

Enabling the Legal and Regulatory Framework for Large-scale Carbon Capture, Utilisation and Storage (CCUS) Projects in Guangdong, China

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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



Founding Members



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Executive Summary

China contributes more than a quarter of global anthropogenic greenhouse gas emissions. Fossil fuel supplies more than 80% of primary energy in China and coal contributes two thirds. Carbon capture, utilisation and storage (CCUS), as the only technology to decarbonise fossil based energy, is therefore important for China's transition to a low-carbon economy.

China has piloted and demonstrated CCUS technologies in the last decade, but the development of a legal and regulatory framework is still lagging behind major developed economies (such as the EU, US, Canada and Australia). Guangdong is one of the most developed provinces and one of five pilot low-carbon provinces in China. The province is keen to demonstrate CO₂ capture, transportation, utilization and offshore storage technologies at large-scale. However, in the absence of a legal and regulatory framework at both national and provincial levels, it will be a challenge to provide the regulatory certainty and assurance needed for the successful commercial deployment of CCUS in the province.

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- Establish a formal full-chain CCUS project permit application, authorisation, and issuance process, and develop a process to certify project completion. To facilitate this, the government may adopt the regulatory test tool kit developed by GCCSI and the Scottish Government (2011: 14) to formulate a regulatory table relevant to China;

- Establish a regulatory framework designed specifically for whole-chain CCUS projects. To do this it may be more efficient to adapt existing laws where relevant, and to pilot the regulatory regime at a provincial level (for example in Guangdong) for the first few large scale demonstration projects.
- Clearly identify and define the responsibilities of the various regulatory departments throughout the lifecycle of a demonstration project, from permitting of the capture plant, to post-closure of the CO₂ storage site. The first few demonstration projects should adapt existing regulatory frameworks where possible, and those regulations may be tightened up as knowledge is gained from early demonstration projects.
- Establish a CO₂ storage permit management system, including a formal procedure to apply, issue, change and cancel permits, to ensure CO₂ is stored safely and reliably, and that monitoring measures are in place;
- In relation to CO₂ storage, explicitly define and regulate the liabilities of the operator throughout the operating, closure and post closure phases of the storage site. Clearly define when and under what conditions liabilities can be transferred from the operator to the government. The definition and management of CO₂ storage related liability and transfer is critical in securing successful investment in and operation of a CO₂ storage project.
- Define what security (e.g. guarantee or bond) a storage site operator needs to post against the liabilities incurred as above. Financial security for CO₂ storage has not been explicitly considered in the current environmental liability framework in China. A requirement to give security should incentivise the storage site operator to adopt the best practice for risk mitigation. However, in order to encourage project development and investment, the State and/or Guangdong province should still be responsible for those additional and very long term risks which commercial companies are not normally capable of carrying.
- An integrated CCUS project communication scheme should be established to ensure successful communication with the public and key stakeholders, to increase the likelihood of acceptance by the public.

- Health and safety measures and a best practice framework related to handling CO₂ should be adapted from a related industry/foreign practice or if necessary developed new; and CCUS projects and regulators need to put in place measures to protect the health and safety of the public and assess and approve emergency plans before the project is authorised.
- Guangdong should follow up on the capture ready demonstration project based on China Resource Power's Haifeng plant, and institute a policy that all new large point sources of CO₂ should be built with capture ready design.
- CO₂ transport and storage infrastructure developed should be open for other industry CO₂ sources and capture ready power plants, through enabling a third party access regulation.
- The National and/or Guangdong provincial government must establish dedicated financing measures for early large-scale demonstration projects (such as government subsidies, concessional tax, concessional loans, public funds) to encourage private capital to invest in CCUS demonstration projects, before carbon emission trading or other carbon pricing systems are mature.
- Collaboration with Hong Kong is a key task highlighted in the medium- to long- term development plan in the Pearl River Delta (GDPG, 2009) that could be turned into an opportunity for financing CCUS projects.

Section 1

Introduction

1.1 Introduction to the Report

Since 2010, institutes in Guangdong and UK have conducted a feasibility study on CCUS technologies in Guangdong and formulated a roadmap for deploying CCUS in the province (GDCCSR, 2013). In 2013, these institutes jointly established the UK-China (Guangdong) CCUS Centre (GEDI, 2013). The core goal of the Centre is to develop large-scale CCUS demonstration projects in South China.

Even though a large number of pilot scale CCUS projects are operating in China (Zhang, 2013), there were very few comprehensive studies on CCUS regulatory frameworks to support the deployment of large-scale demonstration projects in China (Hart and Liu, 2010; WRI, 2010). It is now urgent to review existing CCS policy and legal frameworks in China and in the UK, and to identify gaps for future development. The objective of this report is to provide CCUS project developers, government officials in China and wider stakeholders with an objective overview of the current legal and regulatory environment for developing CCUS projects.

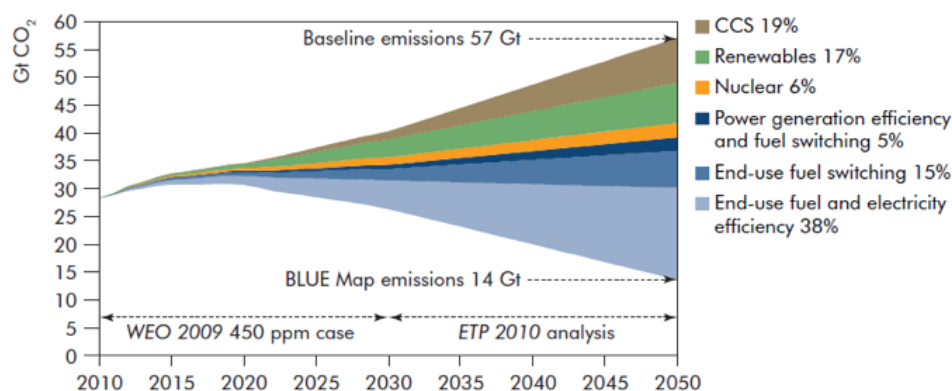
Section 1 of the report will set out a brief review of the role of CCUS in emissions reduction, CCUS technologies, and the CCUS project life cycle. Section 2 reviews the regulatory framework in the European Union and the UK. Section 3 reviews China's legal system and existing laws and regulations which are relevant to CCUS. Section 4 identifies the current legal and regulatory environment for potential CCUS projects in China. Section 5 gives policy recommendations for key stakeholders.

1.2 The Role of CCUS in Emission Reduction

Both the United Nations Intergovernmental Panel on Climate

Change and the International Energy Agency (IEA) considered CCS as one of the key low carbon technologies required to stabilise atmospheric greenhouse gas concentrations at the level consistent with limiting the global projected temperature rise to 2°C by 2050. As shown in **Figure 1.1**, the IEA (2010: 47-48) estimates that CCS technologies could contribute up to 19 per cent of least-cost emissions reductions by 2050; if CCS is excluded as a carbon abatement option, the cost for carbon reduction could increase by 40 per cent from 2010 to 2050. CCS is of great importance in decarbonising the fossil fuel dominated energy sector in China, and past studies have confirmed that more than four fifths of large point sources are within 50 miles of potential storage sites (Dahowski et al, 2009: 5.2).

Figure 1.1 Key Technologies for Reducing CO₂ Emissions under the IEA Blue Map Scenario (IEA, 2010)



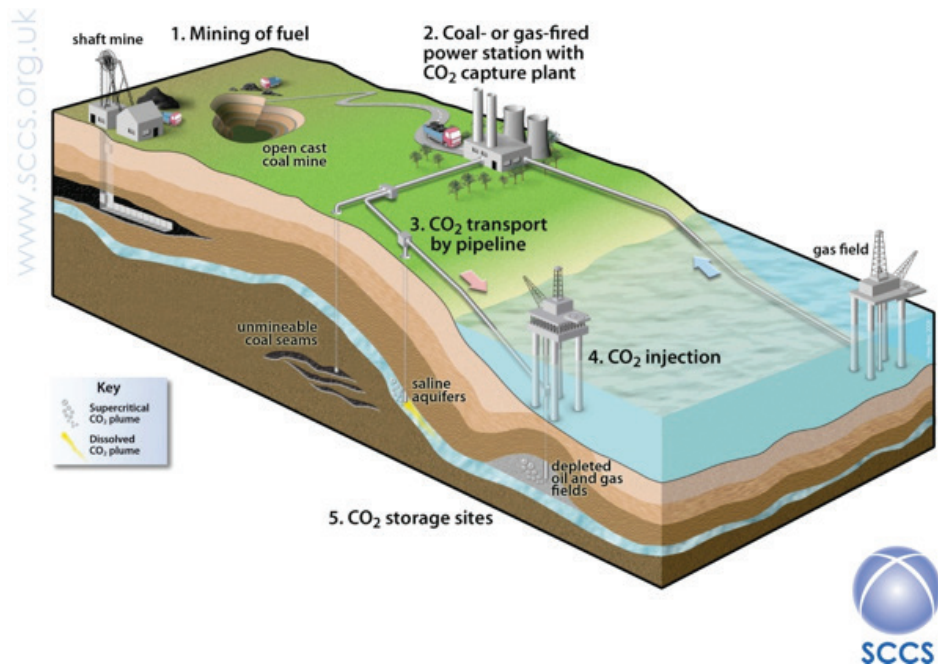
1.3 CCUS Technologies

CCUS is a greenhouse gas emission control technology with three major processes: capture, transportation, utilisation and/or storage of CO₂, as illustrated out in **Figure 1.2**:

- i) Capturing CO₂ from stationary emission sources (e.g. power, cement, natural gas processing, refinery and steel plants),
- ii) Transporting CO₂ to a potential storage site (e.g. by pipeline or by ship) and
- iii) Injecting CO₂ into geological formations deep underground (e.g. depleted oil and gas fields, saline aquifer formations 1-3km beneath the earth's surface) for secure storage or CO₂ geological utilisation¹.

¹ CO₂ could be utilised for food and industry processes but the demand is minor compared to the total emissions. The abatement costs for most chemical utilisation technologies are very high compared to CO₂ geological storage or geological utilisation.

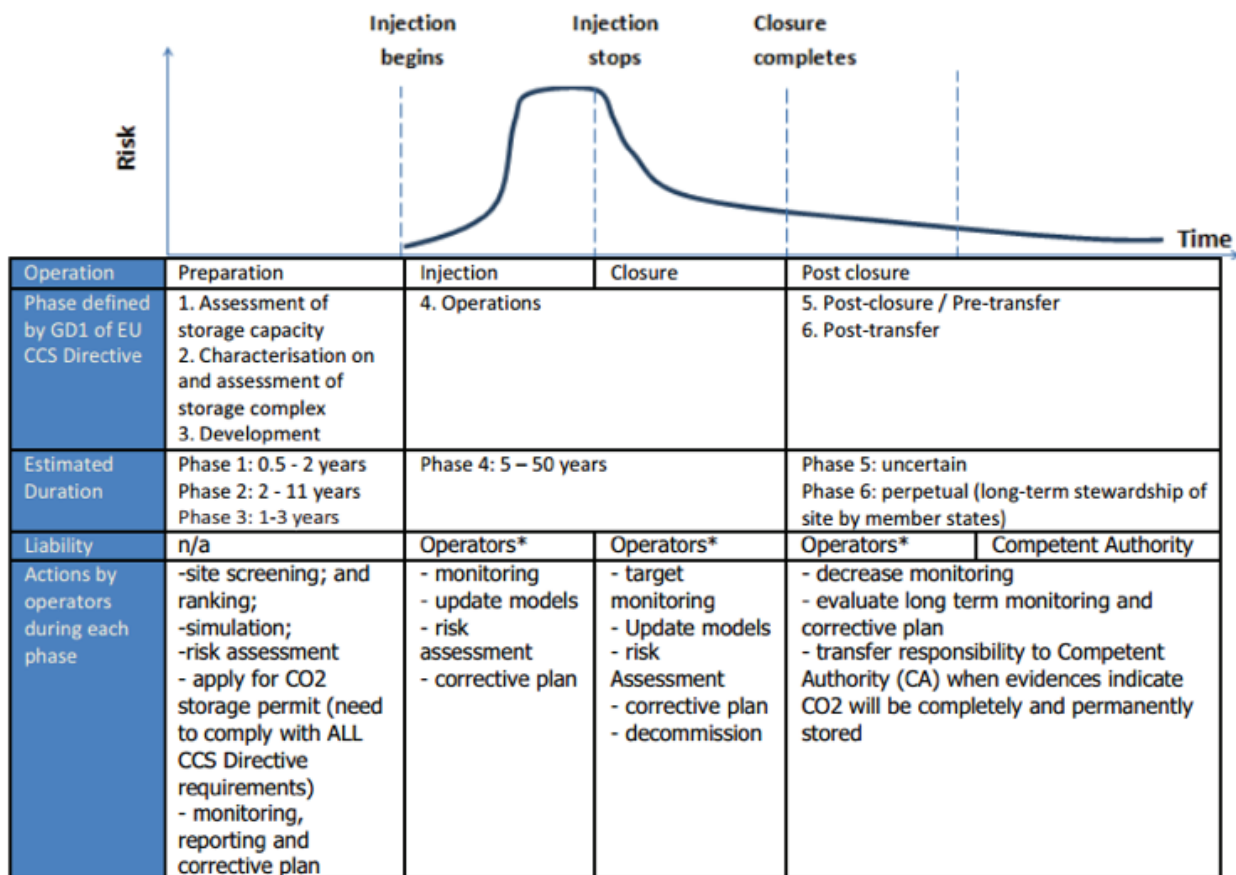
Figure 1.2 Systemic Diagram of CCUS Technologies (SCCS, 2014)



1.4 CCUS Project Lifecycle

The CCUS project development lifecycle can be classified into 5 stages (as illustrated by GCCSI, 2014: 7), Identify, Evaluate, Define, Execute and Operate. The lifecycle of a CO₂ storage project could be divided into six phases: Assessment; Characterisation; Development; Operation; Post-closure / Pre-transfer; Post transfer (EC, 2009: 8), as illustrated in **Figure 1.4**. The final investment decision (FID) will usually be made right after the Define stage. In China, FID is sometimes made after government approval, but just before the detailed definition of a project. Globally, there are 21 large-scale integrated projects (LSIPs) in the Execute or the Operation stage (GCCSI, 2014: 7). However, none of the existing LSIPs with FID is located in China. There are however at least 6 projects at the Design Stage, and consequently it is urgent to adopt and formulate a suitable regulatory framework for CCUS projects in China, before these projects reach the Execute stage.

The central discussion on CCUS regulatory issues focuses on CO₂ storage-related law and regulation, such as the permitting system, the injection process, and the long-term liability of CO₂ storage pre and post closure (Wilson et al, 2009; Morgan and McCoy, 2012). The lifecycle of a CCUS project could also be assessed based on the development of a CO₂ geological storage site (as illustrated in **Figure 1.4**), including Preparation, Injection, Closure and Post-closure. In the EU context, the CO₂ storage project operator needs to



* Member state of the project will be liable for CO₂ storage obligations in an event of operator default.

Figure 1.4 Illustrative Diagram of the Lifecycle and Risk of CO₂ Leakage for a Typical CO₂ Storage Project in Europe (ClimateWise, 2012: 27; EC, 2009)

comply with all EU CCS Directive requirements in order to apply for a CO₂ storage permit (EU, 2009).

The preparation process should include four stages: (a) storage site selection, (b) storage capacity assessment, (c) site characterisation, and (d) site development. The time required for site selection obviously depends upon distance from source, ease of access for transport of CO₂ and availability of geological data on the potential site, and is indeterminate. The storage capacity assessment might usually take 0.5 to 2 years; the site characterisation period varies and can take a minimum of 2 up to 11 years. The storage project development takes another 1 to 3 years. Therefore, a minimum of at least 4 years is needed to secure a CO₂ storage permit in the EU. The process could be shorter if a CO₂ storage site has been well understood through existing knowledge and data in oil and gas field exploration and development activities. CO₂ storage operators also need to manage competing interests in hydrocarbon production, and manage activities in lateral and vertical different geological layers.

During the CO₂ injection and well closure process, CO₂ storage

operators conduct a risk assessment, are responsible for monitoring, and carry the liability to ensure the secure storage of CO₂. Operators also need to implement corrective measures, if CO₂ leakage or other accidents take place. In the current EU CCS regulatory framework, the CO₂ storage liability will be transferred to the nation when there is evidence indicating that the CO₂ will be completely and permanently stored. Clearly the time needed to be confident of this will vary from site to site, but could require a minimum of 20 years. The CO₂ leakage risks accumulate as the pressure of CO₂ in storage site increases, but the actual overall project risk could be at the highest at the CO₂ injection beginning point when the integrated system, including the capture plant, transportation system, and CO₂ storage site are being tested and proved.

Section 2

Review of the CCS Regulatory Framework and Financial Incentives in the EU and the UK

2.1 Europe-wide CCS Regulation

The main regulatory framework for CCS in Europe is the EU CCS Directive on Geological Storage of Carbon Dioxide (Directive 2009/31/EC). The Directive came in force on 25 June 2009. Each EU Member State must transfer the terms of the Directive into its own laws (for example, the UK adopted the terms in the 2008 Energy Act), but they can put their own interpretation on liability issues (Seitz and Schon, 2010).

A developer of a CCS project in any EU member states must follow the provisions of the Directive. The Directive establishes a legal framework for safe geological storage of CO₂, financial security for the operation of CO₂ injection, selection of storage site², and obligations during the operation, closure and post-closure stages of a project (as illustrated in **Figure 1.4**).

² Article 4 of EU CCS Directive

The major benefit of CCS is that it achieves deep cuts of carbon emissions from fossil fuel plants. The EU Emission Trading Scheme was designed as one central instrument to incentivise greenhouse gas emission reduction. The EU Emission Trading Directive (Directive 2003/87/EC) came in force on 25 Oct 2003. It was amended in 2009 to include CCS in the Emission Trading Scheme (Directive 2009/29/EC). The amended EU Emission Trading Directive explicitly excludes any captured, transported and stored CO₂ from the definition of CO₂ emitted to the atmosphere.

According to the above Directives, EU allowances (EUA) must be purchased and surrendered to cover any CO₂ which leaks or escapes from the storage complex. CO₂ storage operators are also required to prove their financial security prior to receiving the CO₂ injection permit. As the operational lifecycle of a CO₂ storage project (from injection to post-closure) could take more than 30 years, the uncertainty in future EUA prices poses significant regulatory

risks and ambiguities for CO₂ storage operators to fulfil their upfront financial security requirements. Although the CCS Directive is often considered onerous and to be ‘creating new challenges’ by CCS project developers in Europe, it may still be a good approach to consolidate regulatory fragmentation into a unified CCS legal framework (Qin, 2013). CO₂ storage operators are required to submit the CO₂ storage permit application to the State Government, who will then commission the issuance of draft permits. As an example in Europe, the European Commission (EC, 2012) has replied with a positive opinion for a CO₂ storage project in Netherlands.

2.2 CCS Policy & Regulation in the UK

As set out above, the CCS Directive was implemented in the UK through the Chapter 3 of Energy Act 2008³. In 2009, Section 36 of the UK Electricity Act 1989 was amended to implement the CCS Directive requirement that all power plants over 300MW net electricity generation installed capacity must be constructed in CO₂ capture ready (CCR) design. In addition, the UK Government implemented a policy requiring any new coal-fired power plant built in England and Wales to demonstrate full-chain CCS at commercial scale on at least 300MW of its capacity (CCSA, 2014).

The seabed in UK territorial waters is managed by the Crown Estate. All offshore oil and gas and pipeline development activities which cross the seabed require consent from the Crown Estate, and this is also the case for CO₂ transport and storage sites. There is no specific CO₂ pipeline regulation in the UK. According to UCL LP (2014), onshore and offshore legislation for CO₂ pipelines could be covered by the existing pipeline safety regulation⁴. However, as common access to pipeline infrastructure is important in developing a CCS cluster, the UK has amended the rights of third party access rights of way to ensure capital investments in pipelines are not stranded (DECC, 2012).

The UK completed the regulation for the licensing progress for CO₂ storage in 2010.

Finally, the health and safety regulations for all projects in the UK, including CCS, are regulated by the Health and Safety at Work etc. Act 1974.

³ Article 17 to Article 35: Chapter 3: Storage of Carbon Dioxide of Energy Act 2008.

⁴ Pipeline Safety Regulations (1996)

2.3 CCS Financial Incentives in the EU and UK

European Union funding for low-carbon demonstration projects, including CCS, is mainly provided through the NER300 system which is an “add-on” to the European Emission Trading Scheme (EU-ETS). CCS projects can also bid into general EU research and innovation programmes.

2.3.1 NER300.

To provide funding for low carbon technologies, in December 2008 the EU agreed to set up the “NER300” funding scheme, managed jointly by the European Commission, European Investment Bank (EIB) and Member States. The NER300 is so called because it is funded from the sale of 300 million emission allowances from the new entrants' reserve (NER) set up for the third phase of the EU ETS (EC 2014). Funds from NER300 are being distributed to projects (originally envisaged to be about 8 CCS and 34 renewable energy projects) selected through two rounds of calls for proposals.

Under the first call in December 2012 the European Commission made funding awards for a total value of €1.2 billion to 23 renewable energy projects. However, none of these were for CCS projects. The second call was launched on 3 April 2013. Although 33 project proposals were submitted by the deadline, only the White Rose (Oxyfuel) CCS Project remains in the running, and is likely to be awarded in principle in the mid of 2014. The White Rose project has also been awarded money by the UK Government under the UK CCS Commercialisation Competition (see below). To have the funds available to support the successful projects, in the April 2014 auctioning round, the EIB sold 10.25 million EU emission allowances. (GCCl 2014)

2.3.2. Horizon 2020.

The EU's current research and innovation funding programme is Horizon 2020, which has replaced the previous series of research and innovation funding initiatives. Horizon 2020 makes Euro 80 billion available over 7 years (2014 to 2020) and the first call closed in April 2014. Though Horizon 2020 is intended to cover all areas of European research and innovation, it can include CCS research. (Horizon 2014)

2.3.3. Financial Incentives in the UK

CCS funding in the UK has experienced changes over the last decade. In 2010 the government announced a levy of 2% on future

energy bills to help fund CCS demonstration projects. However, in the face of a deepening recession, this policy was reversed in 2011, and the government stated that future funding for CCS would come out of general taxation. UK funding for CCS is now centered round two initiatives, and deployment of CCS will be facilitated by recent reforms to the UK electricity market, including a potential contract for differences (CfDs) mechanism for CCS.

CCS Commercialisation Competition

The UK CCS Commercialisation Competition makes available £1 billion capital funding to support the design, construction and operation of the UK's first commercial-scale CCS projects. The current competition opened in April 2012, and closed in July 2012. Four full chain (capture, transport and storage) projects were shortlisted in October 2012. On 20 March 2013 the government announced two preferred bidders, who in December 2013 and February 2014 were awarded multi-million pound contracts to undertake Front End Engineering and Design (FEED) studies. (Gov UK 2014).

The two projects awarded funding are the Peterhead CCS Project and the White Rose CCS Project.

The Peterhead CCS Project is in Aberdeenshire, Scotland. This project involves capturing 1 million tonnes CO₂ pa from an existing CCGT power station at Peterhead, for transporting offshore and storing in the Goldeneye depleted gas field 2.5km beneath the North Sea. The project is the world's first planned CCS project on a gas power station.

The White Rose CCS Project is in Yorkshire, England. This project involves capturing 2 million tonnes CO₂ pa from a new oxyfuel coal-fired power station at the Drax site in North Yorkshire, and transporting offshore to store in a saline rock formation beneath the North Sea. The proposal also includes the development of a CO₂ transport and storage network – the Yorkshire Humber CCS Trunkline – which will have capacity for additional CCS projects in the area.

Following the FEED studies, in late 2015 the companies will take final investment decisions with the government taking decisions shortly after on proceeding to the the constructions of the projects, with expectation to start operation in 2020.

CCS Research and Development

The UK has a 4-year (2011-2015) £125 million cross-government

CCS research, development and innovation programme. It covers:

- £62million to support fundamental research and understanding
- £28million to support the development and demonstration of CCS components and next generation technologies (such as turbines or new solvents to capture the carbon dioxide)
- £35million for pilot scale projects to bridge the gap between research and commercial scale deployment

In total, over 100 separate projects are being funded through this programme (Gov. UK 2014).

UK Electricity Market Reform

In common with all low carbon technologies, CCS could not be rolled out across the UK without reform of the electricity market. Consequently, in 2012 the government embarked upon a process of market reform. The new Energy Act, passed in December 2013 includes the main elements of the Electricity Market Reform (EMR). In relation to CCS, the main benefit will be the provision of “Contracts for Difference” (CFDs), long-term contracts to provide stable and predictable incentives for company low carbon technologies. On 23rd April 2014, the government confirmed the approval of the first 8 CFDs (all for offshore wind farms). It is anticipated that these will cost up to £1billion pa in subsidies, equating to an increase on typical household electricity bills of 2% in 2020 (BBC 2014).

The UK mechanisms to support CCS are summarised in the following table:

Table 2.1 Mechanisms to Support the Delivery of Cost-competitive CCS in the 2020s in the UK (based on CCSA, 2014)

Mechanism	Summary Action
Grant Support	Provide £1 billion in capital funding for CCS demonstration projects
R&D and Innovation Programme	Provide a 4-year, co-ordinated R&D and innovation programme for establishing a new UK CCS Research Centre
Operational Support	Develop CCS specific contract for differences (CFDs) mechanisms and adopt a carbon floor price (a tax) approach.
Intervention	Provide intervention to address key barriers to the deployment of CCS
Emission Performance Standard	A 450g CO ₂ /kWh emission performance standard was set for power generation. New built coal-fired power plants are required to be built with CCS to meet the standard.
International Collaboration	Facilitate international collaboration and encourage knowledge sharing

2.4 CCUS Related International Conventions

As illustrated in **Table 2.2** below, CCUS related international conventions could be classified into two categories: (a) conventions to drive greenhouse gas emission reduction such as ‘United Nation Framework Convention for Climate Change’ and the ‘Kyoto Protocol’; (b) conventions related to CO₂ offshore storage, such as ‘London Convention’ and the United Nations Convention of 1982 on the 1972 Law of the Sea (UNCLOS). Discussions on involving CCS in the clean development mechanism (CDM) started in 2005 (Dixon, 2009). CCS was included in the CDM in the Cancun COP-16, but there are still challenges to resolve such as the CO₂ storage liability.

Table 2.2 CCUS Related International Conventions (IEA, 2012: 24; IMO, 2009; IMO, 2012; OSPAR, 2007a; OSPAR, 2007b)

⁵ Article 1(4) of UNCLOS

Convention Name	Entry Into Force	Summary	Year Ratified by China
Kyoto Protocol	16 Feb 2005	Promote R&D of CO ₂ sequestration technologies; Encourage collaboration, in development, promotion and transfer of CCS technologies	2002
United Nations Convention on the Law of the Sea	16 Nov 1994	Regulate all seas and ocean activities, incl. potential pollution of the marine environment ⁵ . UNCLOS does not specifically prohibit CCS, but some of its provisions could have an impact if the CO ₂ was deemed to be “pollution”. A clarification could resolve the issue, but one is not currently on the agenda of the parties thereto.	1996
London Convention (LC) / London Protocol (LP)	30 Aug 1975 (LP)	The revised convention allows CO ₂ offshore storage in geological structures. The LP amends the LC for those countries which have ratified it. In 2007 it was amended to allow the storage of CO ₂ in sub-seabed geological formations. Cross border CO ₂ transportation is still not allowed.	2006
OSPAR Convention	25 Mar 1998 ((amended in 2007 to allow geological storage of CO ₂	Provides more detailed rules for CO ₂ offshore storage, incl. the content of CO ₂ streams Forbids CO ₂ storage in sea water. The amendment to enable sub-sea bed injection of CO ₂ is formally enabled under the convention and came into force in Jul 2011.	N/A

Section 3

Background to China's Legal System, and Laws and Regulations of Relevance to CCUS

3.1 China's Legal System and Energy Institutional Framework

China's governance structure was established in 1949 when the country was founded. The development of the legal system and laws accelerated in the 1980s and 1990s when the country adopted the reform and open policy. The National People's Congress (NPC) is the authority which issues laws which are binding across the nation. Because the National Assembly meets infrequently, the Standing Committee of the NPC (SCNPC) exercises power to interpret the constitution, formulate and revise laws, and to appoint top government and judicial officials. The State Council, on behalf of the SCNPC, is responsible for the day-to-day operation of government. Within the NPC, there are nine professional committees, one of which, the Environment and Natural Resources Committee plays an important role in formulating, revising and interpreting environmental statutes and laws.

A large number of institutions share the responsibility of making policy and authorising decisions for large-scale CCUS projects in China (as illustrated in **Figure 3.1**). The State Council, NDRC, and provincial and municipal development and reform commissions are considered as key organisations in permitting large CCS projects in China (Reiner and Liang: 26). The Climate Office in NDRC and Provincial DRCs are both likely playing important roles in promoting CCUS demonstration programmes in China. However, the Environmental Protection Law⁶ requires that the local environmental standard or regulation must be more stringent than the national standard or regulation. In addition, local government could formulate its own regulation for specific environmental items not specified in the national regulation or law. The latest institutional reform in China requires provincial and municipal government play a more important role in project authorization process.

⁶ Article 10 of Environmental Protection Law (NPC, 1989).

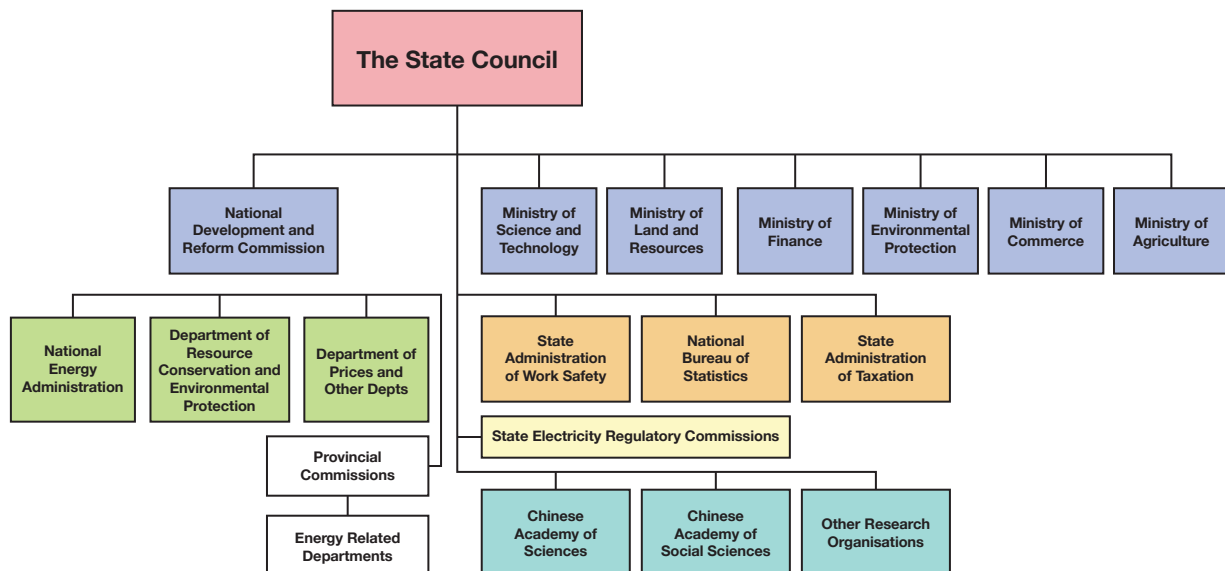


Figure 3.1 Organisations involved in energy policy and project decision making process in China (Reiner and Liang, 2009: 25)

Consequently a full-chain CCUS project will be subject to the policy of, and be authorised, by individual province. It then needs further and final authorisation by the State. The authorization process will be subject to that national and provincial low carbon policy, environmental laws and standards, including any specific low-carbon development plan and environmental legislation unique to that province.

3.2 Review of Existing CCUS Related Laws, Regulation and Policies

Although the Chinese National Development and Reform Commission, NDRC (2013) has released policy support for CCUS demonstrations, there are not yet any dedicated laws established to ensure the legal and commercial certainty for the development of large-scale CCUS projects in China. However, the WRI (2010: 6) study indicated that China already has a portfolio of basic laws on which effective CCS regulatory framework could be established. This report reviews potentially adaptable laws and regulations for CCUS projects⁷, and will cover CCUS projects related law and regulation at both national and provincial levels. In addition, the report also reviews the current policies that could impact the development of CCUS projects in China.

⁷ The study learns from existing papers such as de Doninck et al (2009) on CCS under EU and International laws.

Section 4

CCUS Related Law and Regulation in China

Establishing a comprehensive and competent regulatory regime for large-scale CCUS projects will require clear definitions of a few key issues, such as the overall institutional structure, the ownership, and the legal liability. Currently, no dedicated regulatory framework has been established for CCUS in China, but the country has a portfolio of existing laws that may be adapted or amended to meet the requirements in developing large-scale CCUS projects.

The analysis in the study covers the regulatory framework in relation to:

- Definition of CO₂ and access to surface and sub-surface
- Decommissioning
- Health Safety and Environment in relation to CO₂ capture, transport, storage and utilisation
- CO₂ storage liability (leakage, remediation, decommissioning and monitoring)
- Monitoring of storage sites
- Intellectual Property Rights
- Incentivisation Policies
- Project Authorisation Processes

4.1 Definition of CO₂ and Access to Surface and Sub-surface

4.1.1 Definition of CO₂

⁸ Article 18, 22 30, 31, 41, 43 and 45 specified major pollutants such as 'SO_x', 'NO_x', 'Ash' and radioactive waste. Law on Prevention and Control of Air Pollution (NPC, 2000a)

Similar to other South East Asian countries (ADB, 2013: 82), the Chinese Law on Prevention and Control of Air Pollution⁸ does not consider CO₂ as a pollutant. This is because the classification of CO₂ came later than the operation of large scale CO₂ transport and storage projects (e.g. CO₂ EOR in the US) (Parfomak and Folger, 2013). A consistent definition and classification of CO₂ is important for successful deployment of CCUS technologies, otherwise CO₂ might be considered a pollutant in one jurisdiction but not in another, making widespread deployment of CCUS, and cross border CO₂ transport more difficult. In addition, there is a lack of legal definition and understanding on the ownership of CO₂ during the different stages of a CCUS process.

4.1.2 Access to Surface and Subsurface

There is no specific law regulating the granting of surface and subsurface rights (either onshore or offshore) or the lease of land for CO₂ storage in China. All land in municipal districts is owned by the State. Apart from specific land owned collectively in rural areas, all other land is owned by the State⁹. Project developers of CCUS projects in China will only have the surface land usage rights.

⁹ Article 2 and 4. Land Administration Law of PRC. (NPC, 2004a)

The surface and subsurface rights have significant impact on CCUS projects, because CO₂ geological storage projects will require long-term access to surface and sub-surface space. The property rights law enacted in 2007 in China defines ownership of the subsurface as belonging to the State and also specifies that the usage rights of land can be established based on the surface, above surface and subsurface¹⁰. The water law specifies that underground water resources are owned by the State¹¹. The subsurface in the seas in China is defined as a part of Sea Areas, owned by the State (NPC, 2001). The State Council (2011) specifies that all resources in the subsurface are owned by the State. The right of land usage for industrial use is 50 years. There is no specification for the water usage right of the subsurface in China, but the oil and gas, mineral mining, and water usage rights obtained through a legal process are protected by the Property Right Law (NPC, 2007a)¹².

¹⁰ Article 136, Property Rights Law (NPC, 2007a)

¹¹ Article 2 and 3, Water Law (NPC, 2002a)

¹² Article 123, Property Right Law (NPC, 2007a)

4.1.3. Decommissioning of Offshore Equipment

The decommissioning activities of an offshore CO₂ storage project (including CO₂ marine pipelines to the site) would need to meet the regulation to prevent marine environmental pollution by offshore engineering activities (State Council, 2006).

4.2 Health, Safety and Environment (HSE) Regulations

China has established environmental regulations for reducing the environmental impact during the plant construction and for controlling air and water pollution at the plant operational stage. In addition to HSE issues in conventional power plants, a CO₂ capture unit may generate new pollutants such as degraded amine products from the MEA process (Nurrohkmah et al, 2013). Any proposed CCS project will be required to pass an environment impact assessment (EIA)¹³. Occupational safety and plant safety management has become a prioritised issue for local governments and it is now closely assessed by government officials¹⁴.

¹³ Article 16 of the Environment Impact Assessment Law of PRC (NPC, 2002c)

¹⁴ For example, highlighted in Article 8 of Opinion on further strengthen safety production work (GDCPSC, 2011)

The Ministry of Environment Protection (MEP, 2013) released a notice designed to enhance environmental protection activities for CCUS pilot and demonstration projects. The notice outlines key environmental uncertainties in the CCUS process (as illustrated in **Table 4.1**). This section (4.2) will elaborate how the existing legal and regulatory framework may regulate the HSE aspects of CCS projects in China. However, the notice doesn't specific any potential environmental uncertainties for offshore geological CO₂ storage.

Table 4.1 Environmental Uncertainties in the CCS Process Listed by China's Ministry of Environment Protection (MEP, 2013)

Process	Environment Uncertainties
Capture	Impact on conventional air pollutants; Pollution by waste solvent
Transport	Accidental leakage damaging ecological environment and human health and safety
Storage	Incorrect site characterisation causing seepage or significant leakage that induces underground water pollution, soil acidification, biodiversity and ecology damage

4.2.1 HSE Regulations for Capture

The construction of a CO₂ capture plant (CCP) may require additional EIAs regulated by the MEP through the Environmental Impact Assessment Law. The handling of CO₂ and hazardous material (e.g. chemical solvent) in CCP is regulated by the China's State Administration of Work Safety (SAWS) through the Production Safety Law (NPC, 2002b) and measures for managing dangerous chemicals (SAWS, 2005), the Safety Management Regulation for Dangerous Chemicals (State Council, 2011b) and the health standard for CO₂ in the air of the workforce (SAC, 1996). In addition, the CO₂ concentration in the work environment will be regulated by a standard formulated by the General Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ)¹⁵.

¹⁵ National Standard GB16201-1996: Health Standard for Carbon Dioxide in the air of workplace.

The treatment of waste amine will be regulated under the current law on the Prevention and Control of Air Pollution and the Environment Protection Law regulated by MEP. Though there is no specific regulation concerning chemical solvents in CO₂ capture, the generic definition in the air pollution law will require the flue gas emissions from CCP to reduce the level of poisonous chemicals (e.g. MEA residual) to a minimum¹⁶. MEA storage and transportation may also be required to adopt strict safety measures¹⁷. Amine solvent, if inhaled, is a potential hazard to CCP workers (Gentry et al, 2013). There is not yet a regulation on handling chemical solvents in CCP but the existing regulation in occupational health and safety may be applied for CO₂ capture solvent handling. If the CCP adopts a solid sorbent to separate CO₂, the treatment and transportation of solid waste will be regulated by the Law on Prevention of Solid Waste Pollution (NPC, 2004).

¹⁶ Article 36 of Law on the Prevention and Control of Air Pollution (NPC, 2000a).

¹⁷ Article 42 of Law on the Prevention and Control of Air Pollution (NPC, 2000a)

The additional process and cooling water requirement for the CO₂ capture process will be regulated by the Water Law and the Law on Prevention of Water Pollution¹⁸ (NPC, 2002a; NPC, 2008a). The extra land requirement for CO₂ capture and compression will be administered by the Ministry of Land and Resources through the Land Administration Law¹⁹, the Urban and Rural Area Planning Law²⁰ and the State Council Land Administration Regulation²¹. New build capture plant also needs to comply with stringent environmental regulations, e.g. the Guangdong provincial action plan sets an ambitious target to reduce the conventional pollutants from the flue gas (such as SO₂, NO₂, PM_{2.5} and PM₁₀) by 10% to 20% from 2014 to 2017 even though energy demand is still growing (GDPG, 2014).

¹⁸ Article 17 of Law on the Prevention of Water Pollution of PRC (NPC, 2008a)

¹⁹ Article 43 to 65 of the Land Administration Law (NPC, 2005)

²⁰ Article 36 of the Urban and Rural Area Planning Law (NPC, 2007b)

²¹ Article 23 of the Regulations for Implementing the Land Administration Law (State Council, 1998)

4.2.2 HSE Regulations for CO₂ Transportation

Even though there is no dedicated CO₂ pipeline law, the regulation of CO₂ pipelines in China could build on the oil and gas pipeline protection law (NPC, 2010) and the oil and gas pipeline protection regulation (State Council, 2001). The law sets requirements on pipeline setting, route investigation and pipeline design and provides a procedure for investigating accidents²². The law outlines measures for maintaining pipelines and requires pipeline operators to formulate emergency plans for leakage-related injury and remediation, particularly pertinent for transport of CO₂. The law also requires the development of a pipeline project to follow the Environment Impact Assessment Law (NPC, 2002c).

²² Article 10 to 21 of Oil and Natural Gas Pipeline Law of PRC (NPC, 2010).

There is no universal CO₂ transportation pipeline standard, but

²³ GB/T 50644-2011 Oil and Gas Pipeline Project Construction Design Standard

²⁴ Applicable only if CO₂ is classified as a poison gas according to the article 2 (MOCI, 1995).

some international organisations have formulated a recommended design standard, such as DNV (2010)'s recommended CO₂ pipeline design. Pipeline design in China may also transfer experiences by applying the existing oil and gas design standard in China²³. The health and safety aspects of CO₂ pipelines might follow the Regulation on Safety Management and Supervision over Pressurized Pipelines (MOCI, 1995)²⁴.

Constructing pipelines for offshore CO₂ storage needs to comply with the regulation and implementation measures set by the State Ocean Administration (SOA, 1989 and 1992).

There is still a lack of understanding on CO₂ release and dispersion models (Koornneef et al, 2012) and a study to compare hazard and risks for CO₂ versus natural gas pipelines is needed for building up the CO₂ pipeline transport regulatory environment (Wilday et al 2009). As better information becomes available, this should be incorporated into HSE regulations concerning CO₂ transportation.

4.2.3 HSE Regulations for CO₂ Storage

Law and regulation for CO₂ storage doesn't exist in China. However, all large-scale CO₂ storage projects will be subject to an EIA. WRI (2010: 7) suggested that the existing law (NPC, 2003) to regulate underground storage of radioactive waste could be a good proxy and reference for long-term CO₂ storage regulation. Though some aspects of radioactive underground storage management might be transferable, we believe the physics of CO₂ is very different from radioactive material and radioactive waste regulation is too onerous and could overstate the danger of CO₂ to the public. Consequently this regulation is not very relevant to CO₂ storage.

²⁵ Article 8 of Opinion on implementing the most strict water resources management rule, State Council (2012).

The Law on Prevention and Control of Water pollution and the State Council Opinion on Managing Water Resources²⁵ will be applied for controlling the impact of onshore CO₂ injection on underground water resources. The detailed rule depends on potential auxiliary regulations formulated by State Council or MEP and provincial regulation, such as underground water resources management plan in Guangdong (GDW, 2011). In formulating such auxiliary regulations, Chinese regulators could adapt the concept of a Class VI well as formulated by the US Environmental Protection Agency²⁶.

²⁶ The US EPA (2010) finalises minimal federal requirements for underground injection of carbon dioxide for the purpose of geological sequestration.

CO₂ onshore storage activities would need to comply with the standards protecting underground fresh water sources (AEP et al, 1989). The Environment Impact Assessment Law will be applied for

the development of any large-scale CO₂ storage projects. The Ministry of Water Resources (MWR) and Ministry of Land and Resources (MLR) and their provincial and municipal offices will play key roles in regulating and monitoring surface, ground water and sub-surface impacts. CO₂ offshore storage needs to follow the Marine Environment Protection Law (NPC, 2000b). A marine EIA is needed for the feasibility study of offshore engineering projects²⁷. There is not yet an authorisation process for offshore exploration of CO₂, but international cooperation in exploring offshore oil fields requires approval by the Ministry of Commerce and China National Offshore Oil Corporation (CNOOC) will be responsible for formulating the commercial contract²⁸.

²⁷ Article 47 of Marine Environment Protection Law (NPC, 2000b)

²⁸ Article 6, 7 and 8 of Regulation for International Cooperating in Exploring Offshore Oil Resources (State Council, 2011c)

²⁹ National Standard GB10621-2006:

4.2.4 HSE Regulations for CO₂ Utilisation

No specific law or measure regulates the CO₂ utilisation process, but there are safety standards for handling liquid CO₂ used in chemical processes. For food grade CO₂, a standard for food processing liquid CO₂ is in place in China²⁹, that requires the CO₂ volume concentration to be at least 99.9%, with less than 1ppm SO₂, less than 2.5ppm NO₂, and less than 2.5ppm NO as well as imposing restrictions on other impurities. Industrial CO₂ should have a minimum concentration of 99%, following the Industrial Liquid Carbon Dioxide Standard (SAC, 1993). However, it is very expensive to reach 99% CO₂ concentration with gas captured from conventional coal or gas power plants, and existing large-scale projects in Europe and North America require a CO₂ concentration of approximately 95%. A standard for CO₂ quality for transport and storage should be discussed and established.

CO₂ enhanced hydrocarbon activities will be regulated by the Mineral Resources Law (NPC, 1996) and the implementation rules set by the State Council (1994). The Mineral Resources Law suggests incentive schemes for applying advanced mining technologies³⁰. The Law also highlights the importance of the overall recovery ratio³¹.

³⁰ Article 8 and Article 9 of Mineral Resources Law (NPC, 1996)

³¹ Article 29 of Mineral Resources Law (NPC, 1996)

4.3 CO₂ Storage Liability

A CO₂ storage liability regulatory framework is central to the CCS regulation scheme for large-scale commercial sequestration projects (Davies, et al, 2013). The liability provisions cover certain future liabilities (such as well closure, monitoring), and contingent liability (such as the environmental impact, the cost of CO₂ emis-

sion allowances, the remediation cost during a CO₂ leakage event). There is no explicit Chinese regulation or law covering CO₂ storage liability.

Unless China decides to adopt a different approach to Europe, and the State shoulders a greater share of project liabilities, CCUS project developers must be capable of providing adequate financial security through the whole lifecycle of a CO₂ storage project. The financial security needs to cover the estimated net present value of future financial requirements (e.g. measurement, monitoring and verification, well closure, and the contingent liability for possible post-closure corrective action, and environment restoration in the event of CO₂ leakage). As stated in section 2.1, European project developers have complained that the financial security requirements of the CCS Directive impose excessive barriers for early large-scale CCUS projects, and have caused severe delay and cancellation. The recommended WRI (2008: 58) guideline suggests the financial assurance management framework should balance the policy considerations of making the demonstration of CCUS technologies affordable and the financial assurance requirements. It would be useful if Guangdong province could cap the leakage related liabilities of early CCUS demonstration projects at a level that incentivizes the best practice could be adopted, and the province, as the allowance issuer, carries the residual liabilities.

The WRI (2010: 7) study on China's CCS HSE regulation framework suggested that the existing laws regulating underground storage of hazardous waste, radioactive pollution³², and dangerous chemicals could be a good analogue for designing CO₂ storage regulations. The State Council (2011a) outlined the requirements and liabilities radioactive waste management operators need to meet in order to obtain a permit. It also outlined the post-closure monitoring requirements for radioactive waste storage during the 'safety monitoring phase' carried out by the storage operator and the government. The regulation also requires financial surety or a bond to be posted to meet any financial liability in the post-closure stage prior to transfer of liability to the State. However, the nature of CO₂ is quite different from the radioactive waste management process and it is unlikely the State Council would act as the main regulators for all CO₂ storage activities in the country. Ministries under the State Council and provincial governments are more likely to act as regulators for handling CO₂ storage liabilities.

³² The regulation for radioactive waste management released by the State Council (2011a) entered into force in 2012, indicated the site selection criteria and environmental liability. The national standard for managing radioactive waste can be found at GB14500-2002 (SAC, 2002).

4.4 Monitoring

Monitoring plans are highly site dependent (Clyne et al, 2011), and the regulatory framework should define a site specific long-term monitoring programme for each demonstration site. The regulations should clearly delineate the division of responsibility for monitoring between the project operator and the regulatory authorities.

4.5 Intellectual Property Rights Transfer and Protection

As shown in **Figure 1.1**, CCS technology is not a single system and it consists of combinations of different technologies along the chain. Most CCS technology patent owners are within developed countries, and consequently establishing a technology transfer mechanism is a key driver for achieving successful commercial deployment and rapid cost reduction in China (Liu and Liang, 2011). The Ministry of Science and Technology (MOST) highlights the importance of IPR transfer in the CCS technology 5-year programme (MOST, 2011). The NDRC (2013) notice to support CCS pilot and demonstration also highlights the importance of knowledge transfer. A successful technology transfer process could require practical financing mechanisms (potentially funding support from developed to developing countries), and a credible regulatory environment for intellectual property right holders.

China started to establish the legal and regulatory framework for IPR protection in the early 1980s, through issuing the Trademark Law in 1982 and the Patent Law in 1984 (**Table 4.2**). The last revision of the Patent Law was in 2008 by NPC (2008b) followed by a revision of implementation regulation released by the State Council (2010) in 2010. Even though the legal and regulatory framework to enable IPR transfer and protection in China exists, the enforcement for IPR protection still needs to be further strengthened to enable a credible environment for transferring advanced CCS technologies. There are knowledge sharing programmes within Chinese institutes (e.g. jointly developing CCS technologies and registering patents). However, apart from capacity building projects, there are very few international IPR transfer activities in advanced CCS technologies.

Table 4.2 The Evolution of China's IPR Legal and Regulatory Framework (revised based on Wang, 2013)

Year	Actions
1980	Established State Patent Bureau (Now called State Intellectual Property Office) Joined World Intellectual Property Organisation (WIPO)
1982	NPC issued Trademark Law
1984	NPC issued Patent Law NPS revised Trade Mark Law
1985	State Council released the decision to reform the Science and Technology Management System Joined Paris Convention on the Protection of Industrial Property
1987	NPC issued Technology Contract Law
1989	Joined Trademark Madrid Protocol
1990	NPC Issued the Copyright Law
1991	State Council released the Regulation on Patent Commissioning
1992	NPC revised Patent Law Joined Universal Copyright Convention State Council released the Regulations on Patent Commissioning
1993	NPC issued Law on Science and Technology Progress NPC issued Anti-unfair Competition Law NPC revised Trademark Law
1994	State Council released Decision to further strengthen IPR protection The standing committee of NPC released the decision to publish the crime of infringement of copyright
1995	State Council released Regulations on the Custom Protections of IPR
1996	NPC issued Law on Promoting the Transformation of Scientific and Technological Achievements
2000	NPC revised Patent Law
2001	Joined World Trade Organisation (WTO) NPC revised Copyright Law and Trademark Law
2005	State Council published White Paper on IPR Protection Progress
2006	State Council started to release Annual IPR Protection Action Plan
2008	NPC revised Patent Law State Council published the Outline of National IP Strategy
2010	NPC revised the Regulations on Implementing Patent Law
2011	Released the 12 th National Five Years plan on IP Business Development
2014	Established designated IPR Court

4.6 Incentivisation Policy

There is no CCS specific financial incentive programme for large-scale CCUS demonstration projects in China. In 2013, NDRC published policy to encourage pilot and demonstration of CCUS projects (NDRC, 2013). The Ministry of Sciences and Technology (MOST) has provided grant support for pilot-scale CCUS projects in China. Following the NDRC (2011) notice, seven cities and provinces (incl. Guangdong) started pilot emission trading schemes but the resulting current carbon allowance prices are insufficient to

finance a CCS, or indeed any other low carbon project. The carbon market in Guangdong is the only scheme with the auctioning of allowances at the pilot phase. The income from auctioning could potentially be used for financing CCS projects.

The experience in Europe shows that the large scale deployment of whole chain CCS demonstration projects will not happen if reliant solely on carbon markets. Current carbon prices in the EU ETS are far too low to incentive the construction of demonstration plants. On a national level, the UK has actually recently frozen carbon floor prices from 2016 until 2020 (Gov.UK 2014). The only full-chain CCS projects going ahead are those which have public sector capital grants. Large-scale deployment of CCS demonstration projects in China will almost certainly require a combination of financing support through major capital grants, carbon pricing support, and/or feed-in-tariffs (Reiner and Liang, 2012). Other mechanisms, such as an Emission Performance Standard and CO₂ Storage Obligations could support demonstration and deployment of CCUS projects.

4.7 Project Authorisation Process

There is not yet a formal permitting process for CCUS projects in China. However, there may be potential analogues from the authorisation process of thermal power generation, oil and gas pipelines, and oil and gas field developments. Authorising a power generation project in China is a substantial part of the project development process usually involving a very long lead time and communications with a large number of government departments at both local and national levels. In China's authorisation scheme, approximately 50 clearances or permits are required before construction of a power plant can take place³³.

This section will only focus on a few major permitting documents whilst considering additional requirements in a CCS project. The stage classifications for CCS project will apply the GCCSI definition (**Figure 1.3**) which includes (a) Identify; (b) Evaluate; (c) Define; (d) Execute; (e) Operate; and (f) Decommission.

³³ Based on communication with power plant developers in Guangdong province, China.

Process	Permit Title (Type)	Grant Institute (s)	Stage of Project
Base Power Plant	Provincial Approval for Project Feasibility Study	Provincial Development and Reform Commission	Identify
	National Approval for Project Feasibility Study	National Development and Reform Commission, National Energy Administration	Evaluate
	Environment Impact Assessment	Ministry of Environment Protection, Provincial and Municipal Department of Environment Protection	Evaluate
	Safety Assessment	China Academy of Safety Science and Technology	Define
	Provincial Project Authorisation	Provincial Development and Reform Commission	Define
	National Project Authorisation	National Development and Reform Commission and National Energy Administration	Define
CO₂ Pipeline	Registration for Geological Survey for Pipeline Development	Provincial Department of Land and Resources; Ministry of Land and Resources	Identify
	Environment Impact Assessment	Ministry of Environment Protection	Evaluate
	Land Usage Approval	Provincial Department of Land and Resources	Evaluate
	Provincial Approval for Project Feasibility Study	Provincial Development and Reform Commission	Evaluate
	National Authorisation for Project Development	National Development and Reform Commission, National Energy Administration	Evaluate
Offshore Storage Site	Geological Survey Qualification Certificate (incl. Oil and Gas Exploration)	State Council	Identify
	CO ₂ storage Exploration Permit	Ministry of Land and Resources	Identify
	Environment Impact Assessment	State Ocean Administration	Evaluate
	Project Authorisation	National Development and Reform Commission	Define
	Decommissioning Authorisation	State Ocean Administration	Decommission
Financial Support	Capital Grant by Provincial Government (Financial Incentive)	Provincial Development and Reform Commission Provincial Department of Finance	Define
	Grant Additional Carbon Allowance	Provincial Development and Reform Commission	Define
	Capital Grant by National Government	National Development and Reform Commission National Energy Administration Ministry of Finance	Define
	Feed-in-tariff Support	Provincial Development and Reform Commission	Execute
	Priority Power Despatch (i.e. Higher Annual Utilisation Hours)	Provincial Development and Reform Commission Southern Grid	Execute

Table 4.3 Potential Permit Framework for CCS Projects, Adapted from the Permitting Requirements of Power Plants, Pipeline and Oil and Gas Fields in Guangdong

The EIA is a critical component in authorising any energy infrastructure project in China. It varies across regions. Given the emerging air pollution control measures, in the Pearl River Delta in Guangdong, new coal-fired power plants are not likely to be approved unless their emissions reach the natural gas emission standards (State Council, 2013).

A long lead time is required in developing a CO₂ storage site, and a regulatory definition of an acceptable storage site is essential for storage site development (Zakkour and Haines, 2007; Kjarstad et al, 2011). In China, institutes surveying a potential CO₂ storage site would require a Geological Survey Qualification Certificate issued by the State Council (2008a). As all oil and gas exploration activities would require a permit by the Ministry of Land and Resources (MLR), CO₂ geological storage activities are likely to need a permit from MLR before injection can take place.

Section 5

Discussions and Policy Recommendations

Unlike Europe and the US, China doesn't have a dedicated regulation or policy framework for CCS or CO₂ storage. However, since 2013 the country has started to accelerate policy development for CCS. The CCS policy will shift towards legislation and detailed regulation development (Baker & MacKenzie, 2012: 11). It may take some years to achieve a national level legal and regulatory environment for CCS projects. New technologies in China could sometimes be demonstrated before a specific law and regulation is in place, thus **it would be desirable to start establishing the regulatory framework and permitting process at the same time as developing large CCUS demonstration projects.**

Policy Recommendation 1. As the first step, the government should establish a formal CCUS project permit application, authorisation and issuance process, and develop a project application and authorisation process for the full chain of activities.

The government could adopt the regulatory test tool kit developed by GCCSI and the Scottish Government (2011: 14) to formulate a regulatory table relevant for China for full chain CCUS with offshore CO₂ storage and to identify the gaps for developing CCS project applications. The regulatory table should list all relevant pieces of legislation and permit applications, ranging from permissions to start exploring in order to build CO₂ capture plants to decommissioning plant and platform infrastructure.

The tool kit includes the following information:

- Type of permit / permit title
- Place in the CCS chain / project cycle

- Area covered by the permit (not covered in this report)
- Granting authority
- Potential timing from application to permit
- Details on submission requirements (not covered in this report)

Neither the existing electricity nor the oil and gas industry laws include CCUS. A dedicated CCUS regulatory framework could generate benefits in addressing unique challenges in the complex CCUS chain. It may take a long lead time to establish a new law (e.g. the draft climate change law in China launched in Apr 2012 is still in the public enquiry process as of 20 Apr 2014). Amending existing laws and regulations to include CCUS could be a more effective approach, as it enables the use of existing regulatory capacities within different ministries and departments. This would also help reduce public concerns (Bachu, 2008).

The Chinese environmental laws and regulations have significant gaps compared with Europe and US (WRI, 2011: 8), and China needs more detailed regulation and definitions. In this context, adaptive regulation that balances flexibility and predictability as suggested by Wilson et al (2008) is more practical than implementing prescriptive regulation.

In China, the provincial regulation or law is always stricter than national environment regulation, e.g. the Environment Regulation in Guangdong (GDPC, 2004) sets a higher standard than that at the national level. Therefore, **the national level regulation for CO₂ storage should be less prescriptive to enable effective regulation set at the provincial levels**³⁴. However, understanding specific guidelines for safety and risk management of CO₂ geological storage sites is beneficial (Carpenter et al, 2010). These factors lead to the following policy recommendation:

³⁴ The approach is used in US and Canada.

Policy Recommendation 2. A regulatory framework designed specifically for whole-chain CCUS should be established. For maximum efficiency where possible existing laws should be amended and adapted. The regulations at a national level should be less restrictive than those at a provincial level, and it would be sensible to establish a pilot adaptive regulatory framework at

provincial level (e.g. in Guangdong Province) for the first few large-scale demonstration projects and then improve the regulation through demonstration project experience.

For such a new industry, China has yet to develop standards and best practice for regulators and supervisors to oversee a project through its entire life cycle. Monitoring plans are highly site dependent (Clyne et al, 2011), and the regulatory framework may consider a site specific long-term monitoring programme for each demonstration phase. As proposed in section 4.4 above the regulations should clearly delineate the monitoring responsibilities of the operator and the regulatory authority. Consequently:

Policy Recommendation 3. Specific standards and best practice need to be established for regulators and supervisors to monitor the CCUS project throughout its life. These should clearly identify which supervisory/regulatory body is responsible at each stage of the whole-chain project.

In relation to CO₂ storage, China will have to develop a suitable permitting system, as well as to define and regulate those liabilities which must be borne by the operator, and those which are can only realistically be taken by the State. The current environment regulations in China usually underestimate the cost of an environment pollution event (i.e. without a sufficient penalty defined in such regulations), and this factor needs to be taken into consideration when setting liabilities for environmental damage.

The financial strength of the storage operator has not yet been considered in China in relation to liabilities for environmental damage caused by CO₂ leakage etc. The level of security demanded from the operator should cover the cost of cleaning up and rectifying any environmental damage, but not be so onerous that the operator is unwilling to develop the demonstration project at all. These factors lead to the following recommendations:

Policy Recommendation 4. A CO₂ storage permitting system should be established, including the process for applying for, issuing amending and cancelling permits, to ensure that CO₂ is stored safely and reliability, and monitoring measures are in place.

Policy Recommendation 5. The liabilities of the storage operator should be clearly defined throughout the operating, closure and post-closure phases of the site. When calculating these liabilities, it should be borne in mind that current environmental legislation usually underestimates the cost of an environmental pollution event. It should also defined exactly when, and under what conditions, the liabilities of long term storage can be transferred to the State.

Policy Recommendation 6. The government should define what third party security (e.g. insurance, guarantees or bonds) the operator must post against the liabilities set out above.

Public perception takes on a more important role in major infrastructure development in China. It is critical to establish a communication mechanism with the public and stakeholders on understanding health and safety issues in relation to CCUS (Chrysostomidis et al, 2009). Public concerns over safety during transportation and storage could be a major barrier for CCS deployment in China (Senior et al, 2011). Offshore storage may reduce public pressure, but communication concerning sub-seabed CO₂ storage is still needed (Mabon et al, 2014). Moreover, even with offshore storage, pipelines bring the public into contact with CO₂. Consequently:

Policy Recommendation 7. An integrated CCUS project communication scheme should be established to ensure successful communication with the public and key stakeholders, to increase the likelihood of acceptance by the public.

In regard to health and safety, there is already a great deal of experience in transporting and injecting hazardous gasses, and such experience could inform best practice and regulation for the transport and injection of CO₂. However, as stated in section 4.2., there is still a lack of understanding on CO₂ release and dispersion models and a study to compare the hazards and risks for CO₂ versus natural gas pipelines is needed for building up CO₂ pipeline transport regulatory environment. In addition, **China might learn from the UK Health and Safety Executive (HSE) by setting up**

an emerging energy technology programme (Shuter et al, 2011).

Policy Recommendation 8. Health and Safety measures and best practice relating to handling CO₂ where possible should be adapted from a related industry, or experience abroad. CCUS projects and regulators need to put in place measures to protect the health and safety of the public, and to access and approve emergency plans before permission is given to develop the project.

The STRACO₂ project (2009: pp94) suggested that all new power plants should be capture ready from 2015. A good start has already been made in Guangdong province by the UK-China (Guangdong) CCUS Industry Promotion and Academic Collaboration Centre, which is currently promoting a CCS ready project based on China Resource Power's Haifeng 2x1GW coal-fired power plant. Guangdong needs to build on this, and consequently,

Policy Recommendation 9. Guangdong should promote more full-scale capture ready plant, and bring in regulation or legislation as soon as possible that all new large, high concentration sources should be built capture ready.

Of course a clear and consistent regulatory regime is a key factor to encourage investment in pipeline network (Zarraby, 2012). However, a consistent regulatory regime is insufficient in itself to promote CCUS demonstration plants, and consequently

Policy Recommendation 10. It is critical that a discussion commence on incentive schemes for large-scale demonstration projects in Guangdong. These could consist of a combination of the inclusion of CCS in the emission trading schemes in China, seeking feed-in-tariffs for CCUS power plants, as well as capital grants and tax (and other fiscal) allowances.

If CCS were to be Included in Chinese emission trading schemes, it would also be useful to develop methodology to include CCS in the schemes, and establish rules for potentially negative emissions within the ETS (e.g. biomass with CCS) (Brockett, 2009).

Finally, Guangdong has the great advantage that CO₂ transport infrastructure could be shared with Hong Kong, whose most obvious CO₂ sinks are in the same areas as those of Guangdong province. Collaboration with Hong Kong is a key task highlighted in the medium- to long- term development plan in the Pearl River Delta (GDPG, 2009). Thus the regulations for a CO₂ pipeline network should be formulated to encourage pipeline infrastructure investment and sharing, and Guangdong should seek to cooperate with Hong Kong on developing CCS. Consequently:

Policy Recommendation 11. Guangdong should aim to consider third party access for CO₂ transport and storage infrastructure and share CO₂ transport and storage infrastructure with Hong Kong in its CCUS development plans. It might also supply CCUS electricity to Hong Kong.

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