Stakeholder Perceptions of Demonstrating CCS in China

– A Study for UK-EU-China Near Zero Emissions Coal Initiative (NZEC)

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Executive Summary

A major survey of 131 Chinese stakeholders from 68 key institutions was conducted to assess the potential challenges and opportunities for carbon dioxide capture and storage (CCS) projects. Stakeholders were drawn from 27 provinces and regions using 31 face-to-face interviews and an online survey. This survey is the first to focus on demonstration projects in particular and is the most geographically diverse, with over 60% of respondents from outside Beijing.

The survey offers insights into a wide range of subjects relevant to CCS deployment. Though enhanced oil recovery (EOR) and enhanced coal bed methane recovery (ECBM) may not be a long term solution for CO_2 storage, they are viewed as the most attractive storage technologies for the first CCS demonstration project. In terms of preferences regarding capture technology, post-combustion capture received slightly higher support than pre-combustion capture technologies because most existing power plants are pulverised coal-fired, but respondents from both the power and oil industry actually tended to favour pre-combustion. There was no consensus, however, regarding the appropriate scale for the first demonstration with choices ranging from 10 MW to 300 MW.

The National Development and Reform Commission (NDRC) was perceived as the most important institution in authorising the first commercial scale (600 MW) CCS demonstration project. Most stakeholders believed that the image of the Chinese Government could benefit from developing a commercial CCS demonstration and that such a project could also create advantages for Chinese power companies investing in CCS technologies.

More generally, most respondents viewed climate change as a serious problem, including 20% who perceived it as a challenge in the near future. Those who saw CCS as necessary were more likely to view climate change as a serious problem. Though respondents were specifically chosen to avoid oversampling those working primarily on carbon capture and storage, CCS was not a new concept for the Chinese stakeholders surveyed and was widely seen as an important technology in reducing greenhouse gases. A small number of the respondents expressed concerns over the reliability of CCS technologies, availability of storage sites, and coal supply issues. By contrast, a large number of the respondents were concerned about the energy penalty associated with CCS and its impact on the long-term sustainability of coal supply in China, although such concerns were much reduced compared with the 2006 survey.

On financing, the reluctance on the part of energy firms to provide initial equity capital for CCS and CCR projects meant that foreign governments, the Chinese government and multilateral banks were perceived as the primary sources of equity finance. Concessionary loans from multilateral banks were considered to be the most promising source of debt finance for the CCS projects. There were disagreements between stakeholders from development banks and those from commercial banks over whether a higher than normal interest rate was needed to address

the risks involved in demonstration projects. The expectation was that the extra operating costs for CCS would mainly come from foreign and Chinese governments, whereas the Clean Development Mechanism (CDM), if available, was seen to play a relatively minor role. Finally, many respondents were willing to pay more to ensure new plants would be CO_2 Capture Ready (CCR) – over two thirds of the stakeholders claimed they would willing to pay an extra 2% on their initial investment for CCR

Contents

Executive Summary	2
Glossary of Technical Terms and Abbreviations	5
List of Tables and Figures	6
Section 1 Background	8
Section 2 Research Methodology	11
Section 3 Demographic Information	13
Section 4 Perceptions on Climate Change and Carbon Capture and Storage	16
Section 5 Technology Preference in CCS Demonstration Projects	21
Section 6 Authorising, Regulating and Financing CCS Demonstration Projects	25
Section 7 Discussions on CO_2 Capture Ready in China	33
Section 8 Behavioural Issues and Institutional Framework in Decision-making Process	36
Section 9 Key Conclusions & Policy Recommendations	39
Appendix 1. Previous CCS Consultations in China	42
Appendix 2. List of Stakeholder Institutions	43
Appendix 3. Development of Energy-related Departments in China	46
Appendix 4. Extra Investment Risks Brought by CCS versus conventional coal power	47
Acknowledgements	48
References	49

Glossary of Technical Terms and Abbreviations

"ACCA21"	The Administrative Centre for China's Agenda 21
"AEAT"	AEA Technology plc, UK
"CAPPCCO"	Chinese Advanced Power Plants Carbon Capture Option Project
"CCR"	Carbon Capture Ready
"CCS"	Carbon Capture and Storage, also "Carbon Capture and Sequestration"
"CDM"	Clean Development Mechanism under the Kyoto Protocol
"COACH"	Cooperation Action within CCS China-EU
"DECC"	Department for Environment and Climate Change in UK government
"EPRG"	Electricity Policy Research Group, University of Cambridge
"GDP"	Gross domestic product
"GreenGen"	GreenGen project is a Chinese project funded by seven major energy companies that aims to demonstrate a coal-based generation system with IGCC technologies with near zero CO_2 emissions.
"Hurdle rate"	The discount rate (cost of capital) which the IRR must exceed if a project is to be accepted.
"IGCC"	Integrated Gasification Combined Cycle, a power plant using synthetic gas which is used to power a gas turbine whose waste heat is passed to a steam turbine system
"Industry"	Including power generation companies, oil & gas companies, power grids, energy equipment manufacturers
"IPCC"	Intergovernmental Panel on Climate Change
"Installed Capacity"	The maximum power that could be produced at continuous maximum operation in a power generation facility, in a given period of time.
"IRR"	Internal rate of return
"MOEP"	Ministry of Environment Protection in PRC government
"MOF"	Ministry of Finance in PRC government
"NDRC"	National Development and Reform Commission in PRC government
"NPV"	Net present value is defined as the total present value (PV) of a time series of cash flows discounted at the marginal cost of capital (or a risk adjusted required rate of return).
"NZEC"	Near Zero Emissions Coal Initiative
"Payback Period"	The length of time required for an investment's net revenues to cover its cost.
"PPP"	Public Private Partnerships
"SERC"	State Electricity Regulatory Commission
"STRACO2"	Support to Regulatory Activities for Carbon Capture and Storage project, a European Commission funded project designed to support the development of a regulatory framework for CCS

List of Tables & Figures

Table 1.1 Electricity production growth rate versus GDP growth rate in PRC
Table 1.2 Per capita electricity generationversus real GDP growth
Table 1.3 Total and incremental installed capacity in PRC by fuel type
Table 3.1 Demographic data on selected regions included in the survey
Table 7.1 Capital investments and O&M costs comparisons across different configurations of CCR in PC power plants

Appendix 1 Previous CCS consultations in China
Appendix 2 List of stakeholder Institutions (partial)
Appendix 3. Development of energy-related departments in China
Appendix 4. Extra investment risks brought by CCS versus conventional coal power

Figure 2.1 Overview of research methodology

Figure 3.1 Distribution of responses by the type of institution
Figure 3.2 Distribution of responses by province or region
Figure 3.3 Claimed average working time spent on 'Energy and Environment', 'Climate Change' and 'Carbon Capture and Storage' by respondents
Figure 3.4 Terms already heard of by respondents before this survey
Figure 4.1 Stakeholders' personal perceptions on the importance of climate change (2006, 2009)
Figure 4.2 the role of climate change at respondents' institutions
Figure 4.3 Perceptions on potential for current climate policies to achieve deep cuts in global carbon dioxide emissions over the next two decades
Figure 4.4 Perceptions on potential for current climate policies on achieving deep cuts of carbon emissions in China in the next two decades
Figure 4.5 Perceived importance of CCS in deep cut of greenhouse gas emissions (2006, 2008 & 2009)
Figure 4.6 Perceived impacts of large-scale deployment of CCS on energy security in the long term (2006 versus 2009)
Figure 5.1 Awareness of CCS projects, initiatives or pilots before participating in this survey (a short description of each project was presented beside the question)
Figure 5.2 Preferred scale of the first CCS demonstration project in China
Figure 5.3 Capture technology preferences in first commercial CCS demonstration

project in China (Stakeholders were presented explanations of each capture method based on IPCC CCS special report beside the question)
Figure 5.4 Storage methods preferences in first demonstration project in China (Stakeholders were presented explanations of each storage method based on IPCC CCS special report beside the question)
Figure 6.1 Organisations involved in energy policymaking and administration in China
Figure 6.2 institution perceived as most important in authorising a CCS demonstration project
Figure 6.3 Institution perceived as second most important in authorising a CCS demonstration project
Figure 6.4 Institutions expected to be heavily involved in regulating and monitoring CCS projects
Figure 6.5 Perceptions of the benefits of developing CCS demonstration projects in China
Figure 6.6 Desired mix of? sources of the additional equity capital investment needed for capture facilities on a 600MW Coal fired power plant in China
Figure 6.7 Scatter diagram of hurdle rate and equity capital ratio for the extra investment needed for capture facilities
Figure 6.8 Desired mix of sources of creditors for the additional investment of capture facilities on a 600MW power plant in China
Figure 6.9 Desired mix of sources of finance for the extra operating costs of capture on a 600MW power plant in China
Figure 6.10 Scatter diagram of required payback period and hurdle rate for the extra investment of capture facilities
Figure 7.1 Factors viewed as heavily influencing whether new plants become CO_2 capture ready
Figure 7.2 The hierarchy of questions when investigating acceptable costs of CCR in China
Figure 8.1 Perceived scale of coal price interval (expected higher bound – expected lower bound) in 2010
Figure 8.2 Rating of different criteria in justifying power generation projects as good investments

Section 1 – Background

1.1 Chinese Power Sector and the Role of Coal in Chinese Electricity Generation

Economic growth is closely tied to growth in electricity demand and carbon dioxide emissions. In the past three decades, China has been one of the fastest growing economies in the world with a real GDP growth rate of 9.8% from 1978 to 2007. The Chinese government expects to achieve an average 7.5% annual GDP growth according to its Twelfth Five Year Plan (2011-2015). The growth rate of the power sector largely followed China's general economic growth rate in the 1990s, but since 2000, electricity production has grown at a higher rate than China's GDP due to accelerating industrialization and rising residential power demand (as shown in Table 1.1). However, despite China's high economic growth rate over the past three decades, electricity generation per capita is still lower than those of the higher-income economies in Table 1.2. The potential for growth is high, if China adopts OECD consumption patterns.

Year	Real GDP Growth Rate over Preceding Year (%)	Electricity Production Growth Rate Over Preceding Year (%)
1998	7.8	2.8
1999	7.6	6.2
2000	8.4	9.4
2001	8.3	9.2
2002	9.1	11.7
2003	10	15.5
2004	10.1	15.3
2005	10.4	13.5
2006	11.6	14.6
2007	13	14.5

Table 1.1 Electricity production growth rate versus GDP growth rate in PRC (NBSC,2009)

Year	2007 per Capita Electricity Generation	Real GDP Growth		
		2005	2006	2007
United States	13814 kWh	3.1	2.9	2
OECD	8629 kWh	2.5	2.9	2.4
South Korea	8516 kWh	4.2	5.1	5
Japan	8470 kWh	1.9	2.4	2.1
United Kingdom	6082 kWh	1.8	2.9	3
PRC	2308 kWh	10.4	11.6	13

Table 1.2 Per capita electricity generation versus real GDP growth (EIA,2009; World Bank,2009)

China is a coal-rich country with relatively limited oil and gas resources. As such, coal-fired power generation units dominate the installed electric power capacity in China. Table 1.3 sets forth the total installed capacity and incremental installed capacity in PRC by fuel source at the end of 2008 (CEC, 2009).

Fuel Type	2008 Installed capacity by Fuel type (GW)	2008 Incremental Installed Capacity by Fuel Type (GW)	Availability: Average hours per year	Total Electricity production (TWh)
Thermal	601.3	46.9 GW (Net)	4911	2779
Coal	>560			
Hydro	171.5	26.26 GW	3621	563
Nuclear	8.9	0 GW	7731	68
Wind	8.9	4.91 GW		13

Table 1.3 Total and incremental installed capacity in PRC by fuel type (CEC, 2009)

1.2 Coal-fired Electricity in China's National Climate Change Policy

Coal-fired power plants are expected to remain the largest source of carbon dioxide emissions globally through 2050, and a substantial fraction of those carbon emissions will come from Chinese coal-fired power plants (IEA, 2007). Carbon Capture and Storage (CCS), by which CO_2 is captured when generating power and is injected underground for storage, can significantly reduce greenhouse gas emissions from coal-fired power plants while allowing coal to meet increasing energy demand (MIT, 2007: Executive Summary p. x).

Although Carbon Capture and Storage has moved up the policy agenda quite rapidly, CCS is still not acknowledged as a priority area in China and is rarely mentioned in the Chinese National Climate Change Programme (NDRC, 2007). In part this neglect may be attributed to the novelty of the technology and that China's policy measures still favour low carbon technologies where there is clearer convergence between energy efficiency and climate change policy (Andrews-Speed, 2007). Chinese climate policies need to be compatible with concerns over energy security and maintaining indigenous supply rather than increasing dependence on foreign supplies of natural gas or uranium. On the demand side, energy security considerations encourage energy efficiency to play a central role in reducing overall demand and thereby reducing dependence on foreign sources of energy. CCS is therefore not at the top of the list of possible climate policy options that are also compatible with energy security and energy efficiency priorities. Finally, the lack of stakeholder confidence is also a key challenge in deploying CCS technologies in China (Liu and Gallagher, 2008).

1.3 Purpose of the Study

This study builds on earlier and parallel stakeholder analysis (summarised in Appendix 1), and investigates current views and perceptions of where the future lies with regard to CCS, particularly with respect to the first CCS demonstration projects. The specific questions addressed are: How is CCS viewed outside of the immediate technical community that is involved with CCS activities? What are the necessary conditions for a demonstration project to proceed? What is needed for longer-term and wider-scale deployment of CCS? In addition, this study reviews current thinking on many issues related to CCS, at the national, regional and provincial levels. For example, a series of 'what if?' type analyses using counterfactual scenarios are undertaken on subjects including:

- Financing mechanisms
- Policy and regulation
- Socio-economic impacts
- Environmental concerns
- Energy security
- Market competitiveness
- Decision making behaviour

1.4 Report Structure

Section 2 introduces the research methodology of this study and discusses sample selection, questionnaire design, the online survey system, face-to-face interviews, and data analysis methodology. Demographic information is provided in Section 3, such as regional distribution of stakeholders, types of organization involved, and stakeholder time spent working on energy, climate change, and CCS.

Section 4 summarizes Chinese stakeholder perceptions of Climate Change and Carbon Capture and Storage (CCS). Section 5 focuses on the technology preferences in regard to the first commercial scale CCS demonstration plant in China while Section 6 provides a view on the processes in regard to the authorization and financing of the first demonstration project.

Section 7 investigates the level of awareness and mechanisms in making new coal-fired power plants Carbon Capture Ready, as traditional economic frameworks may not be able to explain all the investment decisions in the Chinese power sector, Section 8 presents an analysis of the institutional framework in China and behavioural finance issues, followed by conclusions and recommendations for policymakers in Section 9.

Section 2 - Research Methodology

2.1 Sample selection and questionnaire design

The study involved four steps: determining the sample, questionnaire design, survey implementation, and data analysis, as illustrated in Figure 2.1. The main criterion used in determining the target population was that the selected stakeholders should have 'significant current or potential influence on CCS demonstration projects or deployment in China'. In addition, the aim was to have a regional and sectoral sample population which was diverse in nature and of a sufficient size to achieve results with minimal bias. Therefore, we set a limit of 30% to each type of institution (e.g. government, academic, industry, NGO, banks etc.) and ensured that less than one fifth of the overall sample was from the community working directly on CCS (i.e., stated they spend most of their time on CCS). A small number of senior Chinese academics based in foreign countries and officials in Chinese energy departments at multilateral, commercial or development banks were also included.

The target group included 256 stakeholders from over 100 institutions, drawn from a database of over 500 contacts. The contact details of key stakeholders were obtained from a range of sources, including domestic and international conferences, and nominations by senior government officials, management of leading power firms and academic institutions.

We designed the questionnaire to complement past CCS stakeholder surveys and consultations (Appendix 1) so that a number of the questions could be compared to those of past surveys, thus allowing us to see if there had been any evolution in stakeholder views. The questionnaire was path dependent, which offered the flexibility of tailoring questions to different stakeholders so that we could ask several questions that drew on their area of expertise. The questionnaire was available in both Chinese and English on the website www.CaptureReady.com .

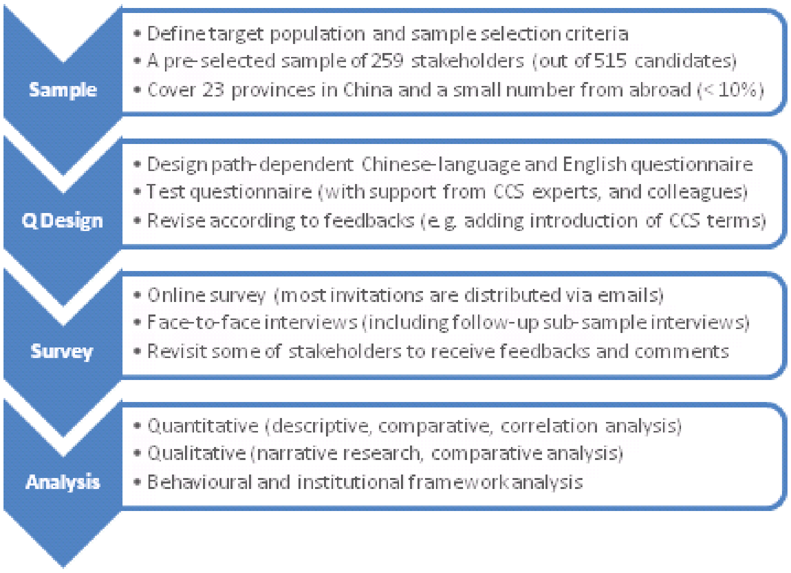

Figure 2.1 Overview of research methodology

2.2 Questionnaire distribution and data collection

An invitation to participate was sent to each stakeholder by email. A little over 50% of the sample (131 of 256) provided complete responses and 25 other respondents started, but did not complete, the survey. The invitation letter included a covering letter explaining the objectives of the survey, together with the background of NZEC. The letter provided assurance that all survey data would guarantee the anonymity of the respondent.

In order to encourage as many stakeholders as possible to participate in the survey, we offered a token of appreciation ('UK-China Olympic stamp presentation pack' issued by the UK Post Office) upon finishing the survey. In addition, we sent follow-up emails to all stakeholders who had not responded, reminding them to take part in the survey.

Apart from the internet-based survey, we conducted face-to-face interviews with 31 stakeholders. 22 out of the 131 participants were selected from the online survey respondents, and further 9 important decision-makers were consulted face-to-face as they did not participate in the online survey nor did they use or check emails frequently.

2.3 Data Analysis

The analysis of data for each question in the consultation begins by describing and summarising how responses are distributed among the categories. Then, we apply tabular analysis and ANOVA (Analysis of Variance) to explore relationships between an item and others in the survey (for example, investigate whether demographic variables can explain the perceptions of CCS priority). For data collected in scale or index format, we first calculate the average, and then illustrate their relationship and distribution on a scatter plot (for example, exploring the relationship between IRR and financial leverage) through correlation analysis. Independent t-tests were used to understand the influence of behavioural patterns on energy investment decisions in a sub-sample.

In terms of qualitative data, narrative research and analysis is adopted for interpreting data collected from follow-up face-to-face interviews which were open-ended and not based on a pre-determined list of questions. In addition, a comparative analysis approach is used in this research, for example, by comparing the required financial returns of conventional thermal power projects to CCS projects or to understand the potential authorisation process of CCS building on their experience.

Section 3 - Demographic Information

3.1 Distributions of online respondents by the type of institution

There were approximately equal shares of respondents from each sector: Governments (24%), Industry (24%), Academia (23%) and Other (Banks, Consultancies, Research firms and NGOs) (29%). A total of 131 respondents came from 68 institutions in PRC and other regions, including the State Council, NDRC, MOST, MOEP, MOF, MOFA, various local governments, Huaneng Power, Datang Power, Guodian Power, BP, CNPC, CNOOC, Tsinghua University, Chinese Academy of Science, and China Petroleum University (see Appendix 2 for additional details).

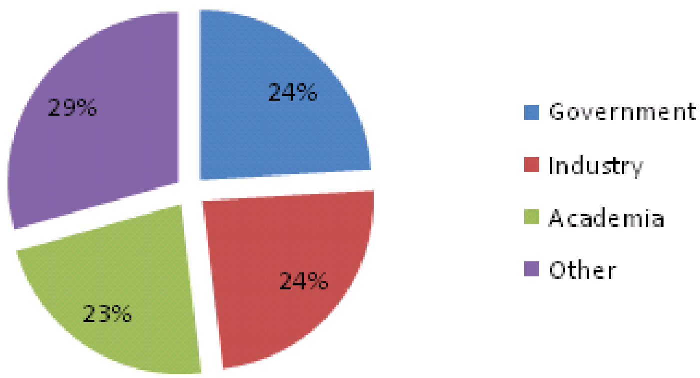

Figure 3.1 Distribution of responses by the type of institution

3.2 Distribution of online responses by office location

The survey covers 27 provinces or regions in China (Figure 3.2). Over 60% of respondents came from outside Beijing. Two regions, Beijing (49), and Guangdong (16) had greater than 10 respondents (highlighted in orange and red colour in Figure 3.2). In addition, we obtained a few responses from stakeholders (e.g. major investment or development banks) based in foreign countries which have strong interests in or are currently involved in CCS development in China.

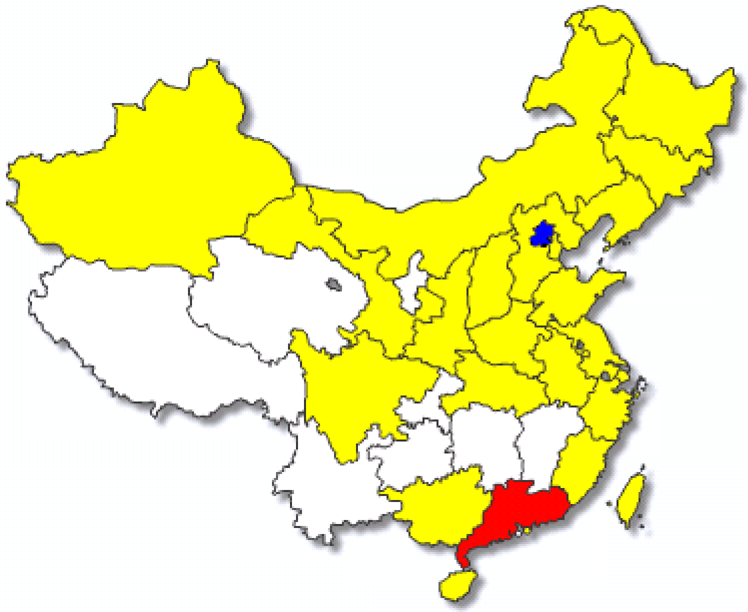

Figure 3.2 Distribution of respondents by province or region (Yellow: provinces with <10 respondents; Red: 16 key stakeholders; Blue: 49 stakeholders)

2007 Data (NBSC, 2009)	Population (thousand)	Electricity consumption (billion kWh)	Electricity production (billion kWh)	GDP/capita (Yuan RMB)	Stakeholders interviewed	Average time claimed spent on CCS
Xinjiang	20950	41.7	34.9	16817	2	0%
Jilin	27300	46.3	42.3	19358	3	7%
Guangdong	94490	339.4	218.7	32897	16	5%
Beijing	16330	62.8	22.8	58204	49	18%
National	1321290	3245.8	3255.9	18934	131	12%

Table 3.1 Demographic data for selected regions included in the survey

3.3 Average working time spent on energy and environment, climate change and CCS

As shown in Figure 3.3, approximately 90% of the respondents claimed to spend more than half of their time on energy and environment issues, but less than 20% spent half of their time or more time on CCS. We found respondents overall, were spending more time on climate change issues in contrast to the results from the CAPPCCO CCS study conducted in Autumn 2008 (Reiner and Liang 2008). In addition, two thirds of the respondents claimed that they had participated in CCS conferences/events or research activities.

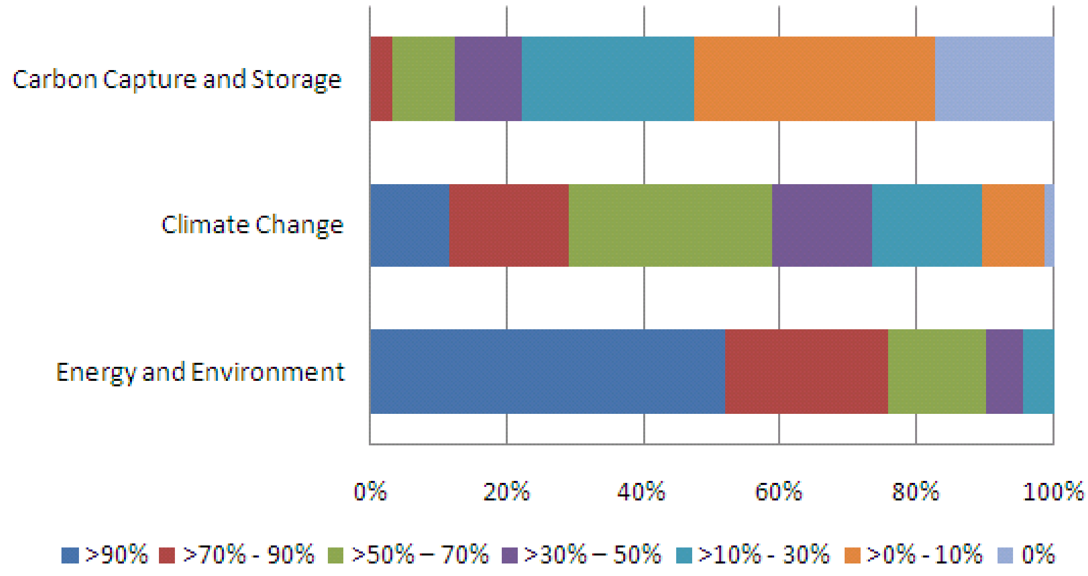

Figure 3.3 Claimed average working time spent on 'Energy and Environment', 'Climate Change' and 'Carbon Capture and Storage' by respondents

3.4 Understanding of Carbon Capture and Storage and Climate Change

At the very beginning of the survey, stakeholders were asked the question: 'CCS and climate change are relatively new topics in China, have you heard of any one of the concepts, both of the concepts or neither, before this survey?' A vast majority of stakeholders (90%) selected 'both', while 7% had heard of only climate change and 4% had heard of neither issue.

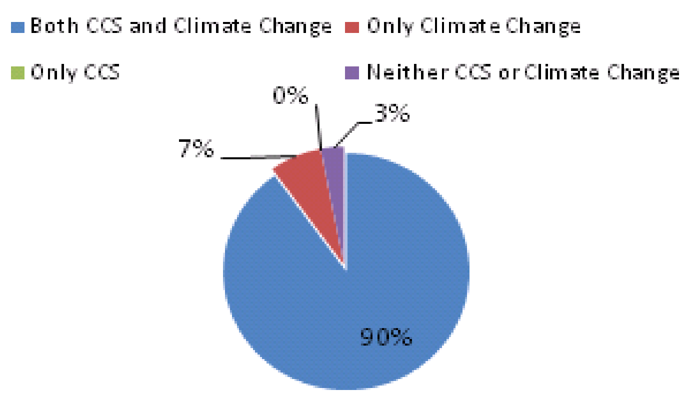

Figure 3.4 Terms already heard of by respondents before this survey

Section 4 - Perceptions on Climate Change and Carbon Capture and Storage

4.1 Views on Climate Change

As illustrated in Figure 4.1, we found that twice as many respondents believed that climate change is an immediate threat, compared to the CCP2 Study of 2006. On the other hand, slightly more respondents considered climate change to be a moderate or serious problem, in contrast to the earlier survey (Reiner et al, 2007).

In addition, when stakeholders were asked about the understanding of climate change issues in their institutions, more than half respondents claimed climate change was a 'very important' or an 'important' issue in their institution (as shown in Figure 4.2). Interestingly, higher importance was attached to climate change issues by the academia and the energy industry rather than the Government; however, we also found industrial stakeholders were less likely to worry about climate change as an immediate threat in contrast to the opinions from the academia or the Government. This is consistent with the finding by Reiner and Liang (2008) in previous CCS stakeholder surveys in China.

When analysing the impacts of demographic factors on perceptions of climate change, we had an interesting finding, Stakeholders who spent higher amount of time on energy were more willing to select climate change as a serious problem in China (1% confidence level), however spending more time on climate change or CCS did not significantly change their perception of the seriousness of climate change. On the other hand, those who perceived CCS was necessary had a significantly higher tendency to view climate change as a serious problem (5%).

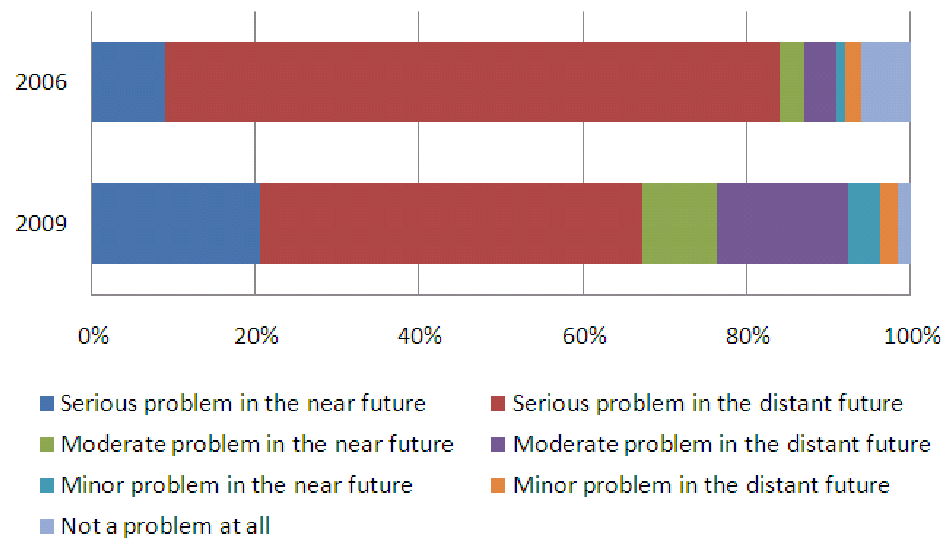

Figure 4.1 Stakeholders' personal perceptions on the importance of climate change (2006, 2009)

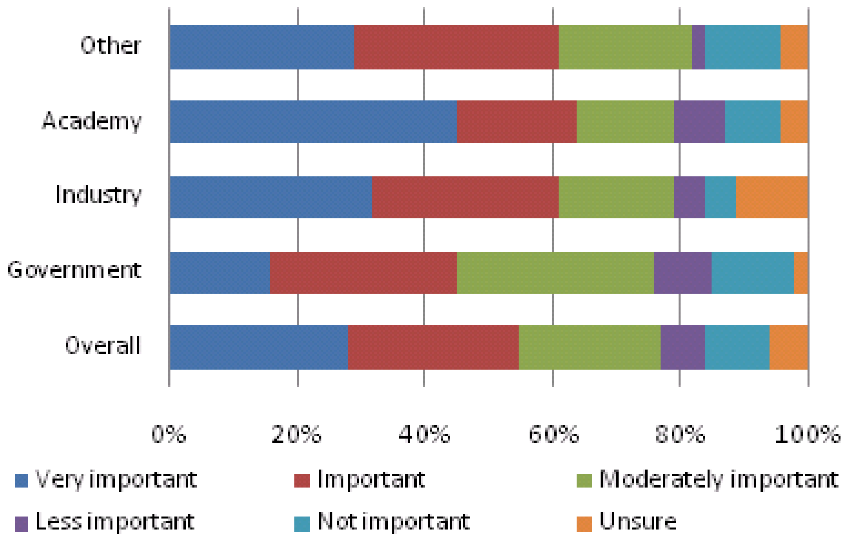

Figure 4.2 The role of climate change at respondents' institutions

Even though a growing number of stakeholders believed climate change would be a serious problem for China in the distant future, more than three quarters of respondents believed it would be 'very difficult' or 'difficult' to achieve a deep cut of carbon emissions globally in the next two decades (Figure 4.3). When questions were asked specifically on cutting emissions in China, the overall result was even more pessimistic, as over 80% of the respondent selected the answers 'very difficult' or 'difficult' to achieve a deep cut of GHG emissions in the next 20 years (Figure 4.4). During follow-up interviews, we found that the most quoted reason given for those with optimistic positions on current climate policies was the current ambitious national energy conservation policy, which according to the stakeholders could result in emissions reductions as well as enhanced political attention on climate change. Those who were skeptical of the usefulness of current climate policies, were concerned about growing demands for energy related to increased GDP, constraints on implementation within the current environmental regulatory framework, and the perceived higher urgency of serious local pollution problems, such as water pollution and air quality. Most of stakeholders believed that the coal dominated energy sector in China will not change in the near future.

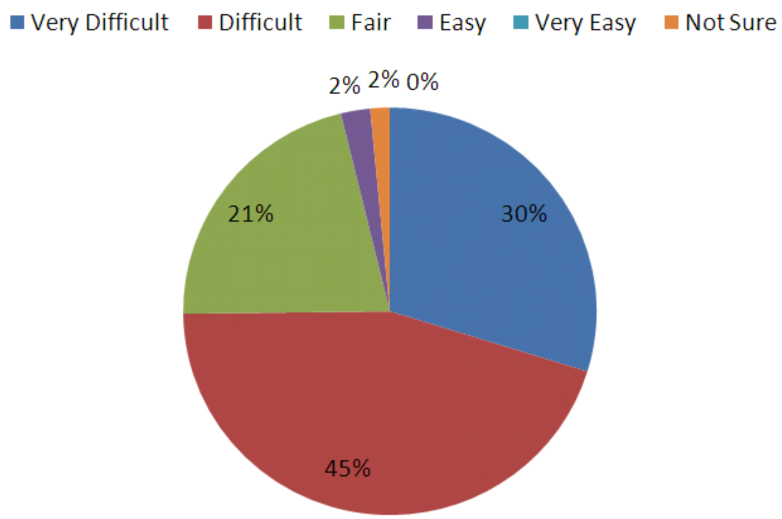

Figure 4.3 Perceptions on potential for current climate policies to achieve deep cuts in global carbon dioxide emissions over the next two decades

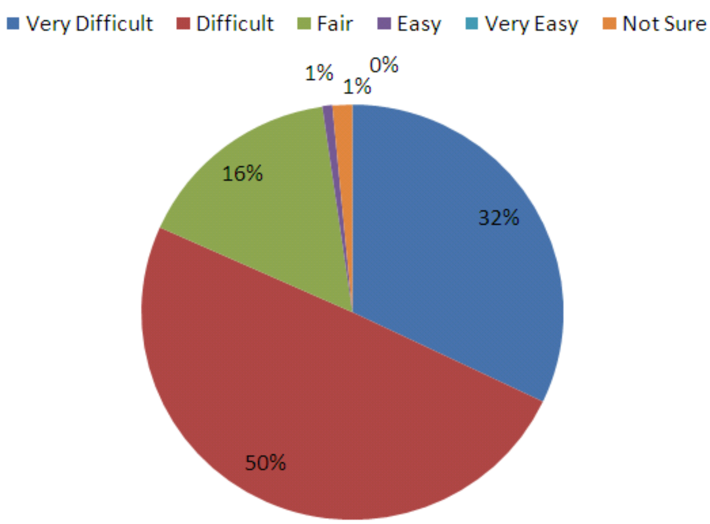

Figure 4.4 Perceptions on potential for current climate policies to achieve deep cuts in carbon dioxide emissions in China over the next two decades

4.2 Views on Carbon Capture and Storage (CCS)

A majority of the respondents (62%) perceived CCS as being 'probably necessary' or 'very necessary' in achieving deep cut of greenhouse gas emissions. Most of the pessimists were from the power industry and the national government. When we conducted our follow-up interviews, three CCS opponents, who originally supported CCS in 2006, were concerned about the reliability of CCS technologies, availability of storage sites, and coal supply problems. They were also more confident in their understanding and knowledge of CCS. Based on a single factor model, demographic variables (such as region, time spent on CCS, climate change or energy) show no statistically significant impact on the perceived necessity of CCS, but those who believed climate change to be a serious problem were more likely to view CCS as necessary (at 95% confidence level).

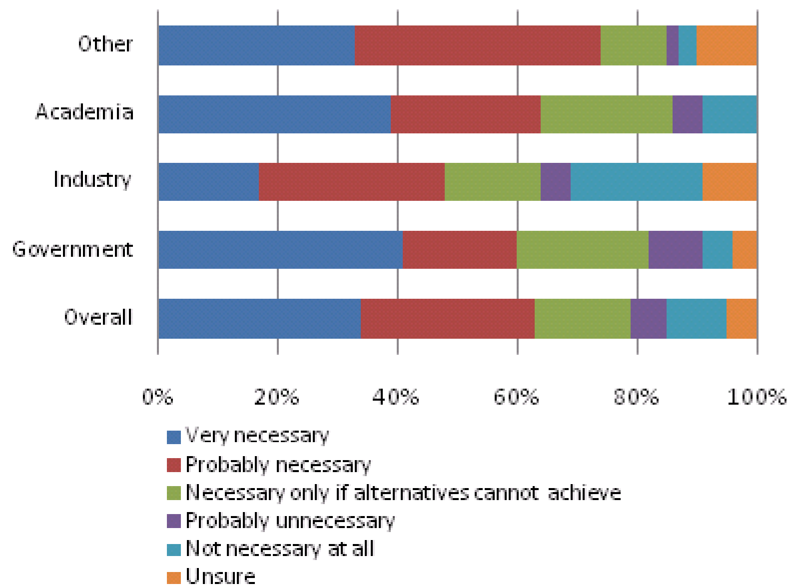

Figure 4.5 Perceived importance of CCS in deep cut of greenhouse gas emissions (2006, 2008 & 2009) (Reiner et al, 2007, Reiner and Liang, 2008)

Attitudes towards the energy penalty for capture, transport and storageof CO_2, were slightly negative overall. A number of stakeholders (38%) believed there would be more energy available for consumption if China did not adopt CCS. Chinese stakeholders generally believed the energy penalty from CCS would have a negative impact on the security of energy supply. By comparison, a majority of European stakeholders perceived of CCS as potentially enhancing energy security (Shackley et al, 2007). However, there has been a shift over time towards a less negative view. Respondents who chose the answer: 'CCS is very positive for energy security in China' almost doubled n 2009 compared to the 2006 survey and roughly half as many selected 'very negative' as an answer to this question in 2009, compared to the 2006 study (19% vs. 9%, as shown in Figure 4.6). During a follow-up study our observation was reconfirmed as we found that a number of interviewees had adopted strategic views on climate and energy policy that coal might not be a reliable energy source for China in the long term unless CCS technologies were adopted.

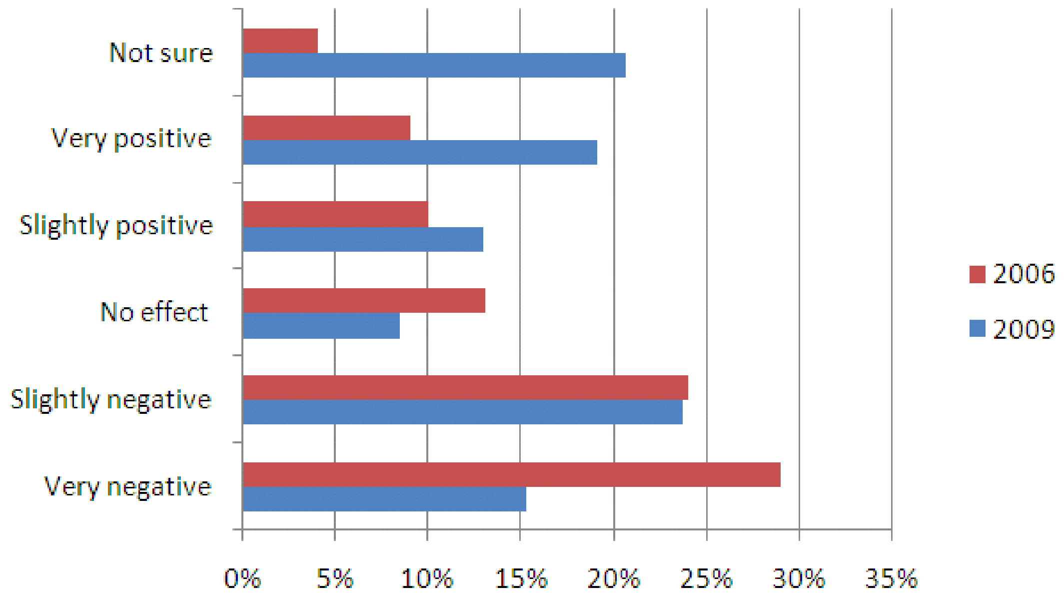

Figure 4.6 Perceived impacts of large-scale deployment of CCS on energy security in the long term (2006 versus 2009)

Though there were split views on CCS in China, nearly 90% of respondents from academia and research institutes expected there would be more CCS Research & Development (R&D) funding available. 38% stakeholders from academia and research institutes claimed they would significantly increase resources on CCS R&D while another 36% said they would moderately increase resources for CCS R&D. It is of course not surprising to find academics and researchers supporting more R&D.

Section 5 - Technology Preference in CCS Demonstration Project

5.1 Chinese stakeholder awareness of CCS projects

In previous CCS surveys, the building of CCS demonstration projects was widely acknowledged as one of the most crucial steps in developing and deploying CCS in China, because stakeholders were lacking confidence on various issues, such as maturity of technologies, availability of finance (Reiner et al, 2008). We investigated the perceptions on CCS demonstration in China, by asking stakeholders of their awareness of current CCS projects (including initiatives or pilots). We found that no single project was recognised by more than a quarter of the respondents. Relatively, the most well known CCS project is GreenGen, an IGCC based project with main investors being Chinese power companies, followed by NZEC, COACH, HNG-CSIRO pilot and STRACO2. On the other hand, only 3 people claimed they had not heard of any of the listed projects before this survey.

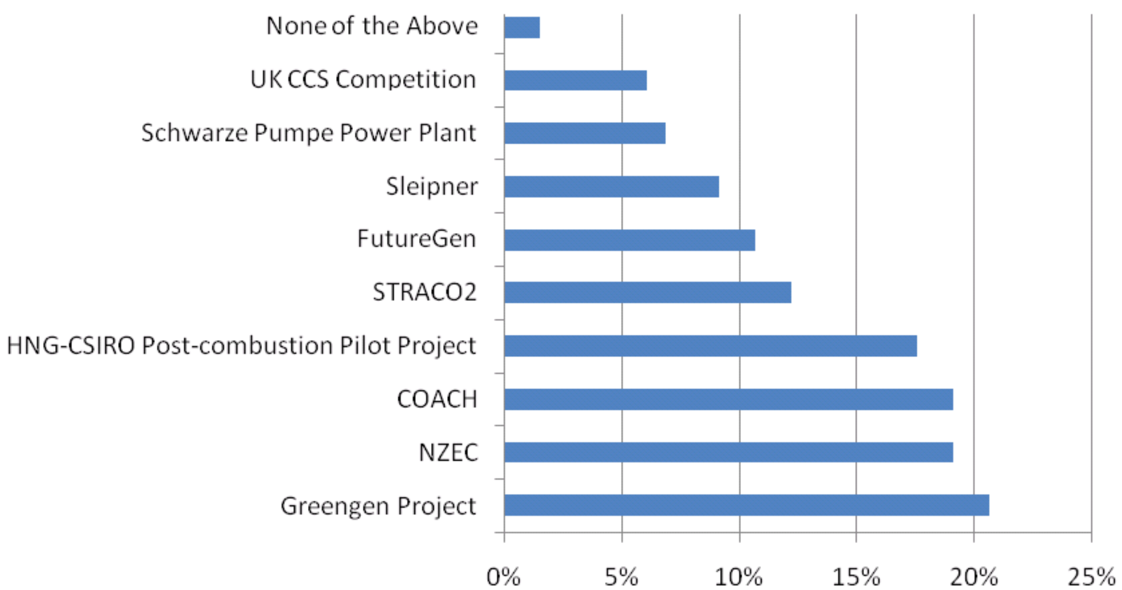

Figure 5.1 Awareness of CCS projects, initiatives or pilots before participating in the survey (a short description of each project was presented beside the question)

5.2 Scale of the first commercial demonstration project

As illustrated in Figure 5.2, there was no consensus with respect to the scale of the first CCS demonstration project in China. Generally speaking, 30MW to 100MW units (or 100,000 to 400,000 tons CO_2 captured and stored) was most popular at 22%. Although, most of the new coal-fired power generation capacity would be equal or above 600MW units, most respondents believed the scale of the capture unit should be restricted to less than 100MW, because of the significant uncertainties attached to CCS technologies, CO_2 storage sites, transportation and financing schemes. Despite the fact that CCS projects of less than 10MW (or <40,000 tons CO_2e) are unlikely to be considered as a commercial scale demonstration, 13% of respondents still selected this option.

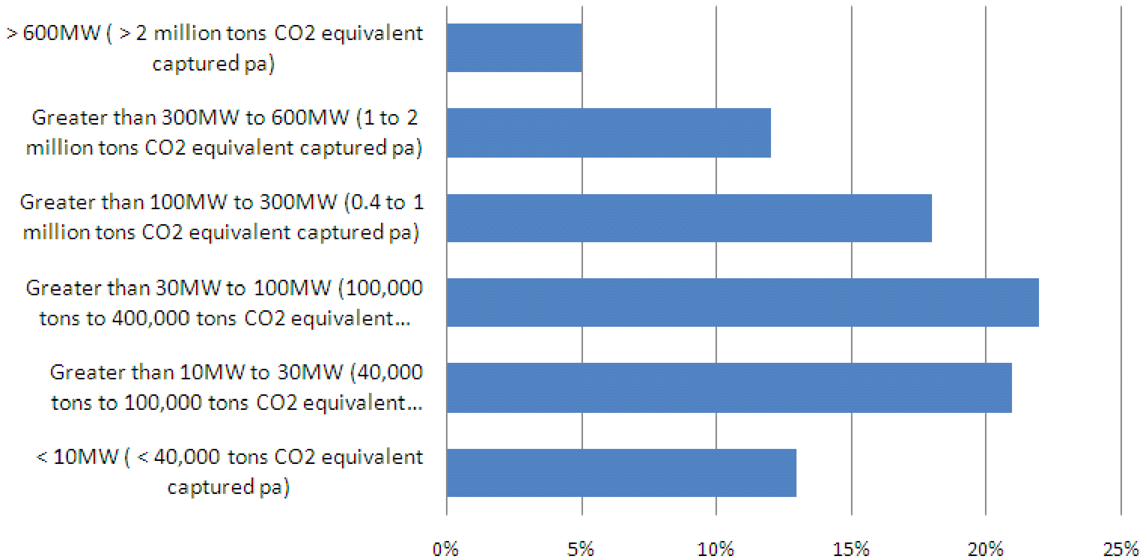

Figure 5.2 Preferred scale of the first CCS demonstration project in China

5.3 Capture technology preferences for demonstration plants

Of the two major capture technologies, post-combustion capture (41%) received slightly higher support than pre-combustion capture technologies (31%). However, respondents from industry tended to favour pre-combustion capture (Figure 5.3). Oxyfuel, as a relatively new technology in China, received minimal support. For this option, a quarter of respondents selected 'unsure', including 40% of government officials. In follow-up discussions, proponents of post-combustion capture often cited the fact that most of existing and planned new coal-fired power plants are conventional pulverised coal units. However, others argued for pre-combustion technology because, according to them, it was 'clean, high efficiency, and more advanced technology, and potentially applied in poly-generation, coal to liquid'. During face –to-face interviews, a majority of participants believed that it would be important to develop both post-combustion and pre-combustion capture technologies.

In the questionnaire, we listed a hypothetical option 'air separation' as an answer, to test whether some respondents were reluctant to say 'unsure' and pretended to know capture technologies. We found that only one respondent selected this option.

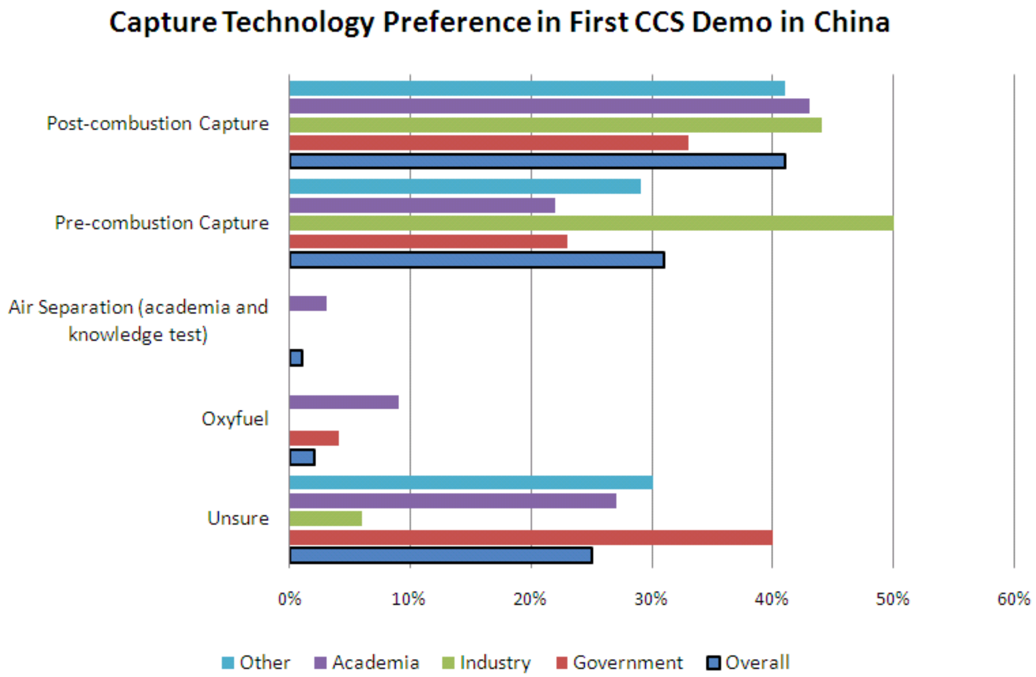

Figure 5.3 Capture technology preferences in first commercial CCS demonstration project in China (Stakeholders were presented explanations of each capture method based on IPCC CCS special report beside the question)

5.4 Preferences regarding storage methods for demonstration plants

Though experience with enhanced oil recovery (EOR) and enhanced coal bed methane recovery (ECBM) has been limited, both were still viewed as offering more benefits for the Chinese population than simply reducing emissions and were favoured by over two thirds of stakeholders (Figure 5.4). It should be noted that there is limited storage capacity and that coal may not be used once CO_2 has been injected for ECBM, but these effects were not described to stakeholders. There was a more clear-cut consensus amongst respondents regarding storage methods in contrast to the question on capture technology options.

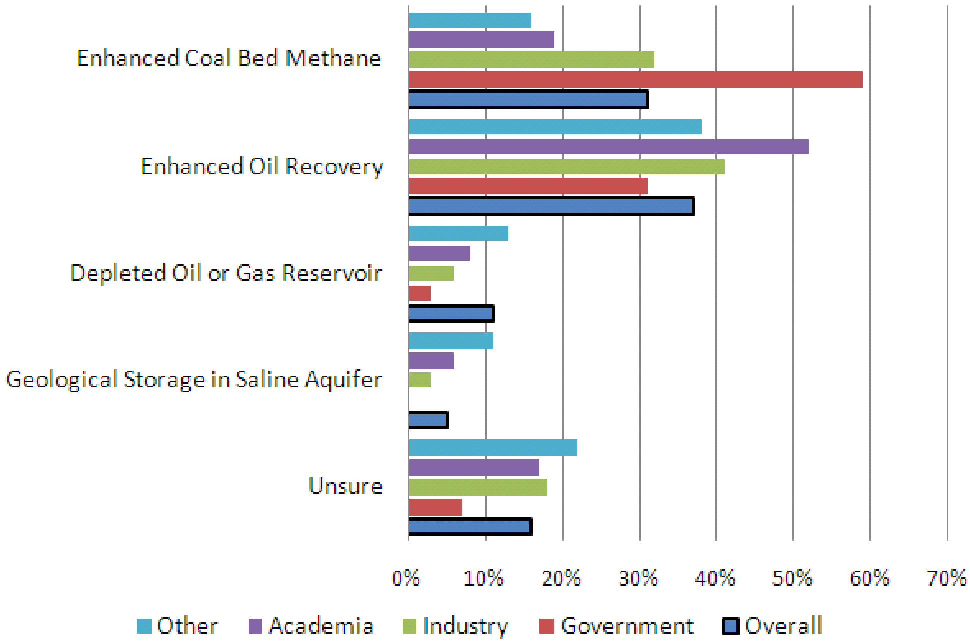

Figure 5.4 Storage methods preferences in first demonstration project in China (Stakeholders were presented with explanations of each storage method based on IPCC CCS special report beside the question, but stakeholders were not told that ECBM may 'sterilise' coal reserves)

Section 6 – Authorising, Regulating and Financing CCS Demonstration Projects

6.1 Authorisation process for a CCS demonstration project

A large number of institutions at the national and local levels share the responsibility for making and implementing energy policies in China (Liang et al, 2008), as described in Figure 6.1 and the evolution history of Chinese energy authorisations is illustrated in Appendix 3. Therefore, we asked stakeholders the importance of different institutions in authorising the first CCS demonstration project in China.

In response to the question: 'are you familiar with the authorisation process of energy demonstration projects?', less than 10% of stakeholders selected 'very familiar', one third selected 'familiar' and another third were 'not sure'. We asked stakeholders to contrast the potential authorisation process for CCS demonstration with that of current IGCC demonstration projects and current coal-to-liquid (CTL) demonstration projects. Over 60% believed authorising CCS demonstration project were 'very similar' or 'similar' to that for IGCC, but only 33% felt similarly with regard to the CTL authorisation process.

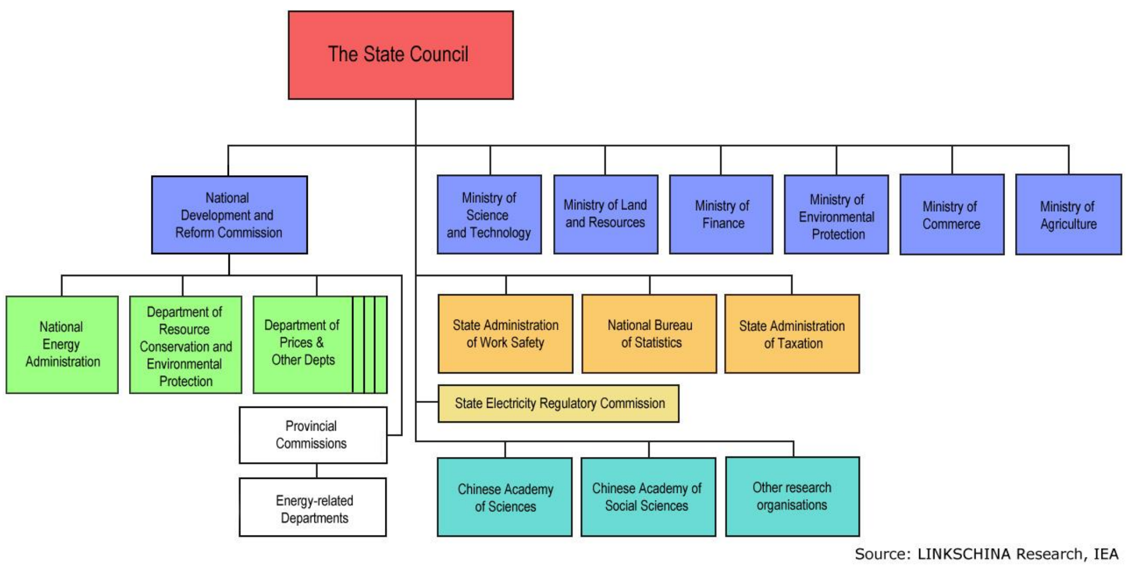

Figure 6.1 Organisations involved in energy policymaking and administration in China

More than 60% of respondents named the National Development and Reform Commission (NDRC) as the most important institution in authorising the first commercial CCS demonstration project in China (Figure 6.2). During face-to-face interviews, a few local government officials suggested that these key institutions would be involved in large scale demonstration projects, but that local departments, the Ministry of Science and Technology (MOST), and/or grid companies and power companies could act as the main decision-makers for a smaller demonstration project.

When being asked which institution was the second most important in authorising a CCS demonstration project, the answers were more diverse (Figure 6.3), as local governments, MOST, MOF and NDRC were all popular options. A large number of respondents believed that the importance of institutions lay in their potential power to offer financial support.

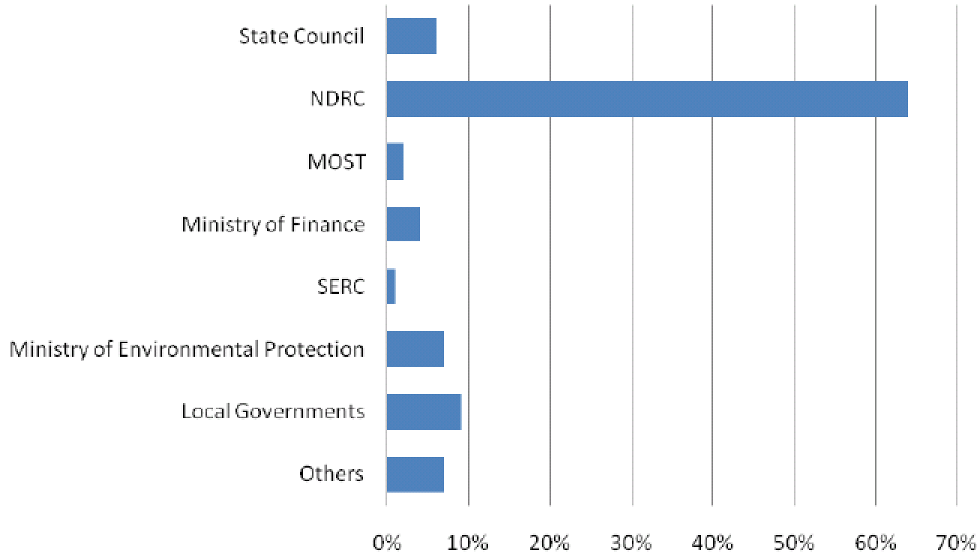

Figure 6.2 Institution perceived as most important in authorising a CCS demonstration project

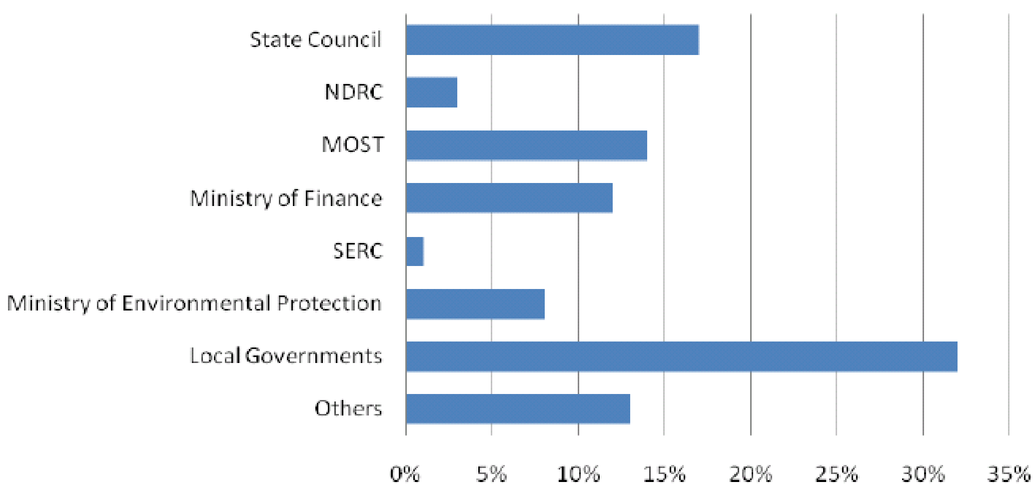

Figure 6.3 Institution perceived as second most important in authorising a CCS demonstration project

6.2 Regulating and monitoring CCS projects

In contrast to conventional thermal power projects, where regulation and monitoring are mainly implemented by local authorities, a higher proportion of respondents believed NDRC, MOEP and MOST should be heavily involved in regulating and monitoring CCS projects. In addition, some believed MOF should be involved because of its potential capacity to provide financial support. Surprisingly, SERC, despite its regulatory power, was only identified by 6% of respondents. Some respondents believed that the State Council should be involved at some stage especially for regulating and monitoring large storage and transportation facilities in relation to CCS projects.

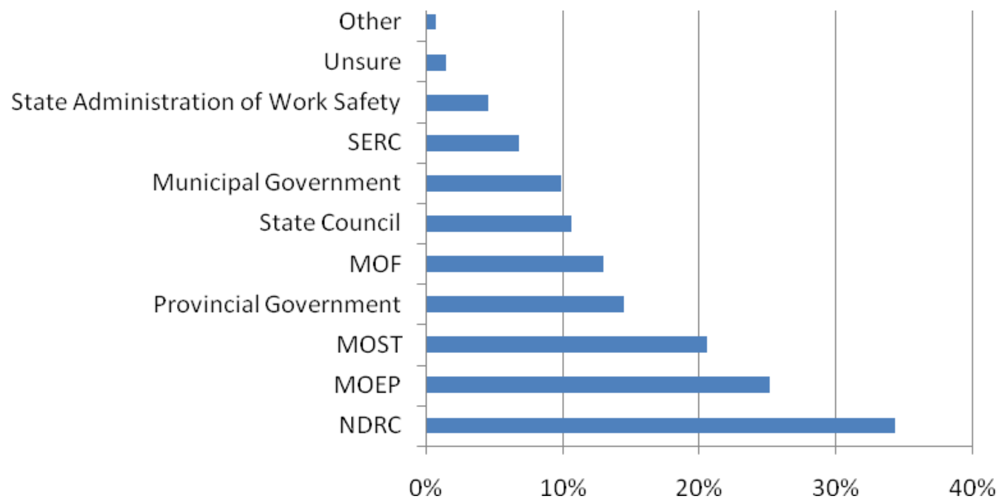

Figure 6.4 Institutions expected to be heavily involved in regulating and monitoring CCS projects

6.3 Potential advantages in developing CCS demonstration projects

Before exploring the potential financing schemes for CCS demonstrations, we asked stakeholders whether they agreed with four statements on potential advantages of developing CCS demonstration projects in China. The average rating (shown in Figure 6.5) implies that developing CCS demonstration projects was best placed to demonstrate Chinese governmental effort in combating climate change as well as potentially create an advantage for Chinese power companies for investing in CCS technologies. Almost half of the respondents disagreed with the statement that the CCS demonstration projects would attract foreign investment, probably because foreign investors have encountered regulatory challenges in entering the Chinese power sector. A few argued that indigenous Chinese equipment manufacturers are unprepared to compete in the CCS equipment or technology market, because of lack of knowledge, and 'CCS atmosphere'. In a question posed specifically to participants from academia and research institutions, approximately half claimed CCS demonstration in China may increase their R&D funding, but 41% were unsure.

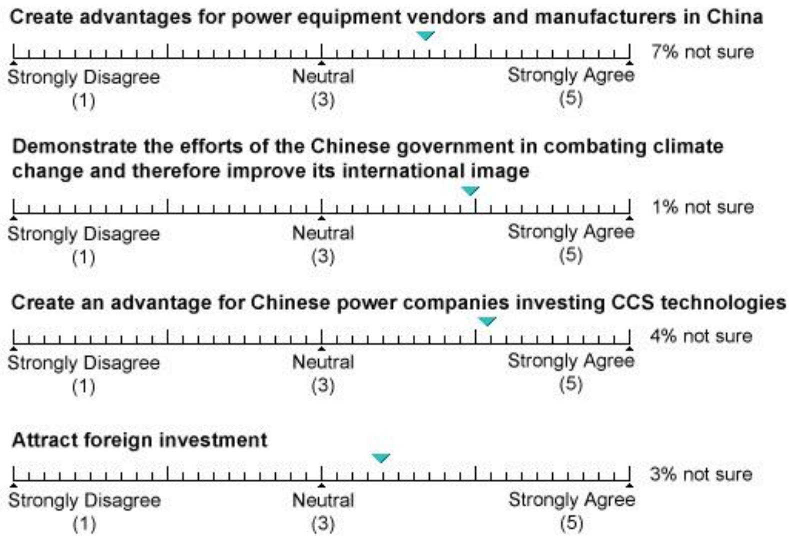

Figure 6.5 Perceptions of the benefits of developing CCS demonstration projects in China

6.4 Financing CCS demonstration projects in China

To understand the potential financing schemes and options for the CCS demonstration projects in China, 16 key stakeholders were selected and consulted, including 5 chief financial officials from the energy industry (3 power companies, 2 oil companies), 7 commercial bankers, and 4 development bank energy specialists. Of these, 5 also participated in follow-up face-to-face interviews.

We first asked the question: 'what is the desired mix of sources for the initial equity capital investment for capture facilities, assuming CNY 1.5 billion is required for capture demonstration investment in a 600MW coal-fired power plant in China'. The results (Figure 6.6) suggest that according to the respondents, **on average**, 51% of equity should come from government divided between the Chinese government (20%) and foreign governments (31%). In addition, respondents believed it would be desirable for charities, multilateral banks, and energy foundations to provide 21%, 23% and 13% support respectively. Although, in terms of developing technological knowledge, power companies are probably one of the most significant and direct beneficiaries in the CCS demonstration project, the survey results suggested power companies might only provide 15% of initial equity to such projects. Five CFOs from power & oil companies consistently argued that the CCS demonstration projects should be fully supported by public funding, as the extra operating, credit and market risks brought by the CCS projects would reduce the value of their base plants (see Appendix 4 for stakeholders' perceived extra 'company-wide' risks brought on by CCS). On the other hand, some bankers believed that both management and operating quality could be enhanced if power companies or other private parties partially financed the initial equity capital to create a structure similar to that of a public-private-partnership (PPP). Two respondents suggested that ideally 'venture capitalists' and ‘technology providers’ should be one source of the initial equity capital (this option was not listed in our questionnaire).

The average perceived ratio of (equity capital) / (total capital) was 47%, much higher than the 20% to 25% value that is common in conventional thermal power projects. Commercial bankers believed much lower capital leverage would be required to create a more stable capital structure, in order to compensate for the extra operating risks involved in CCS demonstrations. However, most financial officials from power companies perceived that a higher than normal equity to debt ratio would be sufficient. Furthermore, they believed that a ‘policy loan’, which was endorsed (or guaranteed) by government with favourable terms for debtors, should be considered for developing CCS demonstration projects in China.

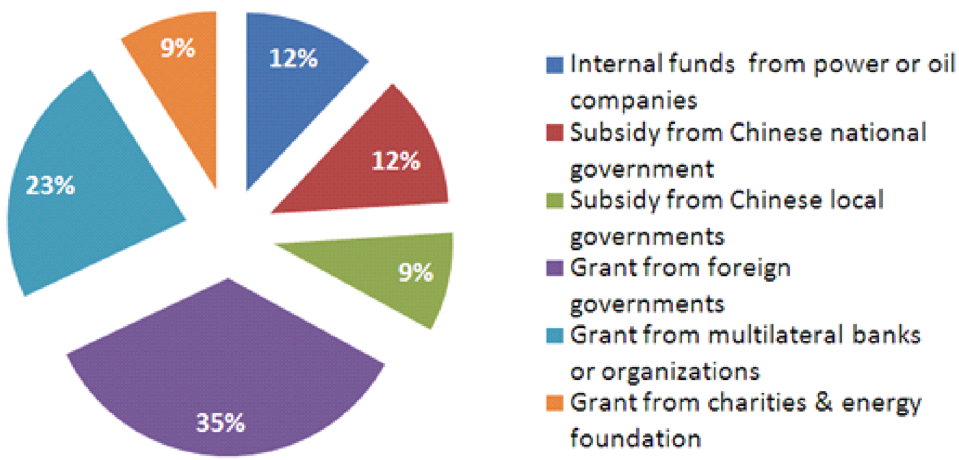

Figure 6.6 Desired mix of sources for the additional equity capital investment needed for capture facilities on a 600 MW coal-fired power plant in China (based on the average results from the 16 financial experts consulted)

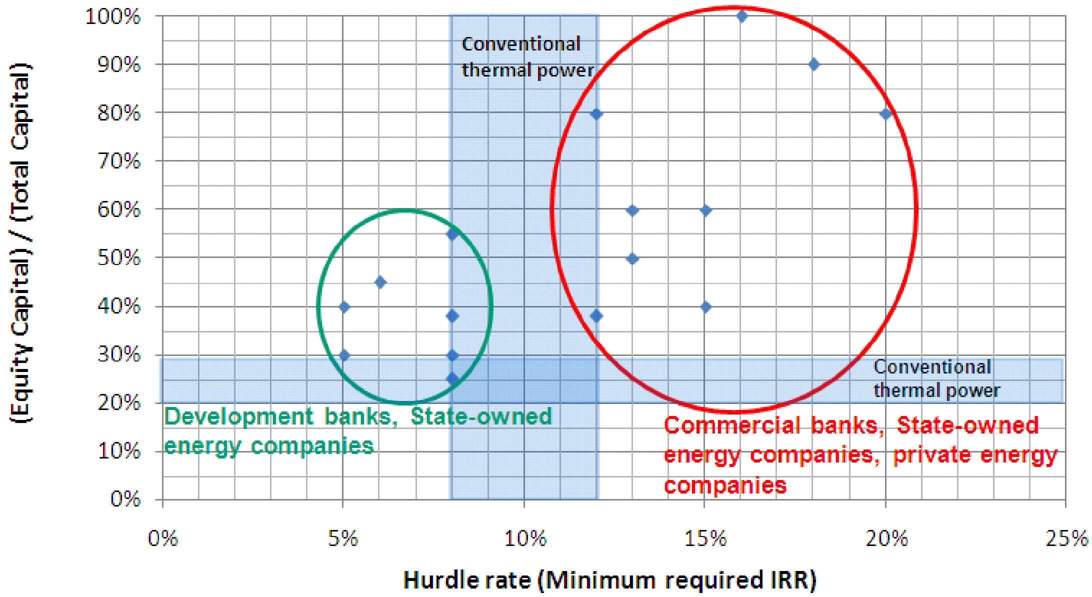

Figure 6.7 Scatter diagram of hurdle rate and equity capital ratio for the extra investment needed for capture facilities (based on average response of the 16 financial experts consulted)

Regarding the perception of the debt composition, concessionary loans from multilateral institutions (41% on average) were considered to be the main source of debt-finance for CCS demonstration projects in China (Figure 6.8), probably because domestic commercial or development banks are unable to provide a majority of the credit without the permission, guarantee or policy support of the Chinese Government. Half of the respondents suggested, strategically, that over 10% of debt-finance should also come from the major equipments or technology vendors.

Measures such as NPV, IRR or payback-period are frequently applied in evaluating the economics or capital budgeting of a power project in China. We provided a 10% reference rate as the hurdle rate for large conventional thermal power investment. The opinions on the hurdle rate of capture facilities investment were split into two clusters (Figure 6.7: 7 respondents, all from development banks and state-owned energy firms, suggested that hurdle rates lower than 10% and payback periods of higher than 10 years were appropriate, as they might consider CCS projects to be a non-commercial investment; 9 respondents, mostly commercial bankers, required higher reference rates and shorter return periods to reflect the risk premium relative to conventional thermal power investment.

In terms of operating costs, most respondents believed a realistic option was to get a ‘subsidy from foreign governments’ which might provide 36% of the financing on average (Figure 6.10), followed by the Clean Development Mechanism (CDM) under the Kyoto Protocol (23% average financing coverage). It should be noted that CCS is not currently included in the CDM (as of June 2009). In addition, stakeholders believed that the Chinese national government (15%) and multilateral banks (17%) might also provide some financial support to fill in the gap in meeting the operating costs.

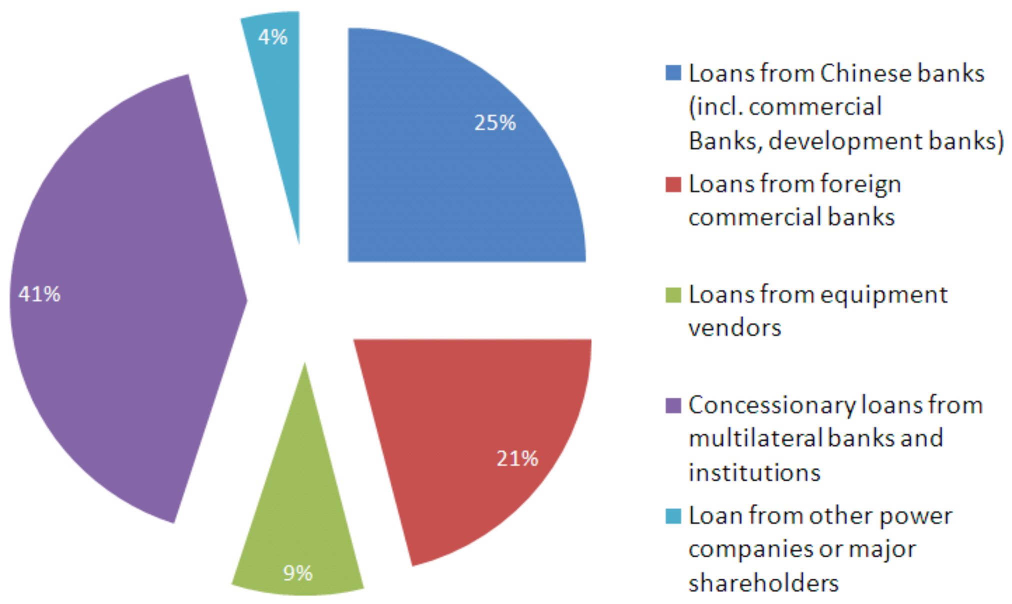

Figure 6.8 Desired mix of sources of creditors for the additional liabilities of capture facilities on a 600MW power plant in China (based on the average results of the 16 financial experts consulted)

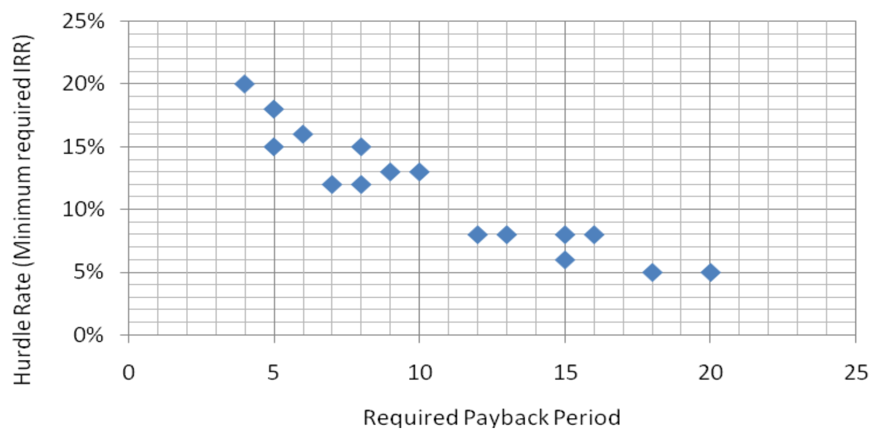

Figure 6.9 Scatter diagram of required payback period and hurdle rate for the extra investment of capture facilities (based on estimates of the 16 financial experts consulted, where a 10% reference rate for a 600 MW plant without capture was provided)

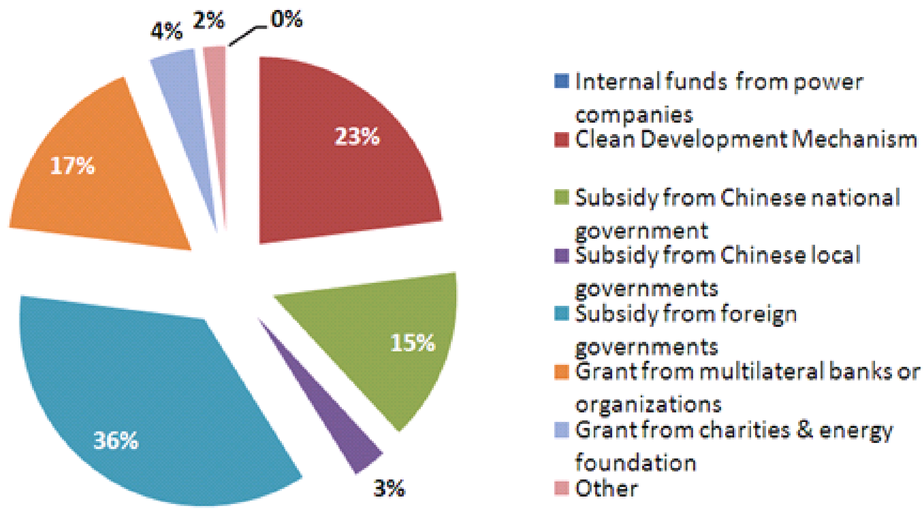

Figure 6.10 Desired mix of sources of finance for the extra operating costs of capture on a 600MW power plant in China (based on the average results of the 16 financial experts consulted)

The questions on capture facilities were then repeated in the context of the whole CCS system: 'What is the ideal mix of financial support for building a 600 MW post-combustion capture unit, 500 km cross provincial borders CO_2 pipeline and facilities for storage of CO_2 in an onshore saline aquifer in China?'. There was no great difference in response, as respondents still retained the view that foreign governments and multilateral banks should be the primary financial sources for CCS systems. A respondent from an oil company said more internal funding from oil companies might become available if the storage included an EOR component.

Section 7 - Discussions on CO_2 Capture Ready in China

Although a few potential projects and initiatives are progressing in China, such as the UK/EU/China NZEC project, the EU-China COACH project, the Greengen IGCC project, the HNG-TPRI-CSIRO post-combustion capture project and the Dagang/EESTECH project, there still has been no construction of a large (or even medium-sized) commercial-scale CCS project (EESTECH, 2009; LinksChina 2008; NZEC, 2008; GreenGen, 2008). In any case, a full-scale project of, say, 300 MW CCS, would only affect a small fraction of the new build of coal-fired generation in any given year, which has averaged 40-100 GW per year in China for much of the last decade. Attention must therefore also turn to unabated coal-fired plants.

An IEA GHG (2007) study concluded that the key elements needed to ensure that a plant was 'capture-ready' included 'a clearly identified strategy by which a credible capture technology can be fitted to the plant; space available both within and around the plant to permit the capture technology to be fitted; a credible route established for captured CO_2 to be removed from site and sent to storage'. What are Chinese energy experts' impressions of 'capture-ready'? In the CAPPCCO study by Reiner and Liang (2008), approximately half of the key stakeholders (dominated by the power industry) in China agreed that 'new power plants capture-ready status' should be clearly defined by all three factors: 'reserving sufficient space', 'considering future retrofit in plant design' and 'building a plant near a geological storage site'.

7.1 Potential factors influencing new plants to achieve CO_2 Capture Ready (CCR) status

Although there is no consensus amongst the respondents over which incentive or policy could make plants Carbon dioxide Capture Ready (CCR), the economics of CCR (29%) was most frequently cited as an important factor affecting new plants' CCR decisions, followed by factors such as China's national climate policy (26%) and the availability of suitable geological storage sites (24%). Although the Clean Development Mechanism (CDM) is an existing and well-known financing mechanism for renewable and low carbon energy sector projects in China, only 13% of respondents believed that including CCS in the CDM would improve the financial viability of implementing the CCR. This is partly because the price for certified emissions reductions (CERs) available through the CDM market is not currently high enough to support the extra costs of CCS projects. Moreover, the uncertainties regarding potential changes to the CDM process further jeopardize the role for the CDM in financing CCS projects.

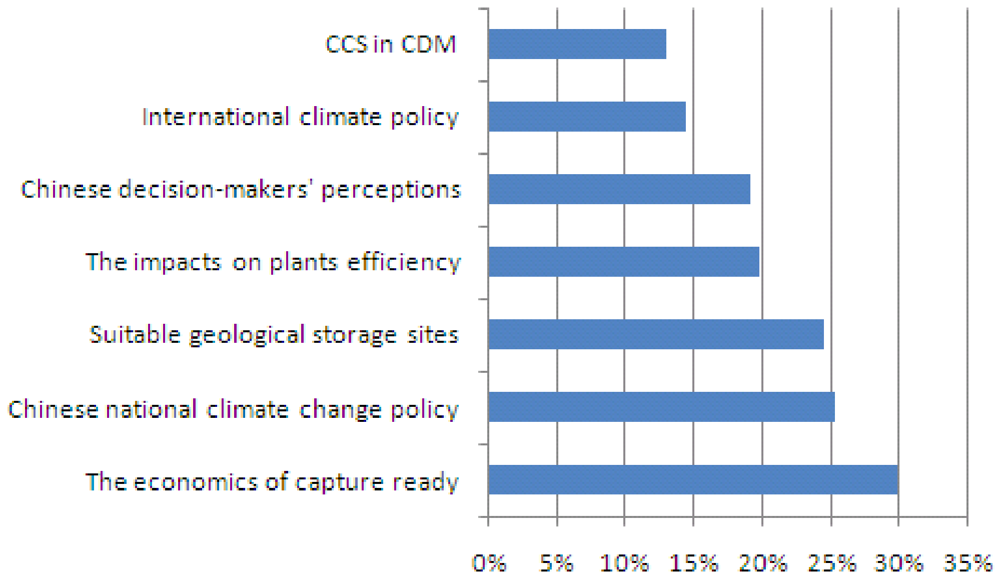

Figure 7.1 Factors viewed as heavily influencing whether new plants become CO_2 capture-ready

7.2 Acceptable costs of CO_2 Capture-Ready (CCR)

IEA GHG (2007) estimates that 0.5% to 2.9% extra pre-investment is required to achieve capture ready status (Table 7.1). When asked the question: ‘are you likely to make new coal fired power plants carbon capture ready (CCR) (which eases the process of retrofitting to carbon capture) if it required 1% extra fixed capital expenditure?’, 78% (102 out of 131) of respondents selected ‘Yes’, 11% (14 out of 131) chose ‘no’, and the remaining 11% (15 out of 131) were not sure (Figure 7.2). Respondents who accepted the extra 1% expenditure were then asked whether they would accept 2% extra fixed capital expenditure, and of these 85% claimed they would. When the sub-sample who selected ‘no’ in the first instance were asked if they would consider CCR if the extra fixed capital expenditure was 0.5%, only 14% (or 2 stakeholders) supported CCR. Overall, two thirds of respondents claimed that they would accept 2% extra fixed capital expenditure to make new plants CCR. In other words, assuming the fixed capital costs was US$600 to $800/kW in China, our results imply that two thirds agreed to invest US$7.2m to $9.6m to ensure a 600 MW capacity plant was Carbon Capture Ready.

	Non-CCR	CCR essential with throttled LP turbine	CCR essential design with floating LPT	CCR essential design with clutched LPT
Additional pre-investment (% of original)		**0.49%**	**0.74%**	**2.89%**
Additional investment for retrofit	**23.58%**	**21.90%**	**21.85%**	**21.23%**
Saving of Retrofitting Cost		**6.64%**	**6.64%**	**7.34%**
Additional O&M costs	**73.15%**	**66.43%**	**63.73%**	**62.07%**
Energy Efficiency Penalty	**-**	**-22.78%**	**-21.51%**	**-20.70%**

Table 7.1 Capital investments and O&M costs comparisons across different configurations of CCR in PC power plants (IEA GHG, 2007: 61-62)

Based on a segmentation analysis, we found that power industry stakeholders were more reluctant to accept CCR investment with only 58% of respondents accepting 1 % extra cost. Some industrial stakeholders during follow-up interviews claimed that they would not be willing to pay for the extra costs unless they were subsidised or received clear policy signals from the Chinese government regarding the need for future CCS retrofits.

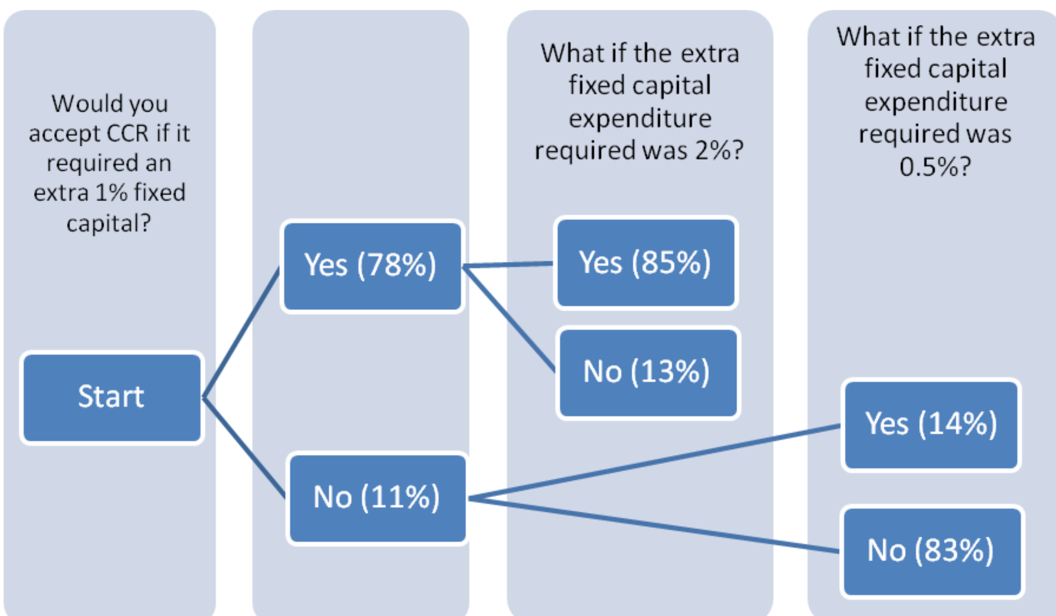

Figure 7.2 The hierarchy of questions when investigating acceptable costs of CCR in China (stakeholders are presented with the IEA definition of CCR alongside these questions)

Section 8 - Behavioural Issues and Institutional Framework in Decision-making Process

8.1 Loss-aversion effect in decision-making

Loss aversion is exhibited when investors justify decisions to pursue opportunities based on the prospects of gain or loss rather than based on uncertainties with respect to terminal wealth (Kahneman and Tversky, 1979**)**. Liang and Reiner (2008) in a study in 2007 asked stakeholders whether they would accept a sure loss of $10 million or a 50% chance of losing nothing and a 50% chance of losing $20 million. 27 out of the 32 (84%) power industry respondents chose the latter option, preferring the chance to recoup the full amount at the expense of the risk of a greater loss. When the question referred to a conventional thermal unit, not a single respondent considered closing down a power plant to mitigate future uncertainties and all were reluctant to accept certain loss.

In this study, we asked stakeholders whether they would terminate a CCS power project much earlier than scheduled (only 10 years after it began operation) which might result in a CNY200 million loss, but with continued operation they might have 50% chance of ending with a loss of CNY400 million and 50% of breaking even (on a present value basis). The results were slightly different from our findings in 2007. A significant proportion, 35% of stakeholders overall (most academics and a minority of government respondents) claimed they would close the plant, and 48% (chiefly from government and industry) preferred continued operation, and 17% were unsure.

Stakeholders from industry, especially state-owned power companies were more willing to accept higher risk to avoid loss. Therefore, the loss-aversion evidence might predict a speculative implication: if capital investments of the CCS demonstration are realized, investors and regulators may be reluctant to close the capture units even under highly adverse operating conditions. On the other hand, during face-to-face interviews, all five senior managers from state-owned power companies explained that closing plants could result in weaker market and political position, because smaller power companies are more likely to be forcibly merged and consolidated into larger power companies.

8.2 Forecasting ability - overconfidence effect

Overconfidence means that people tend to place too much confidence in their ability to predict, for example, by setting narrow bands on their confidence levels (Shefrin, 2000). Overconfident behaviour may lead to surprises as stakeholders may underestimate the range of possible prices or project returns, and there will be a higher than normal probability of a return or prices outside the confidence interval. We asked respondents about their forecasts of the lower bound and higher bound of coal prices in 2010 (Figure 8.1). More than 70% offered an interval of less than 500 CNY/ton (the range in 2008) and approximately one third provided an interval of less than 300 CNY/ton, the average interval from 2004 to 2008. Therefore, if the overall trend of volatility of Chinese coal price is increasing as it has for the last five years (2004 to 2008), a number of stakeholders might have exhibited overconfidence in their ability to forecast. The tendency to provide relatively narrow bands is particularly striking given the volatility of coal prices over the course of 2008.

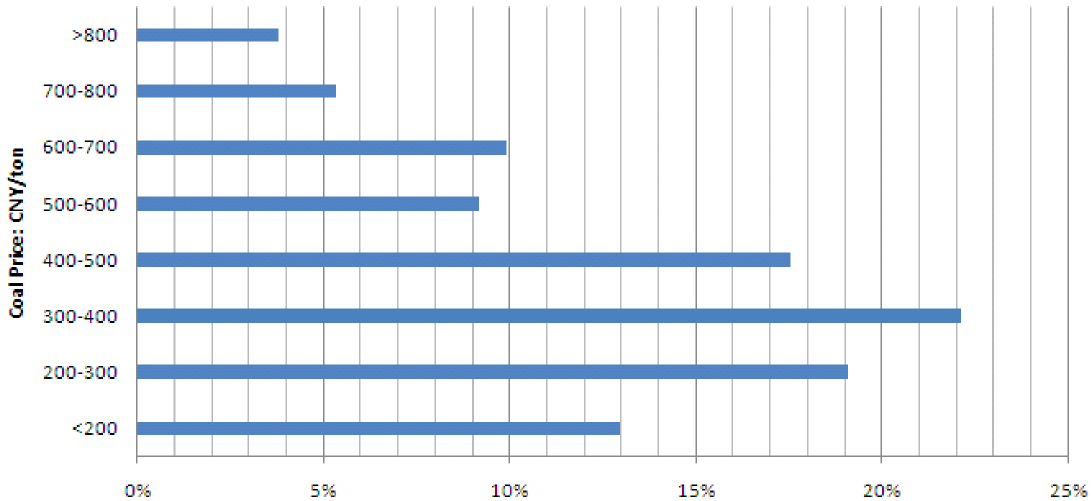

Figure 8.1 Perceived scale of coal price interval (expected higher bound – expected lower bound) in 2010 (information that coal exit prices ranged from 560 to 1060 CNY/ton for Qinghuangdao coal in 2008 was given alongside the question)

8.3 Criteria for good projects – framework dependence and endorsement effect

In the financial sector, the endorsement effect refers to the faith and endorsement of the participants under a defined contribution pension plan who simply assume that the investment alternatives provided by the sponsors or their employers are good investments. Liang and Reiner (2008) analysed behavioural patterns in the Chinese power sector and found that a common belief was that projects proposed by national authorities are 'good projects.' This trust was more important than the conventional economic measures such as, NPV, IRR and payback periods. The authors also found that the endorsement effect was more apparent for state-owned power companies than private sector firms.

In this study, even among respondents from government and academia, there was evidence of an endorsement effect, as a large number of stakeholders believed that projects 'proposed and supported by national authorities' were better investments than projects which used traditional economic parameters or portfolio theory (Figure 8.2). Nevertheless, stakeholders from academia or research institutions placed the great importance on traditional economic measures, while respondents from governments and NGOs paid more attention to the location and scale of the project.

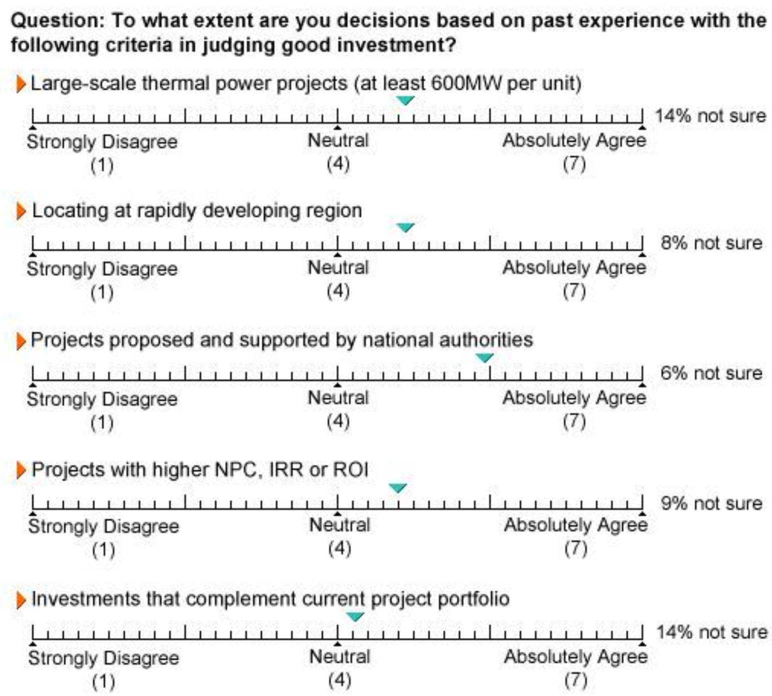

Figure 8.2 Rating of different criteria in justifying power generation projects as good investments

Section 9 Key Conclusions and Policy Recommendations

- Most respondents viewed climate change as a serious problem, and 20% perceived it as a challenge in the near future. We found a strong link between those who viewed CCS as necessary and those who believed climate change was a serious problem.
- A majority of the respondents believed that under the current policy framework it would be very difficult to achieve deep cuts of carbon emissions in China or globally.
- A large majority of Chinese stakeholders did not view Carbon Capture and Storage as a new concept and CCS was widely acknowledged as an important technology in reducing emissions of greenhouse gases, but a small number of the respondents had concerns over the reliability of CCS technologies, availability of storage sites, and coal supply issues.
- A large number of the respondents were concerned about the energy penalty associated with CCS and its impact on the long-term sustainability of coal supply in China. However, the proportion of respondents with such concerns was much lower than in 2006. A number of stakeholders now seem to have adopted a strategic view that coal is neither a sustainable nor a reliable energy source for China in the long term unless CCS technology was installed.
- There was no consensus amongst the respondents over the appropriate scale of the first CCS demonstration project. Though most new coal-fired power plants built in recent years were at least 600 MW, three quarters thought a demonstration project should be less than 600MW. Partial capture from a full-scale power plant could therefore be a necessary step and one might expect that there will be both smaller and larger scale demonstrations in the future.
- With regard to preferences over which capture technologies should be used in the first demonstration project, in general, slightly more respondents preferred post-combustion capture technologies, however, industrial stakeholders slightly favoured pre-combustion capture. It is therefore likely that both pre- and post-combustion technologies will continue to be developed in China for the foreseeable future. Most of stakeholders in face-to-face interviews suggested demonstrating both post-combustion and pre-combustion capture technologies in China.
- Enhanced oil recovery (EOR) and enhanced coal bed methane recovery (ECBM) were considered to be the most attractive storage technologies for the first CCS demonstration project. The tendency to ignore larger storage options such as saline formations and longer-term needs may therefore need to be explicitly addressed.

- The National Development and Reform Commission (NDRC) was perceived as the most important institution in authorising the first commercial scale CCS demonstration project. Local governments, the Ministry of Science and Technology (MOST), and the Ministry of Finance (MOF) were considered to be the next most important actors in the process. NDRC and Ministry of Environment Protection (MOEP) were deemed to be likely to be heavily involved in regulating and monitoring the operations of CCS demonstration projects. Clear support for CCS from NDRC is therefore an important signal that would be needed for larger-scale development.

- Most stakeholders believed that the international image of the Chinese Government might benefit from developing the first commercial CCS demonstration. Demonstration projects were also seen to have the potential to create an advantage for Chinese power companies. Chinese and foreign funding of CCS demonstration plants in China may therefore play an important role in the international climate change negotiations.

- On financing, power firms were reluctant to provide a significant proportion of initial equity capital for CCS demonstration. Foreign governments, the Chinese government and multilateral banks were perceived as the primary source of finance. Effective private-public partnerships were seen an attractive means of filling the funding gap but also maintaining efficiency.

- Concessionary loans from multilateral banks were considered to be the most promising source of debt finance for CCS projects. Some suggested CCS equipment and technology providers and venture capitalists should also provide some vendor finance.

- The extra operating costs for CCS were expected to mainly come from foreign and Chinese governments, and stakeholders perceived that the CDM, if available, would cover less than one quarter of the costs.

- The perceptions of the appropriate project hurdle rate fell into two clusters, making the average IRR of 11.3% effectively meaningless. Stakeholders from development banks believed it should be much lower than the reference rate for conventional thermal units, but commercial bankers argued for a higher than normal rate was needed to address the extra risks in demonstration projects.

- A lower leverage (debt to equity ratio) was proposed by commercial bankers to manage the extra risks of CCS demonstrations. Governments were called upon to bear some of the operating risks, but clearly there are still fundamental disagreements between different stakeholder groups over the nature and magnitude of those risks.

- Decision-makers in the energy industry, similar to investors in financial markets, were found to exhibit behavioural biases such as loss-aversion, over-confidence and endorsement effect in making decisions or forecasts. Investors or policymakers involved in implementing CCS may benefit from explicitly incorporating these behavioural patterns and Chinese institutional frameworks into their models.

- Over two thirds of stakeholders (but only 21% of power company officials) claimed they would accept an extra 2% fixed capital expenditure to make new plants CO_2 Capture Ready (CCR). The economics of CCR, Chinese national climate policy and proximity to suitable geological sites were the main concerns for making new plants CCR in China. Nevertheless, for CCR to expand, the energy industry and investors will need clear signals from the Chinese government on future development of CCS in China.

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Appendix 1 Previous CCS Consultations in China

Project	Year	Sample No. stakeholder	No. institute	Respondents No. stakeholder	No. institutes	Questionnaire format No. questions	Path dependent	Data Collection	Feature
BP/DTI CCP2 Communications (Reiner et al,2007)	2006	186	72	115	39	20	No	face-to-face, telephone	Cambridge in collaboration with Chinese Academy of Social Science, China Coal Information Institute and South China University of Technology
EPRG (Liang,2008)	2007	62	31	33	17	36	Yes	face-to-face, telephone	Aim to understand the institutional framework of Chinese sector, more qualitative assessment
CAPPCCO (Reiner and Liang,2008)	2008	202	84	103	32	23	No	face-to-face, telephone	Focus on industry opinions and investigated stakeholder behaviour patterns in decision-making
HIT Study (Liang and Wu, 2009)	2008	37	n/a	31	13			face-to-face	Conduct semi-structured Interviews to acquire information about barriers to and incentives for the CCS deployment in China
STRACO2 (ACCA21,2009)	2009	n/a	60	n/a	35	21	n/a	n/a	Understand technology and policy preference, risks concerns as well as potential financial sources
NZEC (this study)	2009	256	129	131+9*	68	61^	Yes	online, face-to-face~	Investigate the technical, regulatory and financial schemes for the first CCS demonstration project as well as long term deployment

*131 participated in online survey, 22 joined face-to-face interviews and additional 25 respondents joined but haven't fully completed the online survey

^each respondent answers 30 to 35 questions

~31 stakeholders were consulted face-to-face, and 22 also participated in online survey

Appendix 2 List of Chinese Stakeholders' Institutions

Government Bodies (official roles)

- State Council (Responsible for formulating national energy policy)
- National Energy Leading Group (Responsible for formulating national energy policy)
- NDRC (Responsible for formulating energy policy, climate policy; approve new projects, approve large energy demonstration projects)
- SEPA (Responsible for formulating environmental policy, approve new projects; monitor project operating)
- SERC (Responsible for regulating power sector, approving new projects)
- Ministry of Science and Technology (Responsible for technology roadmap, R&D and technology transfer)
- Ministry of Finance (Responsible for formulating tax or subsidy scheme for new technology; manage CDM fund)
- State Administration of Work Safety (Concern safety issues in energy project, and additional coal mining accidents concerns)
- Ministry of Land and Resources (Approval of land for power plants and other energy facilities)
- State-owned Assets Supervision and Administration Commission of the State Council (Owners of large state-owned power firms)
- China Electricity Council
- Chinese Embassy in the UK
- Local Governments (e.g., provinces or regions such as Guangdong, Guangzhou, Shenzhen, Wuhan, Jilin, Beijing, Hong Kong SAR)

Large State-owned Power Generation Companies and its Subsidiaries (Industry)

- Huaneng
- Greengen
- TPRI
- Datang Power
- Guodian Power
- China Resource Power
- China Shenhua Group (Largest coal mining firm, with a large amount of power generation assets)
- China Power Investment Co. and their subsidies

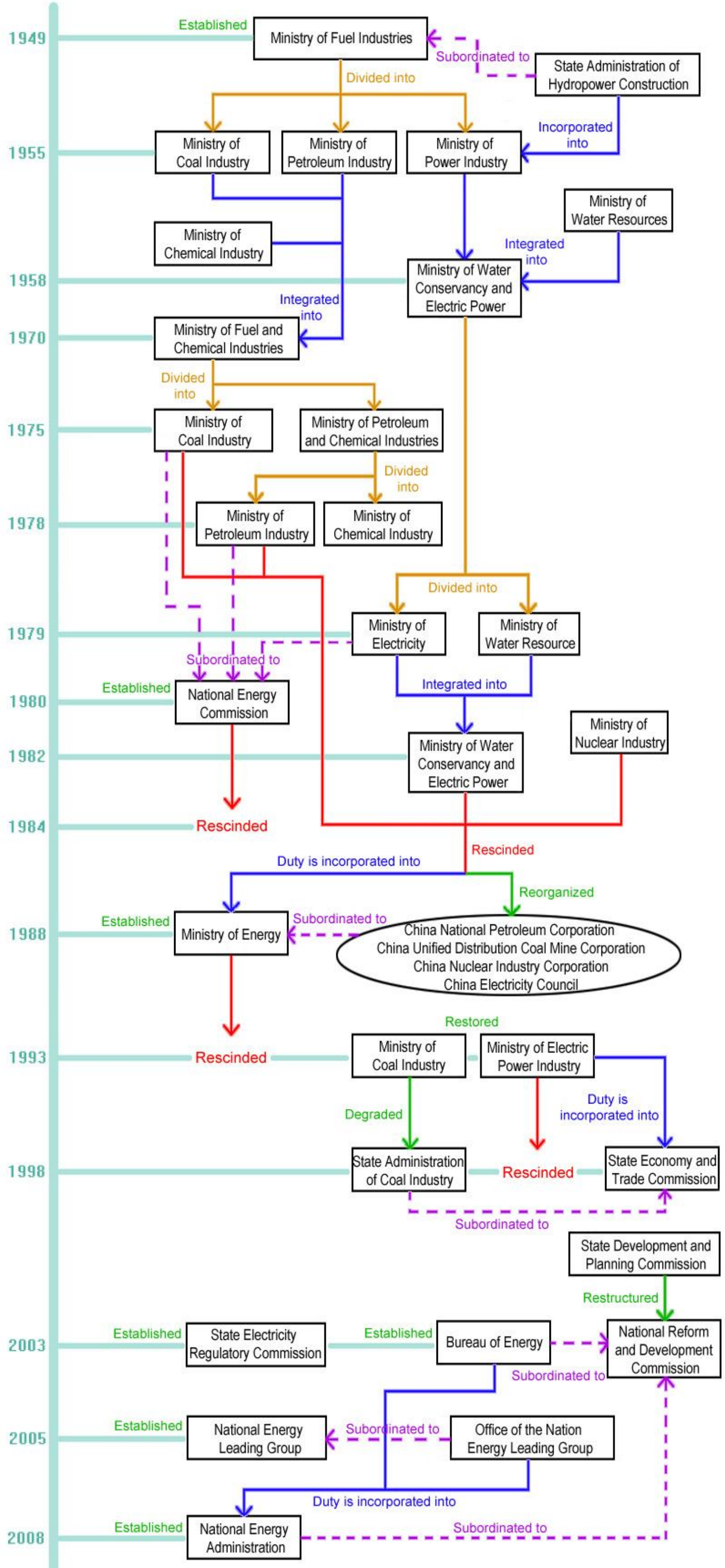
Provincial, Local and Private-owned Power Companies / Power Equipments Providers (Industry) • Zhejiang Power • Shenzhen Power • Guangdong Power Electric • Guangzhou Holding • Nanshan Power • Kaidike Power • Baochang Power • Harbin Boiler • Shanghai Electric • GE China
Oil & Gas Companies/ Technology & Equipment (oil, gas processing, transportation) Providers (Industry) • CNPC • CNOOC • COSL • SINOPEC • BP China • Shell China • CNOOC-Shell • Schlumberger China • AIRPRODUCT Asia • Yantai Raffles • Chiwan Base • China Merchants Group
Grid Companies *State Grid, Southern grid and their local subsidiaries*

Academic Institutions • Tsinghua University • Chinese Academy of Science • Chinese Academy of Social Science • China Coal Information Institute • Peking University • Renmin University • China Petroleum University • North China Electric Power University • Shanghai Academy of Social Science • Tongji University • South China University of Technology • Zhejiang University
Other Institutions • China Development Bank • China Merchants' Bank • Yan Coal • People's Daily • Science & Technology Daily • Guangzhou Marine Geological Survey • The Swire Group • Greenpeace • The Climate Group • World Wild Fund for Nature (WWF)

Note: Financially independent Institutions, for example, subsidiaries within a group, are counted as different institutions. However, institutions listed above are consolidated to highest group or ministry level.

Appendix 3

Development of Energy-related Departments of China



Source: LINKSCHINA Research

Appendix 4 Extra company-wide investment risks created by CCS versus conventional coal-fired power

(Survey of 16 CFOs, commercial bankers and energy specialists from development banks)

Internal Operational Risk		External Operational Risk		Market Risk	Credit Risk
People	**Processes**	**External**	**Physical**		
Employee collusion/fraud	Accounting error	Legal ✓	Fire	Fuel price ✓	Fuel supplier ✓
Employee error ✓	Capacity risk	Outsourcing	Physical security	Electricity price ✓	Electricity buy-side
Employee misdeed	Contract risk ✓	Political ✓	Terrorism ✓	Steel price	CERs/CO2 buy-side ✓
Employee liability	Miss-selling/suitability	Regulatory ✓	Theft	Cost of labour	Governments
Employment law	Product complexity ✓	Stable supply	Natural disaster ✓ (e.g. earth quake and typhoon)	Carbon price ✓	Banks
Health and safety ✓	Project risk ✓	Tax		Oil/gas price ✓	
Industrial action	Reporting error				
Lack of knowledge/skills ✓	Settlement/payment error				
Loss of key personnel	Transaction error				
	Valuation error				

Stakeholders are provided all options in the table and the table design refers to the format of British Bankers' Association Survey

Meaning of Symbols and Highlights:

✓ - Identified by at least one stakeholder in the survey
- Identified by more than 25% and less than 50% of stakeholders
- Identified by more than 50% and less than 75% of stakeholders
- Identified by more than 75% of stakeholders

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