2014/D04

# Guangdong CCUS Project Baseline Public Perception Survey Results

Draft for Discussion

中英（广东）CCUS 中心
UK-China (Guangdong) CCUS Centre

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In 2009, China's State Council proposed its 2020 goal for greenhouse gas emissions, and then in 2010 made Guangdong a low carbon pilot province. Guangdong has made remarkable achievements in greenhouse gas emission control to which the UK-China low carbon cooperation has contributed significantly. In September 2013 the UK Department of Energy and Climate Change (DECC) signed a joint statement in London with the Guangdong Development and Reform Commission, witnessed by governor Zhu Xiaodan of Guangdong Province, to strengthen low carbon cooperation. The joint statement highlights the importance of collaborating in Carbon Capture and Storage (CCS).

Supported by the Guangdong and UK governments, the UK-China (Guangdong) Carbon Capture, Utilisation and Storage Industry Promotion and Academic Collaboration Centre (the "Centre") was officially founded on December 18th, 2013. The Centre is committed to promoting the demonstration of large-scale CCUS projects to tackle greenhouse gas emissions. At the same time, the Centre will also provide an international collaboration platform for solutions to other local pollution problems (such as haze, water pollution) caused by coal utilization, and to accelerate the industrialization for clean fossil energy technologies and to train qualified professionals.

## SUPPORTING INSTITUTES

广东省发展和改革委员会 DEVELOPMENT AND REFORM COMMISSION OF GUANGDONG PROVINCE
英国驻广州总领事馆
Scottish Enterprise
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# Acknowledgements & Disclaimer

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# Contents

# 1. Introduction

In China, to build a successful coal-fired power plant, authorities require an environmental impact assessment (EIA). The EIA includes four public consultations as well as a public hearing. These projects also require another public consultation process conducted through the Municipal Department of Land and Resources for land usage. In addition to the formal process, the project acknowledges the need for more informal engagement with the public to ensure they fully understand project objectives, to reduce the risk of public opposition. The informal engagement becomes particularly important as public riots now frequently impact the development of new infrastructure projects such as coal-fired power plants, waste incineration plants and petro-chemical projects. This is in spite of the formal public hearing process being successful. However, there are growing pressures on the environmental performance of new build coal-fired power plants in China, in regard to both conventional pollutants (SOx, NOx and small particulates) and carbon dioxide CO2 emissions. This means the public may consider a carbon capture utilisation and storage (CCUS) project to reduce emissions and environmental impacts more positively.

CCUS is a large-scale technology that could achieve deep cuts in greenhouse gas emissions from coal-fired power plants. China Resources Power (CRP) Haifeng, is the first proposed CCUS demonstration project endorsed by the Guangdong provincial government. The current plan of the demonstration programme aims to capture one million tonnes[1] of CO2 from the CRP Haifeng power plant and transport CO2 to China National Offshore Oil Corporation's (CNOOC's) Huizhou Refinery to mix with CO2 from other high concentration sources. The mixed CO2 stream will be transported to an offshore CO2 storage site in the Pearl River Delta Basin. In August 2014, the China Resources Power (CRP) Haifeng project appointed the Guangdong CCUS

[1] *Subject to government authorisation and storage site development.*

Centre to develop a CO2 capture testing unit at Unit 1 of their ultra super-critical coal fired power units to compare different technologies. The testing project is expected to complete construction by June 2015. The final investment decision (FID) for the large-scale demonstration project is expected by mid-2018. Public perception has been identified as a key factor that will influence the FID.

The Haifeng Power Plant is located in Xiaomo town (population 13,000) in the Haifeng County (population 746,000). Xiaomo town is located on the west end of Shanwei City, on the east coast of the Guangdong province. The town covers an area of 34.45 km2 including 17 villages. Of the13,000 population in Xiaomo, 49.6% are farmers and 26.9% are fishers. The town also accommodates approximately 1,000 Hong Kong, Taiwan, Macau and overseas Chinese people. As the largest company in Haifeng, CRP has established and maintained close links with the local public in Xiaomo. For example, CRP have helped improve roads in the town, donated stationary for local schools, helped improve local school facilities, as well as set up financial grants to support local residents' children to study at University.

Reviewing lessons learnt from past CCUS project developments (e.g. the Barendrecht project - a proposed CCS project cancelled because of public opposition in Netherlands), experiences reflect that a timely and cohesive engagement strategy for communicating projects with stakeholders will be key to improve local stakeholder acceptance (Brunsting et al, 2011; Terwell et al, 2012). Ashworth et al (2012) reviewed five CCUS demonstration projects from across the United States, Australia and the Netherlands, and found five key factors were critical for a successful communication programme. These included:

*-Alignment of government intentions for CCS with the goals of the project;*

*-Communication experts being part of the deployment team from the outset;*

*-Consideration of the social context in site selection and project design;*

*-Flexibility in framing the project and adjusting the implementation strategy to meet stakeholder needs;*

*-The opportunity for offering competition to promote community self-selection for the project.*

The aim of this study is to identify baseline public opinions toward CCUS technologies in the Guangdong province. The baseline survey will help to inform an effective public communication programme for the Guangdong context. Although there are regional, cultural and social differences in China, the best practices learnt from this CCUS project communication may also benefit communication strategies of other large infrastructure developments in China. To generate such wider benefits, the project hopes to enable a successful demonstration of how a communication programme can contribute to overall deployment of the technology.

# 2.Survey Methodology

Guangdong is the largest province in China with a population of 106 million, approximately US$ 1 trillion GDP and 88GW peak power generation demand. The baseline survey aimed to understand across the Guangdong region, the general public's view of environmental issues, climate change and energy technologies with a focus on CCUS. The survey was conducted through an online survey platform hosted by China Southern Website, a leading online news media company in South China.

The questionnaire design adopted the survey from the Global Carbon Capture and Storage Institute (GCCSI)'s Communication and Engagement Toolkit to act as a guide. The questionnaire was revised for the Guangdong context based on a template designed by the research team. Brunsting et al (2011) suggest that a successful communication programme should include an informed, open, and objective public discussion process in which different views and perceptions of the technology were acknowledged, thus the baseline survey begins by asking questions on wider social and energy issues with a view to informing further dialogue with the public.

As public perception has become a key barrier for a few major CCS projects in the world, building social acceptance for a specific project is critical for demonstrating CCS technologies (Ashworth et al, 2012). In addition to the generic questions, project specific questions were also asked at the final part of the survey. The data collected from the baseline survey provides a foundation for formulating both general and site specific communication plans, which are both important for demonstration project development (Lupion et al, 2013).

The survey was completed by 2,410 participants in August 2014. Of those, 5.5% of participants were from Haifeng County, Shanwei City; 6.9% were from other areas of Shanwei City; 1.4% from

Huizhou; 71.3% from other cities in Guangdong and 15% from other provinces. Fifty six percent (56%) of stakeholders claimed they had university graduate education level. Two thirds of stakeholders were from a family with equal or more than 3 members. Within all participants, the male to female ratio was 1.87 to 1. To encourage participation, respondents were offered a gift of 10 tokens of the UK 'Working Horse' stamp presentation through a random selection if they left a valid address. As less than 10% of respondents left their correspondence address, it seems that most respondents were not motivated by the token to participate in the survey, instead they did it for other reasons. They may also have held concerns about the possibility of their answers being associated with them personally.

Although a full chain CCUS project includes capture, transport, utilisation and storage. This study did not seek respondents' views on offshore storage in this instance. Mabon et al. (2014), in their Scottish study, suggest that offshore storage is easier for public acceptance. As the project develops, and becomes more focussed, future project stakeholder engagement will consider the issue by ascertaining public responses to both off shore and on shore storage.

# 3.Survey Results

## *Priority of Social Issues for Local Community*

When asked to rate the priority issues for local community, more than 87% of public stakeholders ranked environment as either important or very important (Figure 1). This was followed by water pollution (82%), housing availability (79%), water availability (78%) and economic development (75%). Most stakeholders prioritised all 17 options with more than 45% net support for all issues. Of least importance were sporting and recreational, population control and noise pollution which were only seen as important by a relatively small group of respondents.

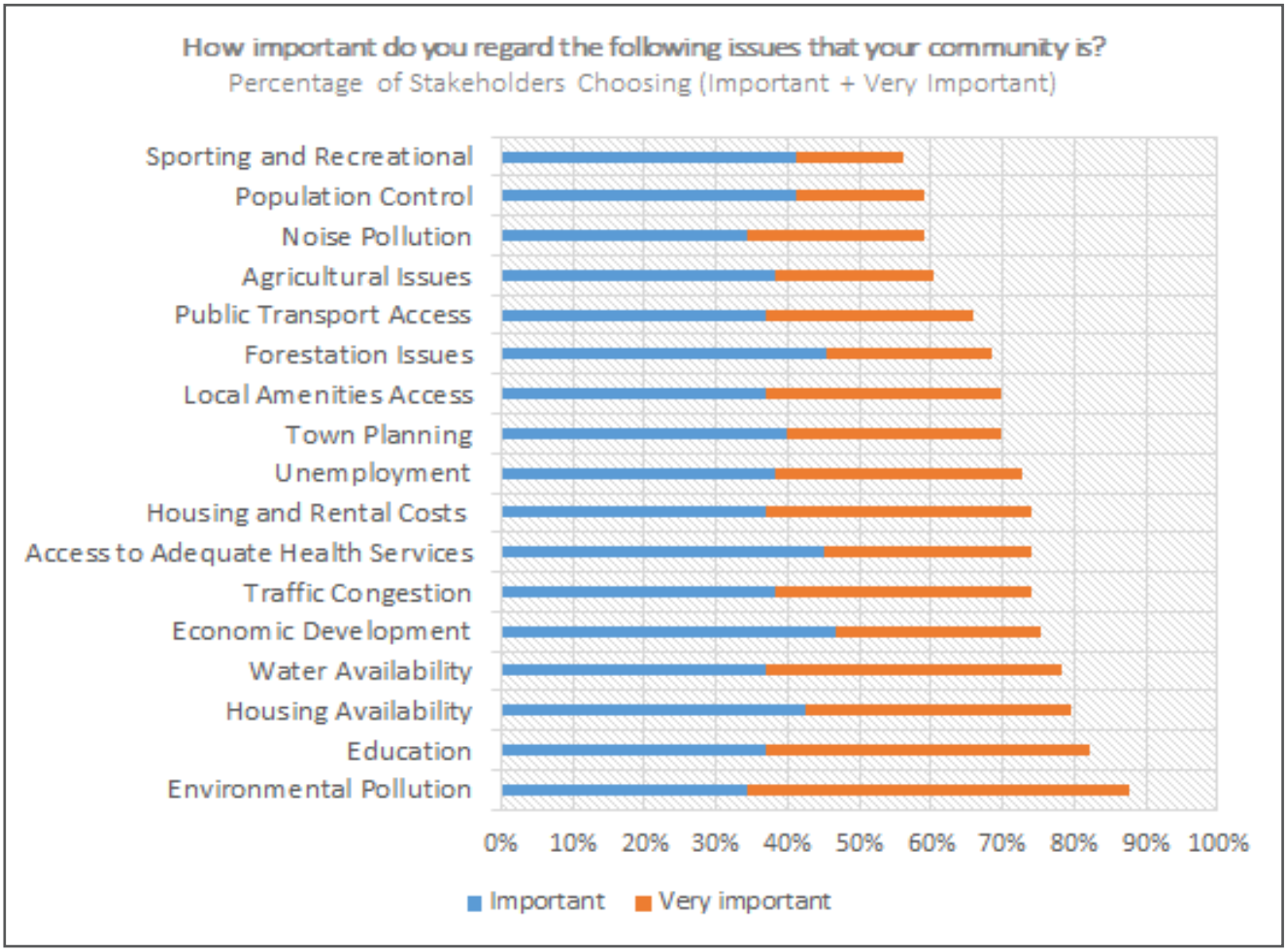


*Figure 1 Percentage of Respondents' 'important' and 'most important' local community issues*

When asked about the trade-off between economic development and the environment, there was a lack of overwhelming consensus (Figure 2). Approximately half of the respondents (49%) considered protecting the environment should be a priority, but only 10% of all respondents believed environmental protection should be prioritised, even though it might hinder economic development. Approximately 26% of stakeholders chose neutral, i.e. both issues were considered equally important. Still a significant proportion of respondents considered economic development as a priority (24%) but only 1% or 33 of the 2,410 respondents believed economic development should be always prioritised even if it might damage the environment. More than a third of stakeholders in Shanwei region selected 'both economy and the environment are important, but the economy should be prioritised', this result was perhaps driven by the fact that Shanwei is a less developed region in Guangdong.

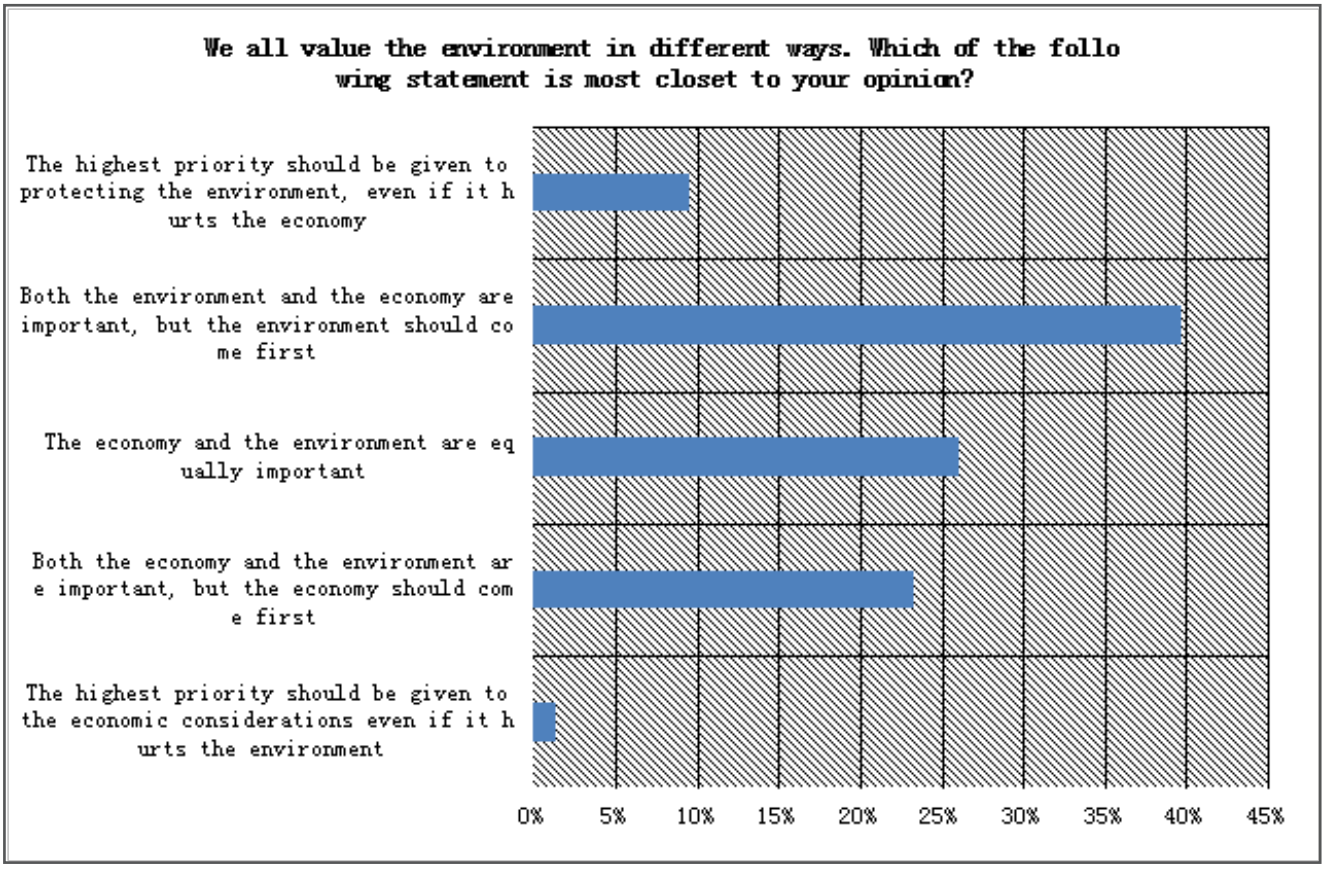


*Figure 2 Preferences between economic development and the environment*

### *Awareness of a Range of Environmental Issues*

In response to the question on environmental issues, most respondents claimed they had heard of these issues. More than 95% claimed they had heard of water pollution, particulate control and PM2.5. Even though PM2.5 is a subset of particulate, slightly more respondents claimed they had heard of the issue, perhaps due to the PM2.5 issue that was frequently reported in the Chinese media at the time of the survey. However, only a small minority of respondents claimed they were highly knowledgeable or very much understood environmental issues (Figure 3). Although there have been mature technologies and processes applied to large stationary emission sources for SOx and NOx control, more than 10% of public respondents claimed they had not heard of these terms. More than 20% of respondents claimed that they either very much understood or were highly knowledgeable about sources of greenhouse gas emissions or water pollution (Figure 3).

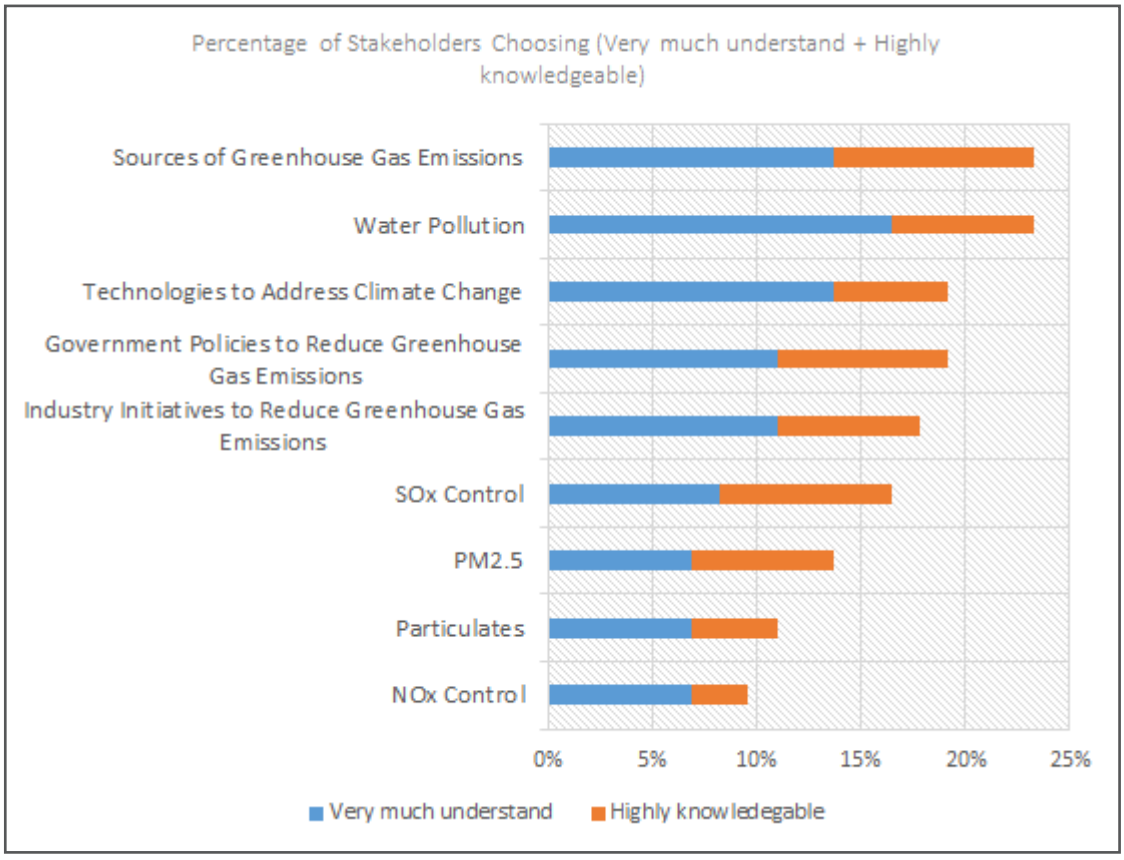


*Figure 3 Respondents self-rated knowledge of key environmental issues*

### *Self-rated Knowledge and Understanding of Conventional Power Generation Technologies*

In response to their self-rated knowledge and understanding of conventional power generation technologies, there was a mix of responses. Respondents claimed they were most familiar with conventional power generation technologies such as coal, gas, nuclear and hydroelectricity. Figure 4 shows the percentage of respondents rating their knowledge and understanding as high for each of the four technologies. In total, more than 98% of respondents indicated they had heard of nuclear, more than 93% of respondents indicated they had heard of gas power. More than 40% of respondents believed they had a good understanding of hydro-electric power, while only less than a quarter claimed they understood well gas power. From the subsample in the Shanwei region (near the China Resources Power Haifeng project) a marginally higher number of respondents claimed they very much understood and were highly knowledgeable on conventional coal-fired power.

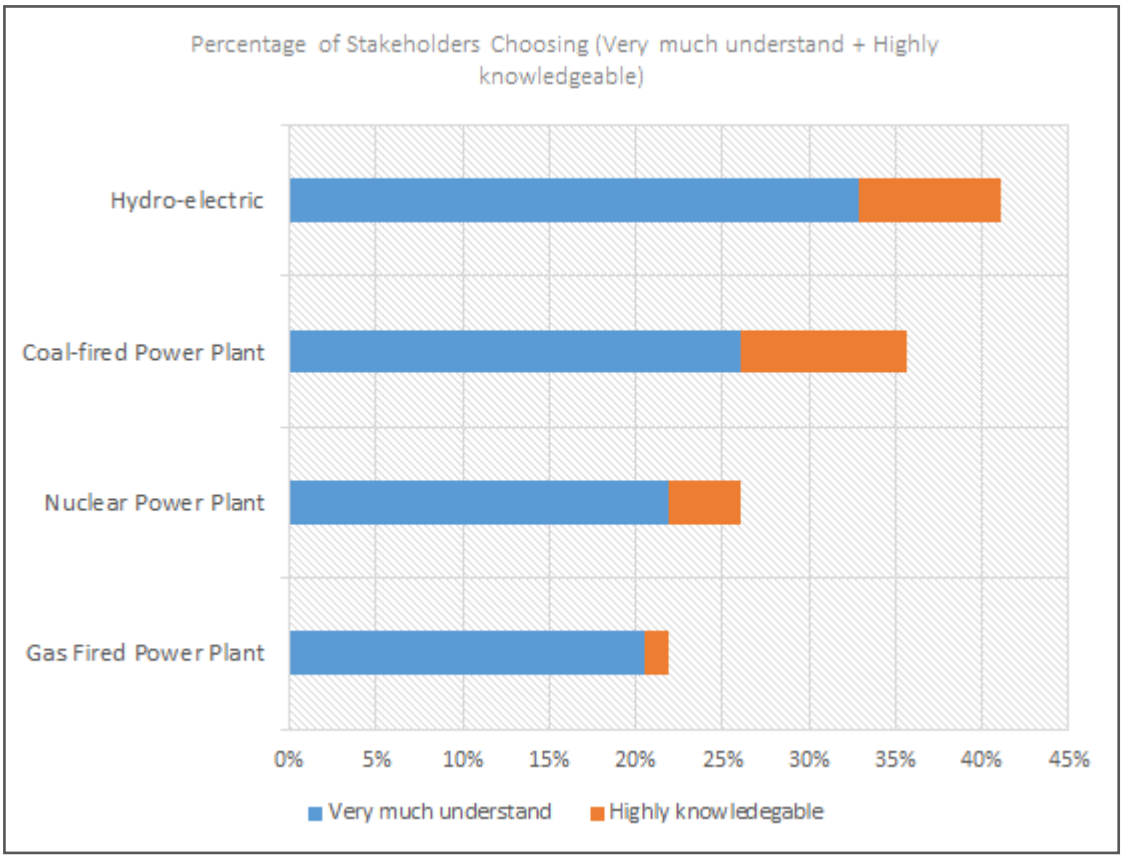


*Figure 4 Self rated knowledge of conventional power generation technologies*

### *Perceived Role of Climate Change Issue in China*

When asked about the role of climate change as an issue in China, approximately 88% of respondents considered climate change was an important issue in the near future, with 71% believing climate change would be a very important issue in the near future, followed by another 17% rating climate change as a moderately important issue in the near future. Less than 10% considered climate change to be an important issue in the distant future, while less than 3% considered climate change to be 'not important'.

The results were very different from the findings of an opinion leader survey conducted in 2009 for UK-China Near Zero Emission Coal (NZEC) project, where only 29% of 131 respondents rated climate change as a very important or moderately important issue in the near future, while 43% perceived climate change a very important issue in the distant future. The difference of results is possibly driven by two reasons: (a) the audience of 2014 survey was public while the 2009 survey had been focusing on key opinion leaders (influential stakeholders); (b) the public along with other stakeholders' views have changed dramatically since 2009. However, until further investigation is carried out it is difficult to ascertain the difference in responses.

When asked how likely it was that China would adopt an absolute greenhouse gas emission cap within the next 10 years, 24% believed the chance is very high, 33% chose possibly, 23% were neutral, while approximately 15% selected 'not very likely' or 'unlikely' and less than 3% of respondents chose the 'unsure' option.

### *Awareness and Priority of CCUS Technology*

Stakeholders were presented with a basic description of the technical process of CCUS. Approximately, two thirds of respondents claimed they had not heard of CCUS technology. In contrast, the awareness was lower than developed countries (i.e. 61% in Canada, 84% in Netherlands, 77% in Australia and 36%

in Scotland were aware of CCS technology) (Ashworth et al, 2013), as shown in Table 1 below. However, in the next question regarding the willingness to pay, surprisingly more than 38% of public claimed they were willing to pay an extra 20% of their electricity bill for CCUS while a slightly lower percentage (35%) claimed willingness to pay an extra 20% for renewable power.

| | Australia | Netherlands | Canada | Scotland | France | China |
|---|---|---|---|---|---|---|
| **Sample Size** | 84 | 111 | 80 | 99 | 1076 | 2410 |
| **Year** | 2011 | 2011 | 2011 | 2011 | 2007 | 2014 |
| **Data Collection** | Workshop | Workshop | Workshop | Workshop | Questionnaire | Questionnaire |
| **Percentage Heard of CCS** | 77% | 84% | 61% | 36% | 34% (on $CO_2$ storage) | 32% |
| **Source** | Ashworth, 2013 | Ashworth, 2013 | Ashworth, 2013 | Ashworth, 2013 | Ha-Duong, 2009 | This study |

*Table 1 An International Comparison on the Public Awareness of CCS Technologies*

In most past studies around the world, support for renewable energy appears to be more popular than CCUS. For example, in a study of 82 public stakeholders in Calgary, Canada, stakeholders on average gave wind, solar and hydro-electric a higher funding priority than CCS (Einsiedel et al, 2013). Similarly, in a public engagement workshop of 99 participants around Edinburgh, UK, the use of renewable energy received a higher level of support than the use of CCS (Howell, 2014). A small scale survey of lay public in Switzerland also suggested the public favoured renewable sources of energy (Wallquist et al, 2009). The outcome could be driven by the design of survey (i.e. the key theme was CCS) and driven by the fact that fossil fuel plays a more important role in the Chinese energy system and those respondents might expect CCUS to help reduce local air pollution. On the other hand, more than 41% of respondents claimed the willingness to pay for a home retrofit to reduce energy consumption with a payback period of 10 years.

### *Perceived Reliability of Information Sources*

In regard to the perceived reliability of information sources, public stakeholders believed academic papers, newspapers and books were the three most trustful sources. Internet social media was

selected as the least trustful source, followed by Internet websites and government correspondence. This suggests that conventional newspaper media and academic studies could play a critical role in complementing other information sources provided by governments and project proponents. The findings were consistent with analyses in the Eurobarometer (2006) where academic researchers were found to be the most trustful source of information on energy issues by the public. It also suggests that researchers could play an important role in how CCS will be perceived in the social context (Vercelli and Lombardi, 2009).

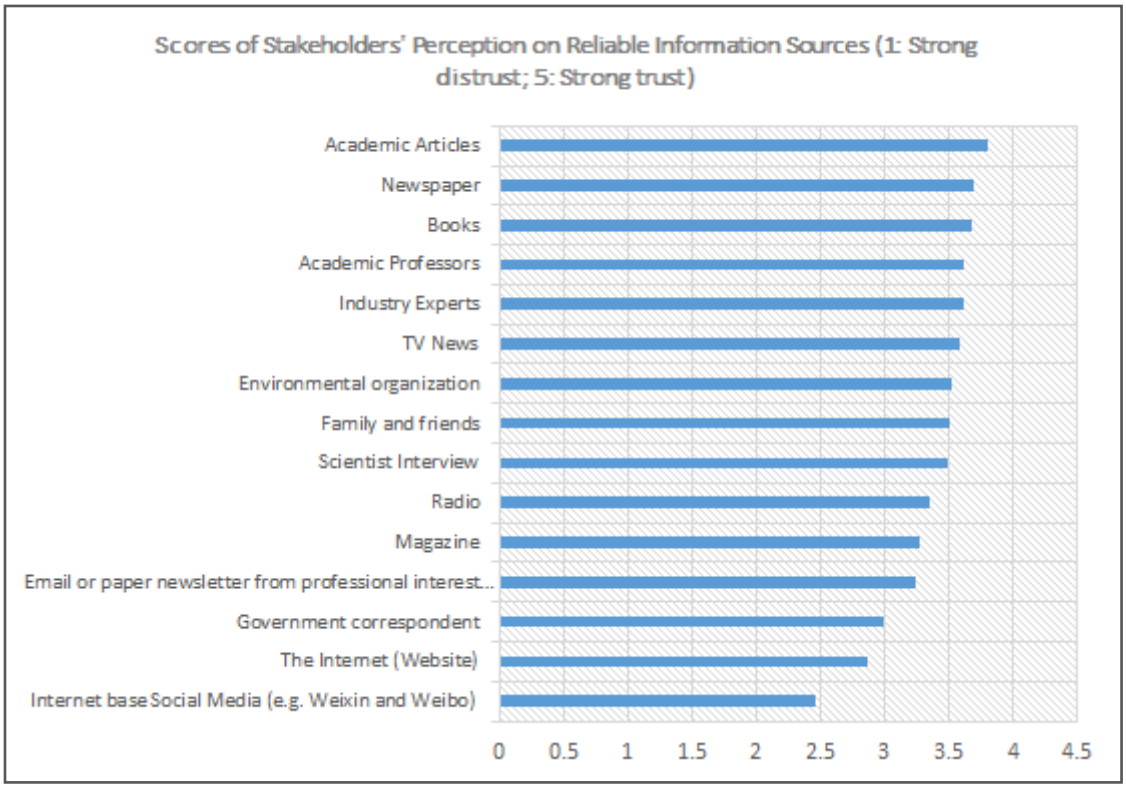


*Figure 8 Perceived Trustfulness of Information Sources*

### *Awareness of Specific Demonstration Project*

In the final part of the survey, stakeholders were asked about their awareness of the coal-fired power plant where a specific CCUS demonstration project in Guangdong, the CRP (Haifeng) CCUS project will be hosted. A majority (60%) said they had not heard of the project. Of those that had heard of the project, 29% claimed they knew the project has adopted the SOx removal technology, while 42% who had heard of the project

indicated it would adopt CO2 capture technologies. In regard to views on building a CCUS demonstration project in Haifeng Town, Shanwei City, 45% expressed support or strong support (with more than three quarters of stakeholders having heard of the project), 14% selected moderate support, 29% were neutral, with only 12% of respondents indicating they were against the project. In regard to attending a follow-up free seminar, 55% of respondents said they would be likely or very likely to attend, the proportion of willingness to attend is approximately the same in Shanwei and Haifeng regions. This feedback provides a solid foundation to establish an engagement platform for local stakeholders and the broader public, whereby a formal and transparent feedback system can be established as this had been deemed a criticial contributing factor for project success (Hund and Greenberg, 2011).

# 4.Summary of Findings & Next Steps

The baseline survey of public opinion for CCUS in Guangdong found environmental issues were perceived as the most important social problem for respondents. Respondents claimed they had a good understanding of conventional energy generation technologies. Although only one third of respondents said they had heard of CCUS technologies, more than 85% of respondents did not oppose the concept of CCUS technologies. In regard to information channels, academic articles, newspapers and books were considered as the three most reliable sources. There were a few limitations of the first survey and they need to be addressed and calibrated as part of the next steps in the project.

- *The study has not tried to understand the drivers of perceptions. The communication team may use both focus group (incl. online focus group suggested by Riesch et al, 2013), information choice questionnaires (Daamen et al, 2011) and other alternate data collection methods in future studies to try to understand these in more detail.*

- *Past projects have demonstrated that the socio-political context, within which a project operates, may significantly affect perceptions of CCUS technologies (Terwel et al, 2012). However, this online survey really only set out to understand baseline attitudes and as such the socio-political context has not been dealt with in this process. We hope to organise regular stakeholder workshops to investigate the issue and potentially may establish a local consultative committee to guide project proponents about community perception of the project.*

- *Predictors of public perception on the risks and benefits of CCUS projects may not be universal (Seigo et al, 2014), hence the next major public survey should try to understand estimations of public perception and record how it might evolve in the future. Such analyses could be strengthened by a well designed experimental study.*

- *There was a limited amount of past information to support the design of public survey in Guangdong. To inform future communication strategies and project decisions, the communication project team would establish an archive for both generic and project specific communication activities.*
- *The survey did not record individual age groups. Future communication activities would target different age groups to ensure a cross section of respondents.*
- *As part of the communication activities there is potential to reach out to local schools within the Guangdong province to educate children about the range of low-carbon energy technologies, particularly the local CCUS project.*
- *In addition to public stakeholders, it would be useful to investigate key opinion leaders (e.g. key government officials administering low-carbon projects, senior management of utilities companies). A possible agent-based model could be used to analyse the interaction between different stakeholders and reveal the network effect.*

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# Annex: Survey Questionnaire

## Guangdong CCUS Project Online Survey Questionnaire

**Carbon Capture, Utilisation and Storage (CCUS) is the only large-scale technology to decarbonize thermal power plants. Coming CCUS and other flue gas cleaning technologies, coal-fired power plant could achieve near zero emission. The UK-China (Guangdong) CCUS Centre in collaboration with Nanfang Media, University of Queensland in Australia and University of Edinburgh in the UK conducts this survey to understand public perception towards Carbon Capture, Utilisation and Storage Technologies (CCUS) and a potential CCUS Demonstration Project in Haifeng, Shanwei, Guangdong. We would be grateful if you could kindly fill in the questionnaire below.**

**In acknowledgement of your participation, you will have the chance to win a gift from the UK.**

1. How important do you regard the following issues that your community is currently facing?

   (1 = not important at all, 2 = not important, 3 = not sure, 4 = important, 5 = very important)

   - Unemployment
   - Housing and Rental Costs
   - Housing Availability
   - Public Transport Access
   - Traffic Congestion
   - Noise Pollution
   - Access to Adequate Health Services
   - Town Planning
   - Economic Development
   - Population Control
   - Education

- Local Amenities Access
- Environmental Pollution
- Water Availability
- Sporting and Recreational
- Agricultural Issues
- Forestation Issues
- Other _____

2. We all value the environment in different ways. Which of the following statement is closest to your opinion?

-The highest priority should be given to the economic considerations even if it hurts the environment

-Both the economy and the environment are important, but the economy should come first

-The economy and the environment are equally important

-Both the environment and the economy are important, but the environment should come first

-The highest priority should be given to protecting the environment, even if it hurts the economy

3. How would you rate your knowledge of the following?

**(1: Not at all; 2. Heard of but do not understand; 3. Somewhat understand; 4. Very much understand; 5. Highly knowledgeable)**

- SOx Control
- NOx Control
- Particulates
- PM2.5
- Water Pollution
- Technologies to Address Climate Change
- Sources of Greenhouse Gas Emissions
- Government Policies to Reduce Greenhouse Gas Emissions
- Industry Initiatives to Reduce Greenhouse Gas Emissions

4. How would you rate your knowledge of the following power generation technologies?

   **(1: Not at all; 2. Heard of but don't understand; 3. Somewhat understand; 4. Very much understand; 5. Highly knowledgeable)**

   - Gas Fired Power Plant
   - Nuclear Power Plant
   - Coal-fired Power Plant
   - Hydro-electric
   - Wind Power
   - Solar PV
   - Geothermal
   - Biomass
   - Marine Power (Wave/Tidal)

5. To what extent, do you consider climate change is an issue for China? Please indicate your agreement with the following statement:

   **(1 = strongly disagree, 2 = disagree, 3 = a little bit disagree, 4 = unsure, 5 = a little bit agree, 6 = agree, 7 = strong agree)**

   - Climate Change is a very important issue in the near future
   - Climate Change is a moderate important issue the near future
   - Climate Change is a less important issue in the near future
   - Climate Change is a very important issue in the distant future
   - Climate Change is a moderate important issue the distant future
   - Climate Change is a less important issue in the distant future
   - Not Sure

6. How likely do you believe Chinese climate policy could set an absolute limit for cutting greenhouse gas emissions in China in the next decade?

   - 1 = Very unlikely
   - 2 = Somewhat Unlikely
   - 3 = Unsure
   - 4 = Somewhat likely
   - 5 = Very likely

7. **Have you heard of carbon dioxide capture, utilisation and storage (CCUS) before?**
   - YES
   - NO

   Definition of Carbon Dioxide Capture, Utilisation and Storage

   CCS – also known as CO2 sequestration – is a process whereby CO2 is captured from gases produced by fossil fuel combustion, compressed, transported and injected into deep geological formation for permanent storage or utilisation.

8. **How willing would you be to accept the follow changes, which could be used to address climate change?**

   **(1 = not at all, 3 = somewhat, 5 = very much so )**
   - Invest to retrofit the building / flat to reduce household electricity consumption and get it paid back in 10 years
   - Buy low-carbon electricity from renewable sources (e.g. hydro, solar and wind) with a 20% higher electricity bill
   - Buy new low-carbon electricity from fossil fuel sources (gas and coal) with Carbon Capture, Utilisation and Storage (CCUS) with a 20% higher electricity bill

9. **Please rate the following information sources to match how much trust you hold in the information source or news.**

   **(1: Strongly distrust; 3: Unsure; 5: Strongly trust)**
   - The Internet (Website)
   - Internet based Social Media (e.g. Weixin and Weibo)
   - TV News
   - Radio
   - Magazine
   - Newspaper
   - Email or paper newsletter from professional interest groups
   - Environmental organization
   - Books
   - Academic Articles
   - Family and friends
   - Government correspondent

- Scientist Interview
- Industry Experts
- Academic Professors

10. Have you heard of China Resources Power Group?
    - Yes
    - No
11. Have you heard of China Resources Power (Haifeng) large coal-fired project?
    - Yes
    - No
12. Have you heard of the following pollution control technologies adopted in the project?
    - SOx Removal
    - Particulate Removal
    - Water Treatment
    - Carbon Dioxide Removal
13. Do you support the development of Carbon Dioxide Capture, Utilisation and Storage project developed in Haifeng, Shanwei in Guangdong?

    (1 = not at all, 4 = unsure, 7 = strong support)

    -
14. If there will be a community workshop about CCS, how likely will you attend the workshop?

    (1 = very unlikely, 2 = somewhat unlikely, 3 = unsure, 4 = somewhat likely, 5 = high likely)

    -
    -
15. Would you like to be involved in a community liaison working group around a CCS project if the opportunity arises?
    - Yes, Contact Number: _____;
      Email: Address: _____
    - No

## 16. Demographics

Age

Gender

Education

Employment

Occupation

Household Size

Household Income

Location (Choose from a List of Village and Town)

## 17. If you would like to entre a lottery for a small gift (10 UK stamp sets), please kindly provide your name and correspondence address, your information would be treated strictly in confidence.

Your Name:_____

City: _____

Town: _____

Street:_____

Community:_____

## ANNEX News Articles on *Nanfang Daily*

# The First CCS Project in Guangdong has been a focus of the Public

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By Lin Yamin from Southern Daily

Brussels, Belgium: Carbon dioxide (CO2) emissions, which have threatened the sustainability of human beings, are key to global climate change. Reducing (CO2) emissions has been a common goal of countries across the world as a result. As part of this, CCS is an emerging technology to cut emissions. Recently, delegates from Europe, America, Canada, Australia, Japan, India and China participated in an annual meeting on CCS in Brussels, Belgium in which the development of CCS in China aroused concern. The first large-scale CCS demonstration project in Guangdong, 2×1000 MW project of Huarun's Haifeng power plant under construction has attracted attention, because it plans to capture 10 million tons of CO2 a year after construction.

"It can be widely used in decades."

The world counts on energy, especially fossil fuels, from which CO2 emissions result. These increasing greenhouse gas emissions have led to higher temperatures on the earth and this has greatly impacted on the living environment and been attributed to being one of the major causes of sea level rise. Data provided by Dr. Liang Xi from Edinburgh University, presented at the meeting, shows that the global temperatures can increase by up to about 2 ℃by 2050 without further control. More than 100 countries across the world signed an agreement on emission reductions, which intended to keep the global warming temperature below a rise of 2 ℃ . However, the recent release of

more modelling suggests that the urgency of actions for cutting CO2 emissions is growing.

In addition to using cleaner energy technologies such as nuclear energy, wind and solar power to reduce CO2 emissions, the CCS process can be applied to various industrial processes to cut emissions. In these processes the CO2 emissions are captured and stored in the deep underground of depleted oil and gas wells. In previous years a great deal of investment, (more than ten billion dollars) has been spent on related research and development and CCS demonstration projects. It is predicted by the Global Carbon Capture and Storage Institute (GCCSI) that CCS will be widely used in the power and industrial sector in the future decades.

The delegates that presented at the Europe meeting actively discussed how to promote carbon capture. This included Members of Parliament and Environment Ministers from the EU and its member states, along with representatives of big businesses in Europe, North America and Asia. It is calculated that there are 74 large-scale CCS projects under operation and construction around the world, among which projects under operation are located in America, Canada and North Europe. Those projects stored about 30 million tons of CO2 last year (2013), which equates to the same emissions being produced by 6 million cars.

It is estimated, by authoritative organizations, that the potential of the globe to geologically store CO2 can be at least as large as 200 billion tons, while the global potential to capture CO2 can be between 2.6-4.9 billion tons a year by 2020. However, because of problems such as high costs, high energy consumption and untested storage safety in the longer term, it is quite difficult to be applied to other industries in commercial operations except for oil companies in which the application tends to be mature and is profitable for use in enhanced oil recovery. For example, at this meeting, according to the introduction from Shell, a plant which will complete construction this April, can capture 90 percent of its CO2 emissions. And, in addition to getting subsidies, it can also sell the CO2 to oil companies. More than 200,000 tons of carbon dioxide was captured and stored in China last year.

Because the main source of fuels in China is coal, CO2 emissions are very large. Moreover, with the rapid growth of the national economy in China, it is difficult to change our energy consumption and sources. At the EU meeting, Dr Chapman, Honorary President of UKCCS, said that the development of CCS in the future seven years is key. Issues that he deemed very critical included: policy and financial support from the government; industry, technological research and development to reduce costs;and public understanding . The progress of CCS in the aspects of technology and policy in China should be a focus in this year.

Dr Liang Xi's presentation introduced the CCS development in China. He said that the Chinese government has considered CCS as a key technology to reduce greenhouse gas emissions in the medium and long term since 2009. Especially to facilitate enterprises in the coal, chemical, steel, cement and power industries to develop the application. Corporations like PetroChina, CNOOC, Sinopec, Shenhua, and Huaneng in China have used it at large scale. He told to a journalist from Southern Daily that most of this technology in China has fallen behind developed countries at present, but 12 percent of them are in a relatively leading position. Last year, China captured and stored about 200,000 tons of carbon dioxide. It is required, by related plans in China, that costs and energy consumption of this technology should be significantly reduced by the end of the 12th Five-Year period and build up of carbon dioxide capture, usage and storage integrated demonstration systems will reach a scale of 300,000-500,000 tons/year.

Meanwhile, Dr Liang Xi said that the task of energy saving and emission reduction is large since Guangdong is the main energy consumer in China. Guangdong is actively seeking efficient ways to reduce emissions. Guangdong's Governor Zhu Xiaodan witnessed the release of a statement on further cooperation on low-carbon between the Development and Reform Commission of Guangdong and the Energy and Climate Change Department of UK during his visit to the UK, which highlighted the significance

of CCS research and industrial development. With the support of Global Prosperity Fund under the Foreign and Commonwealth Affairs Office of UK, the first UK-China (Guangdong) CCUS Center in China started in Guangzhou last year.

Zhu Heping, who is the Deputy Technological Director of Huarun's Haifeng Power, the only Chinese delegate at the EU meeting, said that the Guangdong government and its Development and Reform Commission are promoting the opportunity to become a national low-carbon pilot province, when 2×1000MW project expanded by Huarun's Haifeng plant becomes the first large-scale CCS demonstration project in Guangdong. He told a member of the EU Parliament, who was interested in the project, "If it is constructed, the project can capture 10 million tons of carbon dioxide a year. During the early stage, 50 million yuan needs to be spent on the construction of reserved interfaces and land. Under the design by Edinburgh University of UK and now the Electric Power Design Institute of Guangdong, the project is expected to implement small-scale tests in May this year."

Those participants showed interests in Zhu Heping's speech at the meeting, some of whom put forward questions and suggestions about it.

## The industrial chain of CCS

### *Capture:*

Post combustion process which captures carbon dioxide after combustion from conventional power plants.

Oxyfuel with post-combustion processes uses oxygen rather than air for combustion of fuel. It is theoretically promising, but seldom used in practice. If the pilot is successful, it can be used to compete with post combustion process on the market.

Pre-combustion process which captures carbon dioxide before combustion of conventional power is very likely to provide hybrid power, hydrogen and low-carbon fuels or raw materials.

### *Transport:*

Carbon dioxide is compressed from emission sources and then transported to storage sites. The most viable way is to transport it is with pipelines, but shipping is needed for longer distance.

### *Storage:*

The storage process involves not only the part of storing the carbon dioxide deep underground, but also monitoring to ensure there is no leakage. The most suitable storage site for CO2 is deep geological storage in depleted oil and gas wells.

### *The use for EOR (Enhanced Oil Recovery)*

An alternative use of CCS with potential benefits is for EOR. In detail, the process is to inject CO2, and to push reservoirs where it is difficult to extract oil or gas to  make them more productive wells. It is a proven process by related commercial operations and can lengthen the life expectancy of depleted wells by up to 20 years. Of course, the point that CO2 remains undispersed underground is yet to be tested in this step.

# CO2 is Buried at Sea

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In recent years, nature has suddenly turned hostile— global warming, the onset of natural disasters, sea level rise, and the flooding of islands and coastal areas—— are sending a warning to humanity.

It is therefore necessary to try to reduce the effects of global warming by mitigating CO2 emissions. After many years of research, scientists have identified a significant correlation between the presence of atmospheric CO2 concentration and rising temperature - the higher the concentration of atmospheric CO2 so too is the global temperature. Reducing the concentration of the main greenhouse gases in the atmosphere is the key to control global warming because CO2 acts likes a layer of blankets.

In addition to reducing emissions from the production of a variety of human activities, there is a need to find a way to collect CO2 emissions and then find a "new home" where they can be stored and obediently stay, rather than being directly emitted into the atmosphere.

Carbon capture and storage (CCS) is this kind of new technology, that will capture CO2 from coal-fired power plants and then bury the CO2 deep underground, in order to reduce concentrations of greenhouse gases in the atmosphere.

Reporters have learned that Guangdong is planning to build China's first carbon capture, utilization and storage demonstration projects offshore. It means that Guangdong is likely to build the first "offshore new home" of CO2 in China.

## The requirement for emission reductions

To achieve the 2050 global temperature target of no more than 2 degrees Celsius compared with the 1990 target. Countries will need to target a 50% reduction in carbon dioxide emissions. Therefore "rounding up" of carbon dioxide emissions becomes an important tool.

## Emission reduction is a huge problem, why we start with CO2?

Prof Di Zhou is a researcher and Professor of South China Sea Institute of Oceanology. In 2003, she was involved in writing “geological storage of carbon dioxide” of "Special Report on Carbon Capture and Storage" which was conducted by the United Nations Intergovernmental Panel on Climate Change (IPCC) as one of five representatives of China.

Now, when interviewed by a reporter of Nanfang Daily, she says “since it was set up in 1988, IPCC has organized thousands of experts to conduct assessment of global climate change for five times and confirms the fact that global temperatures are rising at an unprecedented rate, and this warming is mainly caused by human emissions of greenhouse gases, including the largest “contributor” carbon dioxide (CO2).

In order to avoid the insufferable disasters which are brought about by global warning, IPCC put forward “By 2050, global temperature rise should be no more than 2 degrees Celsius (compared to global temperature value in 1990).” It means that humans need to reduce 50% of CO2 emissions before this time.

According to data from the IPCC, the biggest source of global greenhouse gas emissions is the burning of fossil fuels (coal, oil and gas etc.), and the CO2 they produce occupies about 56.6% of total greenhouse gas emissions.

In China, coal accounts for nearly 70% of energy infrastructure. So experts suggest that we must “start to clean up” CO2 produced by fossil fuels, capture and store them, and prevent them from entering the atmosphere. This is known as CCS technology

and it can make fossil fuels as clean as solar energy, wind energy and nuclear energy, and achieve near zero emissions of CO2 from fossil fuels.

In 1996, Norway set out to operate the world's first CCS project in the Sleipner gas field of the North Sea. This project is able to capture approximately one million tons of CO2 per year from the recovery of natural gas, and injecting captured CO2 by metal pipes into saline and sandstone layers which is 1,000 meters below sea level. The injected CO2 is effectively sealed up, and it will not escape into the atmosphere because the layer is covered by thick and air-tight mudstones. Sleipner platform manager Helge Smaamo once said in an interview, "the annual amount of CO2 sequestered and buried here, is the equivalent of one year's emissions of 300,000 to 400,000 cars".

CCS technology has raised the attention from around the world especially from developed countries. This year, in the latest Global Carbon Capture Status Report which is released by Global Carbon Capture and Storage Institute points out that up to February 2014, there are twelve CCS projects in operation, nine under construction and thirty-three in the planning around the world, among which American projects comprise the largest number, while Chinese projects are the fastest-growing.

## To the dilemma of cost

Enterprises using CCS technology will inevitably increase their costs, but this price is paid for compared to the costs of dealing with climate warming. Without CCS, the overall cost of achieving the goal of global emission reduction would be much higher.

The article about CCS which was released in the American popular science journal Scientific American in 2006 mentions that according to conservative estimates, the future expenditure required to capture and store all the CO2 emissions from coal-fired plants for 200 years, is about $1.8 trillion, accounting for 0.07% of the world total. According to 2013 International Energy Agency (IEA) report, from now until 2050, the deployment of 3,400 CCS projects will cost from $2.5 trillion to $3 trillion.

## How to interpreter these numbers?

Prof Di Zhou explains that seemingly costly, compared to other energy saving and emission reducing technologies such as biomass, wind and geothermal etc., CCS is not the highest. “People have said that cost increases. It should be understood that enterprises’ costs increase when it adopts the CCS technology compared with previous costs. But studies show that the coal-fired power plants which use CCS technology will be competitive in cost when the carbon price rises to 200 to 300 yuan.”

The International Energy Agency’s report in 2009 pointed out that to achieve the target of halving global greenhouse gas emissions in the process, CCS technology will undertake about 19% of the emissions reduction, next to another two important technologies: improving terminal fuel utilization efficiency (24%) and use of renewable energy (21%). If CCS technology does not work, the overall cost to achieve this goal will soar by up to 70%.

But early application of CCS will always require a large investment. However, China, the US and other countries hope to focus on the “U” (utilization) on the basis of CCS, namely carbon capture, utilization and sequestration (CCUS), by making use of CO2 to offset part of the costs.

“The largest-scale CO2 use requires injection of CO2 into oil or gas fields for enhanced oil recovery. What’s more, captured CO2 can be also used in chemical industry, building material and bio-diesel. But Prof Di Zhou speaks bluntly that CO2 can only be used this way by accounting for a small part of total human emissions. To achieve the target of emission reduction mainly depends on CO2 sequestration.

The large-scale, commercial CCUS operation is expected to appear in 2030, so scientists have proposed methods to reserve CCUS. From now on, when designing and constructing new fossil fuel power plant, the transformation of the space must be reserved for CCS so that future applications can be realized at low cost CCUS.

### The confusion of safety

If emitted, high concentrations of CO2 will make livestock suffocate. However, evidence suggests that, as long as there is strict compliance with norms of siting, construction and operation, CO2 can be safely stored deep underground without leaking.

## People might ask is it safe to sequester CO2 underground?

Experts introduce that CO2 is not flammable, so it is relatively safer than natural gas which is flammable, but sequestration of CO2 suddenly leaking from the underground and gathering in considerable concentration, will bring a choking hazard: when CO2 concentrations exceed 4% (i.e., more than 100 times the current air concentration of CO2), headaches and shortness of breath and other symptoms will appear within a few minutes; when CO2 concentrations exceed 17%, it will lead people to become unconsciousness, fall into a coma and even death within one minute.

But Prof Di Zhou believes that the possibility of large-scale leakage of CO2 from a storage place is very small. This is because the storage requirements of the site are at least 800 meters deep underground in rock formations, the above must be covered by airtight shale, and away from the active faults and earthquake-prone areas. As long as the underground injection of CO2 strictly complies with regulations, the leakage can be completely avoidable.

She also gave some examples: The US has injected CO2 into underground for forty years for the purpose of enhanced oil recovery. Europe usually stores natural gas, which is more dangerous than CO2, in underground rock formations, even in a sealed place in the center of the German capital of Berlin, and these projects have not resulted in any serious accident.

## Exploration in Guangdong Province

Now, CCUS has been in the list of “the twelfth five years plan” to control greenhouse gas emissions and strategic emerging industries catalogue, National Development and Reform

Commission has issued a notice to promote CCUS test demonstrations, thus the rapid development of CCUS in China has received the attention of the world.

But up to now, the large-scale CCS projects which have been built, are under construction and plan to be built lie in the North, only a few of them lie in Yangtze River areas, and the southeast of China is empty.

Reporters have known that as the only low-carbon pilot province in the southeast of China, Guangdong has already upgraded pilot demonstrations of CCUS to a low-carbon strategic height. Since 2009, our province in collaboration with the UK, has affirmed the necessity and feasibility of development of CCUS and proposed a roadmap of CCUS. In 2013, the Governor of Guangdong Province Zhu Xiaodan visited Britain, signing a Memorandum of Understanding with the British, and establishing the Sino-British (Guangdong) CCUS Industrial Promotion and Academic Exchange Center.

As Secretary-General of Guangdong CCUS center and Associate Professor of the University of Edinburgh Liang Xi said the growth of energy consumption is still speeding up with the rapid development of the economy. The province is the country's leading position in nuclear energy development, but to achieve the GHG target reduction, the application of CCS technology in large emission industries such as thermal power plants is imperative; the primary task is actively preparing to build the Guangdong Province's first CCUS demonstration project.

What the reporters know of the latest situation is that China Resources Haifeng Power Plant in Guangdong has decided to undertake the task of building a carbon capture demonstration project. The chief technology officer of China Resources Haifeng Power Plant Zhu Heping said that “We hope that at the end of this year Unit One and Unit Two can be constructed and invest 40 million yuan to build a CCUS research platform, open to world scientists. At the same time, according to a "Strategic Cooperation Agreement" which was signed by Guangdong provincial government and the China Resources Group, Unit Three and Unit Four in China Resources Haifeng power plant are

listed as Guangdong Province CCUS demonstration units, and are applying for inclusion in a national CCUS demonstration project."

## Where does CO2 sequester after it is captured?

"Our previous studies indicate that Guangdong Province lacks geological conditions for CO2 sequestration and it is densely populated land and is short of land, so it is not suitable as a CO2 sequestration site. However, the northern South China Sea's Pearl River Mouth Basin near Guangdong Province has good geological sequestration of CO2 conditions and huge storage potential." Prof Di Zhou (South China Sea Institute of Oceanology, SCSIO) points to the map and says that "Compared to a lot of low porosity and permeability onshore basins in China, the Pearl River Mouth Basin's sealed geological conditions are much better, and there are no land acquisition issues, potential risks damaging the environment and pollution of groundwater is also smaller."

But Zhou speaks bluntly that compared to onshore geological storage, the cost of undersea geological storage is much higher, so we need to make a more comprehensive plan. She attests that undersea geological storage, the whole CCUS demonstration project in Guangdong province, is different from other regions. Due to China's southeast coastal provinces not having the same geological conditions onshore storage like Guangdong Province, Guangdong Province takes the lead in the construction of undersea geological storage demonstration projects and will play an important role in the development of CCUS globally.

What's more, the development of CCUS must receive the support of the public. The Sino-British (Guangdong) CCUS Industrial Promotion and Academic Exchange Center recently cooperated with Nanfang Daily Press Group and other institutions to distribute a questionnaire to investigate various opinions about CCUS technology and CCUS projects developing in Guangdong Province.

## Noun Explanation

Intergovernmental Panel on Climate Change: IPCC is an intergovernmental agency which is jointly constructed by World Meteorological Organization and United Nation Environmental

Programme. Its major task is to make an assessment of research status, potential impact and countermeasures of climate change.

International Energy Agency, Carbon Sequestration Leadership Forum and Global Carbon Capture and Storage Institute are three major agencies which are responsible for researching and developing CCS technology, and our countries has a share in these three big agencies. (Links China)

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