for lucrative CDM opportunities in China, a number of key parties referenced contact, communications and cooperation through the SICCS project, which had impacted their attitude towards CCS and their experience of adopting the technologies (A26;G02;I13).

- A number of Chinese interviewees reported receiving CCS-related capacity building in China, which facilitated knowledge sharing between Chinese and Italian academia. Italy had “promoted CCS technology exchanges and scientific research collaboration between both countries, but also conducted a prefeasibility study on a full-chain demonstration project, including capture of CO_2 from coal fired power plants, with CO_2 transport and storage" (A26;G02;I13).

Case Study XVI – Australian Department of Resources, Energy & Tourism (DRET)

Committed to significant GHG emissions reductions, Australia was heavily reliant on fossil-fuels in its power generation and industrial sectors. Announcing its "Clean Energy Future Plan" (2011) and subsequent "Energy White Paper"(2012), these plans recommended increased investment in low-carbon technologies. Leading to calls for an Australian road map for CCS, this eventually attracted significant Government funding for CCS-related R&D, national pilots and demonstrations, and increased interaction with international initiatives, such as the IEA and CSLF. As the world's largest net exporter and greatest consumers of coal, Australia and China continued to have many strategic and economic interests, none less so than sustaining their trading relationship through the advancement of clean coal technologies for the abatement of CO_2 emissions.

Recognising the opportunities available and the necessity to continue this relationship, the Australian Department of Resources, Energy & Tourism (DRET) and China's NEA established the Australia-China JCG in 2008. Led by Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) and China's Huaneng Clean Energy Research Institute (CERI), both sides signed MoU in December 2010 to use US$12m committed under the JCG to collaborate on the Australia-China Post-Combustion Capture (PCC) Feasibility Study Project for China's first commercial-scale integrated demonstration project, at Huaneng's Gaobeidian coal-fired power plant in Beijing.

Facilitated under the APP, between March and June 2011, the project's partners (now including China National Petroleum Corporation (CNPC), China University of Petroleum (Beijing), and Geosciences Australia (GA), agreed on the scope of the project. Beginning in August 2013, their intent was to capture 3000-5000 tCO_2 per year, making this the world's largest CO_2 capture research platform at a coal-fired power plant at that time. As the largest coordinated bilateral agreement between both countries, the JCG continued to meet periodically, continually renewing their commitments to reducing emissions from fossil fuels to meet emission reduction targets, and to reiterate the vital role that CCS will play in meeting those targets. Described as playing a critical part of the ongoing development of the Australian-Chinese CCS community, the JCG-related events (some of which are CAGS activities) were considered to "reinforce the communication channels" between stakeholders on both sides (GCCSI, 2015; Hannan, 2013:11).

Findings:

- Chinese parties recognised that the Australian Government's main motivation for supporting the development of clean-coal technologies was to reduce its energy-related CO_2 emissions (R09;I05).

- Early engagement with Australia reportedly led to China's initial interest in demonstrating CCS and provided the internal expertise and confidence to move forward with domestic CCS projects, by way of the first pilot project at the Gaobedian plant in Beijing (I05;I18).

- The fact that Australian PM Kevin Rudd and the Minister for Climate Change Penny Wong visited the Gaobedian facility (in April 2008) increased the profile of CCS technologies and their importance to China and its bilateral relationship with Australia. These developments also contributed to have led the way for the later Shanghai Shidongkou and Tianjin GreenGen projects (I05;I18).

China-Australia Geological Storage of CO_2 (CAGS) (2009-2012)

Emerging from the APP's Clean Fossil Energy Task Force (CFETF) in November 2007, CAGS objectives and scope were negotiated during meetings in Canberra and Beijing the throughout 2008 and agreed through a signing of letters in 2009. Funded by DRET, it was led by GeoSciences Australia (GA) and jointly managed by MOST/ACCA21, but brought together a great many Australian, Chinese and international partners and participants to "further develop China and Australia's technical skills in the area of geological storage of CO_2 through capacity building activities; training opportunities; sharing of expertise through scientific exchanges; and advancing geological storage science through sponsored research projects in China." With just under AU$3m for CAGS1, different activities were targeted towards different stakeholder groups; such as technical workshops for experts, training schools for students, projects for researchers, study tours for policy makers, and personnel exchanges at partnering institutions and participation at international conferences and events (CAGS, 2010a:1; CAGS, 2013a:1; Geoscience Australia, 2015:1-3; CAGS, 2016:1; CAGS, 2016b:1; CAGS, 2017).

Since April 2010, CAGS sought the broadest dissemination of knowledge possible by making all event presentations, technical papers, research reports and training materials, and a period newsletter publicly available online, while also hosting a discussion forum to facilitate networking and communications in order to encourage interaction between participants (CAGS, 2010a:1,5; Kalinowski, 2013:7305-8; Geoscience Australia, 2015:30-31). Organising location-based workshops (in Canberra, Wuhan, and Changchun) with often more than 60 technical experts and cross-sectoral stakeholders provided opportunities for relationship building and networking. Splitting these workshops into thematic sessions that covered the technology value-chain, the ultimate goal of enabling discussions and promoting activities that would assist in making Australia and China “storage ready.”

There were also three ‘CAGS Training Schools on Geological Storage of CO_2,” held by CAS-IRSM in Wuhan, CAS-SCSIO in Sanya, and in Beijing. Targeted towards postgraduates and early career researchers, over 130 Chinese and Australian participants were selected based on their academic backgrounds to take part in these training schools. With little prior understanding of CCS, many participants had fed back to CAGS that these schools and the contact with others had influenced their academic and/or future career pathways towards CCS. In order to foster much closer collaboration, Chinese researchers and students were also encouraged to take part in visiting-scholar exchanges to partnering organisations in Australia. Encouraging wider global engagement, providing opportunities for collaboration outside CAGS, and enabling participation at international events, it was hoped that building strong research relationships would produce concrete findings that could be disseminated through academic journals and publications (CAGS, 2010a:2-3; CAGS, 2010b:1-3; CAGS, 2010c:1-5; CAGS, 2011a:2-3; CAGS, 2011b:1-4; Kalinowski, 2009:1; Kalinowski, 2013:7301-4; CAGS, 2017).

The CAGS leadership team and non-Chinese partners took a deliberate “hands-off” approach to the CAGS1 research component and provided only modest funding for three separate projects. This was in order to provide opportunities for direct “learning by doing” and in the hope to devise China-specific methodologies, guidelines, and case studies. Australian partners stepped in, when needed, but the overall ambition was to accrue a portfolio of studies needed to be “storage-ready” and as a reference point for policy makers, regulators, and operators. Concluding with a two-day technical symposium in April 2012, the partners reflected on the outcomes of CAGS1 and expressed a willingness to continue collaborating through an AU$1.39m JCG/DRET-funded CAGS2 (CAGS, 2010b:3; CAGS, 2011a:3; CAGS, 2011b:4; CAGS, 2013a:2; Geoscience Australia, 2015:25; Kalinowski, 2013:7300-6,7299; CAGS, 2017).

CAGS2 (July 2012 and March 2015)

Building on its earlier successes, to a large extent CAGS2 replicated the activities of CAGS1. In May 2013, a technical workshop took place in Melbourne, which included visits to CO_2CRC’s Otway Pilot and Energy Australia’s Iona Gas Plant, and in May 2014 a workshop took place at the Shanghai Advanced Research Institute (SARI). Similar to CAGS1, training schools were held in China, this time at the Sichuan Clean Development Mechanism Center (SCDMC) and the Productivity Centre of Jiangsu Province in Nanjing. During CAGS2, twelve people took part in short or longer-term visiting fellowships at a partnering institution, with one official from GA undertaking a placement with the China Geological Survey (CGS), this historical first demonstrated the trust built up through the project over time (CAGS, 2013a:2-3; CAGS, 2013b:1-4; CAGS, 2014a:1-3; Geoscience Australia, 2015:1-16; Feitz, 2016:2).

The CAGS2 research component funded five projects intended to provide outcomes and case studies to assist policy makers and industrial investors in their decision making. For example, based on the recommendations of Project Four, the Chinese Ministry of Environmental Protection (MEP) issued the "Notice on Strengthening the Environmental Protection of Pilot and Demonstration Projects for CCUS." As well as acting as a catalyst for attracting additional funding (at least AU$700k), these projects led to Chinese parties identifying next steps and putting forward policy recommendations for R&D, demonstration and deployment. For example, for Project Five, the Chinese parties focused on local conditions while creating the "development vision, stage goals, key directions, priority actions and implementation pathways" for a CCS roadmap for China's north-western Xinjiang Province (HB [2013] No. 101).' Ending again with a technical symposium in November 2014, this time there was a willingness by Chinese parties to co-fund future CAGS projects and activities, perhaps including a CCS Week (CAGS, 2013a:3; CAGS, 2013b:2; CAGS, 2014a:3; Geoscience Australia, 2015:1-27; Feitz, 2016:2).

CAGS3 (2016-2018)

Co-funded by China, CAGS3 largely followed the same format as its predecessors, although with a definite shift towards activities that promoted, supported and facilitated large-scale CCS demonstrations in China. Recommended during CAGS2, it was also suggested to increase engagement at the regional, provincial and local levels, with Xinjiang Province highlighted due to its geographical and industrial attributes offering strategic possibilities for demonstration. Also recommended in earlier phases, in June and July 2016, CAGS3 organised study tours for Australian and Chinese delegations to meet with key government and industry stakeholders on both sides, as well as to visit pilots and demonstrations. In order to maintain and strengthen its network, CAGS3 relaunched its 'Scientific Exchange Program' in October 2016, with the CAGS3 research projects focused on technical, policy, and road-mapping studies, that would accelerate regional CCS demonstration. Although the specific outcomes of CAGS are still unknown, it is possible to review the outcomes, achievements, opportunities and challenges from CAGS1 and CAGS2.

Recognised by MOST in a letter to the Australian Government, the CAGS research outcomes (assessments, methodologies, case studies, and roadmaps) had contributed substantially to China's CCS-related technical capacity and policy capabilities and proved useful tools for experts and policy makers in their decision-making. CAGS have acknowledged its influence on Chinese R&D, demonstration, and policy development, and recognized its role in China becoming a major CCS player within this time. For example, the Chinese MEP began to explore the implementation of national environmental regulations for CCS pilots and demonstration through its "Notice," while four GAGS participants inputted into the Government's "Scientific and Technological Development of CCUS (2010)," which was used in the formulation of China's "Twelfth Five Year Plan (2011-2015)."

Achieving its programmatic objectives, the real successes of CAGS1 and CAGS2 was that it brought together over 60 Chinese and 20 Austrian institutions to explore the prospects for collaboration, promoted the opportunities for CCS within their organisations, facilitated dialogue between 420 multi-sectoral individuals, developed working relations to set domestic plans in action, and inspiring a number of people to redirect their careers towards CCS. At a strategic level, the Australian Government and industries seen great value in collaborating with their Chinese counterparts, as the country had been increasing its own funding in this area and placed CAGS as trusted partners at the forefront of this new frontier, with one-to-one agreements beginning to emerge outside the initiative (Kalinowski, 2013:7307; Geoscience Australia, 2015:1,7,26,28; Feitz, 2016:7).

Findings:

- The main motivation for Chinese parties to take part in these collaborative activities was the potential for mutual cost savings and opportunities for significant learning (A11;I10;R09;R20;I37;I05).

- Mutual interests and similarity in circumstances have made the Chinese and Australian cooperative relationship on CCS a very beneficial relationship, with Chinese parties particularly noting increased possibilities for demonstration and increased awareness of the need for public acceptance (I10;I13).

- A number of Chinese parties reported small amounts of funding for CCS-related projects through CAGS (R24;R06;R35;R09;I34;R20;A26).

- Many reported attending the symposiums, technical workshops and training schools in both China and Australia, while also providing the opportunity for on-site visits and demonstrations, which reported allowed participants to feel more positive about CCS and its potential (R22;A36;R23;I34;R24;R06;A26;R20;A39;R35;G27;I10).

- Although considered "not real technical cooperation, just some people exchange, some know-how exchange" (I05), the Australian and Chinese government agreements provided opportunities for Chinese parties to visit Australian demonstrations which allowed them to "keep learning or collecting information about CO_2 capture and its importance for Chinese companies and the power generation industry" (I18;A17;R35).

- Close interpersonal relationships with leading Australian experts also developed though these exchanges, with a number of interviewees (who lacked English language skills) mentioning that the fact GA had a Chinese national managing the project, which made bridging communications much easier (G02;R06;R23).

- The GAGS project was also reported as a source of email and newsletter communications which kept participants informed of project updates and upcoming events (A30).

- Having participated in CAGS phases one (CAGS1) and two (CAGS2), Chinese parties looked forward to the much-anticipated CAGS3 (G02).

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