



CCS IN CHINA: TOWARD AN ENVIRONMENTAL, HEALTH, AND SAFETY REGULATORY FRAMEWORK

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CCS DEFINED

Carbon dioxide capture and storage (CCS) encompasses a number of technologies used together to capture carbon dioxide (CO₂), the most abundant greenhouse gas (GHG), separate it from point sources, such as power plants and other industrial facilities, then compress it, transport it (typically by pipeline), and finally inject it into deep subsurface geological formations. The underground formations used for geological storage may include saline aquifers as well as depleted oil and gas reservoirs. Individual technologies for each part of the CCS process are advanced and already operable, though as a whole the CCS process has yet to be fully commercialized. There are currently four commercial-scale integrated CCS projects operating—Sleipner and Snøvit in Norway, Weyburn in Canada, and In Salah in Algeria—and numerous others are under construction or in planning stages around the world. Governments are also making significant investments in research and development to address perceived risks associated with this emergent industry and advance the competitiveness of CCS as a commercially viable, technologically mature method for limiting GHG emissions and the severity of climate change impacts.

WRI AND CCS

This brief is one in a series of publications that the World Resources Institute (WRI) has published on CCS. Our work on this topic is not designed to endorse the technology, but rather to explore whether and how society might safely move forward with CCS projects as part of a broad climate mitigation strategy. In 2008, WRI published well-received *Guidelines for Carbon Dioxide Capture, Transport, and Storage* (see <http://www.wri.org/publication/ccs-guidelines>). This first attempt to develop best practices to responsibly implement CCS projects was based on a broad stakeholder process where WRI con-

vened experts from academia, industry, and NGOs from the United States. Follow-up publications will include briefs on CCS development in two critical markets, the European Union (EU) and China, the focus of this paper. In addition, WRI will publish guidelines for local community engagement on CCS projects in the fall of 2010. These will cover potentially contentious issues for CCS plants in relation to disclosure of information, community engagement in the review and approval of plans, and public participation in general.

CCS AND CHINA

In this policy brief we address CCS regulation within China's unique policy context, with an emphasis on ensuring protection of human health and safety if the Chinese government deploys CCS projects as a greenhouse gas mitigation tool. This paper presents the key regulatory criteria China should take into account in designing CCS oversight. The analysis drew heavily from WRI's *Guidelines for Carbon Dioxide Capture, Transport, and Storage* and to a lesser extent on the forthcoming community guidelines. While the potential for accidents is an important issue, we do not attempt to address it in detail in this brief given the complexities of liability regimes in any country.

This paper is designed to frame CCS issues facing China for a broad audience, including Chinese policy makers, donor governments, and agencies investing in CCS development in China, and companies seeking to pilot CCS projects there. It will precede and complement a joint effort by Tsinghua University and WRI to develop a set of comprehensive technical guidelines for CCS development in China, which will explore liability and community engagement in the Chinese context in much greater detail.

EXECUTIVE SUMMARY

Carbon dioxide capture and storage (CCS) is one of several technologies that many countries are looking to in order to reduce greenhouse gas emissions and keep rising temperatures from reaching dangerous levels. Many experts and policy makers believe CCS may be a critical option in the portfolio of solutions available to combat climate change, because it has

the potential to achieve significant reductions in CO₂ emissions from fossil fuel-based systems. There remain, however, many questions regarding the commercialization of the technology and issues surrounding the regulatory frameworks needed if CCS is to be deployed. These questions must be answered quickly to identify whether CCS can play the role that many

LIST OF ACRONYMS

CCS	Carbon Dioxide Capture and Storage
EIA	Environmental Impact Assessment
EOR	Enhanced Oil Recovery
IGCC	Integrated Gasification Combined Cycle
MEP	Ministry of Environmental Protection
MIIT	Ministry of Industry and Information Technology
MLR	Ministry of Land and Natural Resources
MOF	Ministry of Finance
MOHURD	Ministry of Housing and Urban-Rural Development
MWR	Ministry of Water Resources
NDRC	National Development and Reform Commission
NEA	National Energy Administration
NEC	National Energy Committee
SAIC	State Administration for Industry and Commerce
SASAC	State-owned Assets Supervision and Administration Commission of the State Council
SAWS	State Administration of Work Safety
SOA	State Oceanic Administration

hope, and if so, how best to deploy it. Renewable energy sources are also projected to play a major role in the future and are rapidly expanding. Renewables, however, are not predicted to overtake fossil fuel generation for several decades; hence CCS, if safely deployed, could help provide a bridge to a more sustainable energy future.

As CCS technology moves from an R&D effort to demonstration-scale projects and ultimately commercial developments, governments in many major economies, including Australia, Brazil, Canada, China, the European Union, France, Italy, Norway, South Africa, the United Arab Emirates, the United Kingdom, and the United States have announced plans to construct commercial-scale CCS demonstrations. The International Energy Agency's CCS Roadmap, designed to determine the role for CCS in achieving a 50 percent reduction in 2005 energy-related global CO₂ emissions by 2050, states that 100 CCS projects should be online by 2020 (IEA 2009b; IEA 2009c).

The first tranche of announced demonstration projects—let alone the 100 projects suggested by the IEA—will require not only significant financial investments by industry and the private sector, but also a robust regulatory framework for ensuring that projects proceed safely. The development of rigorous regulations for ensuring environmental protection and managing the risks associated with CCS efforts is paramount, and pilot regulatory frameworks for protecting environmental health and safety have been developed—and in some cases adopted—for the European Union, Australia, and the United States.

CCS and China

China now emits more greenhouse gas emissions than any other country, due in large part to its reliance on coal to fuel its expanding economy. In 2009, China derived 70 percent of its primary energy from coal, and this heavy dependence is projected to continue into the future. Since CCS offers the prospect of reducing greenhouse gas emissions while coal use continues, the emerging technology is a key element in prevailing energy use models in China. These models estimate emissions rising to a peak by 2030, but declining after 2030 if CCS is widely deployed in China (IEA 2009).

Key elements to successful deployment of CCS include not only development of technology, geologic knowledge, financing instruments, and long-term stewardship rules,¹ but also a regulatory framework for ensuring environmental health, safety, and efficacy. While CCS technology development and research are already underway in China, a comprehensive domestic regulatory framework to provide oversight of future CCS projects has not yet been developed. While China's CCS framework should be informed by emerging regulatory frameworks in other countries, it must also be crafted to fit China's specific legal and regulatory systems.

About this Brief

This brief frames how CCS might be regulated within the Chinese environmental policy context, with an emphasis on ensuring protection of people and the environment. After summarizing China's existing CCS research and demonstration projects, it outlines the country's existing CCS-related legal structure and the government agencies with a role in oversight of CCS development in China. The paper then lays out CCS-related environmental, health, and safety challenges and gaps in China's existing regulatory and legal structures that need to be addressed for China to establish an effective and safe regulatory framework. Next it provides key criteria for

geologic storage—universally applicable and based on WRI’s stakeholder-led *Guidelines for Carbon Dioxide Capture, Transport and Storage*—which China could apply in order to ensure environmental protection and human health and safety. This list of criteria focuses exclusively on regulations for geologic storage, the area where there is the most technical uncertainty and where existing regulations are less applicable compared with capture and transport.

Appendix I gives a comprehensive overview of the laws and policies in China that pertain to CCS development and deployment. Additional supporting materials, including a comparison of proposed CCS frameworks in the European Union, United States, and Australia, are available online.²

The information in this policy brief can be utilized by Chinese officials, other governments, and industry representatives to better understand the evolving regulatory environment for CCS in China. As governments and businesses begin bilateral and multilateral CCS demonstration projects, a shared basis for communication and a common understanding of regulatory approaches will be increasingly critical.

Findings and Next Steps

This brief demonstrates that political institutions exist to support a CCS regulatory framework in China, along with some potentially adaptable laws and regulations. However, elements of CCS regulation not closely related to current industrial activities, primarily those related to geological storage, are not yet established. These will need to be in place before large-scale commercial CCS initiatives can move forward. One approach is to develop and implement a pilot regulatory framework for the first demonstrations that can be revisited prior to wide-scale deployment of the technology. With regard to environmental, health, and safety issues related to storage, China can and should look to key criteria used by other countries, that are also outlined in this paper, in designing its own CCS regulations and legislation (Box 1).

I. INTRODUCTION

China’s Energy Trajectory

Fossil fuels—in particular coal—will likely remain a significant global fuel source for decades to come. This is especially the case in China, whose known coal reserves account for 14 percent of the world total, trailing only Russia and the United States (BP 2009). The world’s second largest energy consumer, China accounts for 43 percent of global coal consumption. Heavy energy use fuels China’s industry and economy, which grew by an average of nearly 10 percent every year between

Box 1

Key Criteria for CO₂ Geologic Storage Regulations

1. Site selection should be based on site-specific geologic data.
2. Monitoring plans should be adapted and designed for the geology at a specific site.
3. A model and simulation of the CO₂ injection should be conducted and data routinely collected and reported to the regulator.
4. A comprehensive risk assessment should be conducted based on site-specific data.
5. The area to be evaluated and monitored should extend beyond the injected CO₂ plume.
6. The regulatory framework should be reviewed regularly and adapted as new information becomes available, it should perhaps first be issued as a pilot regulatory framework that applies to the demonstration phase.
7. A plan for the post-closure stewardship of the site and transfer of responsibility should be clearly articulated.
8. Public engagement is necessary.

1980 and 2010, lifting 235 million Chinese out of poverty in the process (Hart and Liu 2010). China’s energy infrastructure is rapidly growing and energy consumption is expected to double again by 2030, with major implications for emissions of greenhouse gases (IEA 2009).

While much of China’s current coal demand can be met domestically, net imports of crude oil grew to 3.9 million barrels per day in 2008, placing China as the third largest importer of oil, behind the United States and Japan (EIA 2009). To safeguard supply and increase energy security, China has accelerated coal power plant production and has invested heavily in larger, more efficient, next-generation coal power plants such as Integrated Gasification Combined Cycle (IGCC) plants ideal for CO₂ capture.

Low-Carbon Scenarios

Although coal makes up 70 percent of China’s energy mix today and will remain the primary fuel for the next few decades, the country is also investing heavily in clean energy alternatives. The ongoing development of renewable technologies in China will increase its domestic energy supply, alleviate energy security issues, and decrease the CO₂ intensity of Chinese energy production. In 2009, China led the world in clean technology investment at US\$34.6 billion, nearly double that of second place United States (Pew Charitable Trusts 2010) and boasted the fastest growing wind energy sector in the world (GWEC 2009). In 2010, China aims to reach the goal of increasing

energy efficiency by 20 percent compared to 2005 levels. Additionally, China plans to increase nuclear power capacity from 10 gigawatts (GW) in 2009 to 160 GW by 2030 (World Nuclear Association, 2010).

However, even with current efforts and targets for increased renewable energy, coal is still expected to account for 50 percent of China's total power generation in 2030 (Liu and Gallagher 2009). China has a number of academic modelers looking at low-carbon scenarios that would enable the country to stabilize and ultimately reduce its greenhouse gas emissions. Their collective efforts were published in two major reports in 2009: *The 2050 China Energy and CO₂ Emissions Report and the China Human Development Report 2009/10; China and a Sustainable Future towards a Low Carbon Economy and Society*.³ The consensus that emerged from these efforts is that energy efficiency advances will enable Chinese greenhouse gas emissions to grow at a substantially lower rate than they would under a business-as-usual scenario and will be responsible for the bulk of avoided emissions up to 2030. Additionally, substitution will occur as nuclear and renewable energy grow and oil and coal are increasingly replaced by fossil fuels lower in carbon content, such as natural gas. Taken together, these interventions should slow growth and ultimately flatten emissions. However, most current models suggest that, without the additional use of CCS, China's emissions would stabilize around 2030 but would not actually decline from this peak.⁴ A reduction in emissions will require that some carbon dioxide emissions be captured, leading these models to posit a role for CCS, beginning in the next few years, growing in importance between 2020 and 2030, and reaching significant deployment post 2030. A low-carbon future for China in this century therefore suggests a pressing need for a comprehensive research, development, and demonstration effort to clarify whether CCS can play a role in the future and if so to ensure that CCS can become a safe and commercially viable option.

Government and Business Support for CCS

The importance of developing CCS capacity has not been lost on the two stakeholders most crucial for CCS deployment in China: government and industry. In 2007, President Hu Jintao announced research into carbon sequestration technology as a component of shifting to a low-carbon economy (Capture Ready 2009). Other national leaders, including Premier Wen Jiabao and the National Development and Reform Commission's (NDRC's) chairman Zhang Ping, have explicitly mentioned developing CCS technology as part of a suite of climate change and environmental reforms. Such statements have been

followed up in national plans. For example, the 11th Five-Year Plan specifically mentioned the GreenGen and Shenhua Direct Coal Liquefaction CCS pilot projects under construction in 2009. Also, in November 2009, the NDRC formed an official Leading Group for CCS in China. Interest in exploring CCS in China dates back to 2005, when China first integrated CCS into its national science and technology research and development plan and launched a specific technology research program for carbon capture and storage (see Box 2).

China is also seeking to collaborate with other nations in CCS development. In November 2009, memorandums of understanding (MOUs) between the United States and China established the U.S.-China Energy Cooperation Program (ECP) and U.S.-China Clean Energy Research Center (CERC), both of which include CCS as one element of joint clean coal initiatives.

Following the government's lead in supporting CCS technology research activities, leading Chinese energy enterprises have been investing in CCS technology demonstration projects (see Figure 1). Petro China, the largest national oil company, began building China's first CO₂-Enhanced Oil Recovery (EOR) project at the Jilin Oil Field in Jilin Province in 2006. Two rival companies have plans to deploy plants with components of CCS technology in the next two years: GreenGen Co.'s IGCC plant with associated CCS plant, and Shenhua's direct coal-to-liquids power plant with CO₂ capture and storage. Numerous other, relatively low-cost opportunities for CCS also exist around the country, including the potential to contain over 117 million tons (Mt) of CO₂ emissions from capture-ready ammonia production plants (see Box 2 for more details). To move from CCS in energy models to demonstration projects and ultimately commercialization and deployment requires a number of steps. These include scientific and technological development, financing and financial incentive programs, and a regulatory infrastructure for safely and effectively deploying CCS both in the pilot stage and for broader deployment.

As described above and in Box 2, a significant number of pilot programs and technology experiments are already underway or are likely to be financed in the near future. Under the Chinese legal system, it is not uncommon for new industrial practices to begin operating while unregulated. This is because large industrial projects must go through individual approval processes, unlike in the United States, European Union, and other OECD countries where projects can proceed if they do not violate existing regulations. In China, the absence of a coherent or unified regulatory framework for project approval

Government Initiatives:

- 2005. China integrated CCS into the national medium- and long-term science and technology development plan as a cutting-edge technology to achieve near-zero emissions fossil energy development (Lu, 2005).
- 2006. The Ministry of Science and Technology launched the National Basic Research Program (973 Program) of Utilization of CO₂ for Enhanced Oil Recovery and Geological Storage.
- 2007. CCS technology noted as key research area for GHG emissions reduction in the National Climate Change Program (NDRC, 2007).
- 2008. The Ministry of Science and Technology launched the National High Tech Program (863 Program) of Technology Research for CO₂ Capture and Storage.

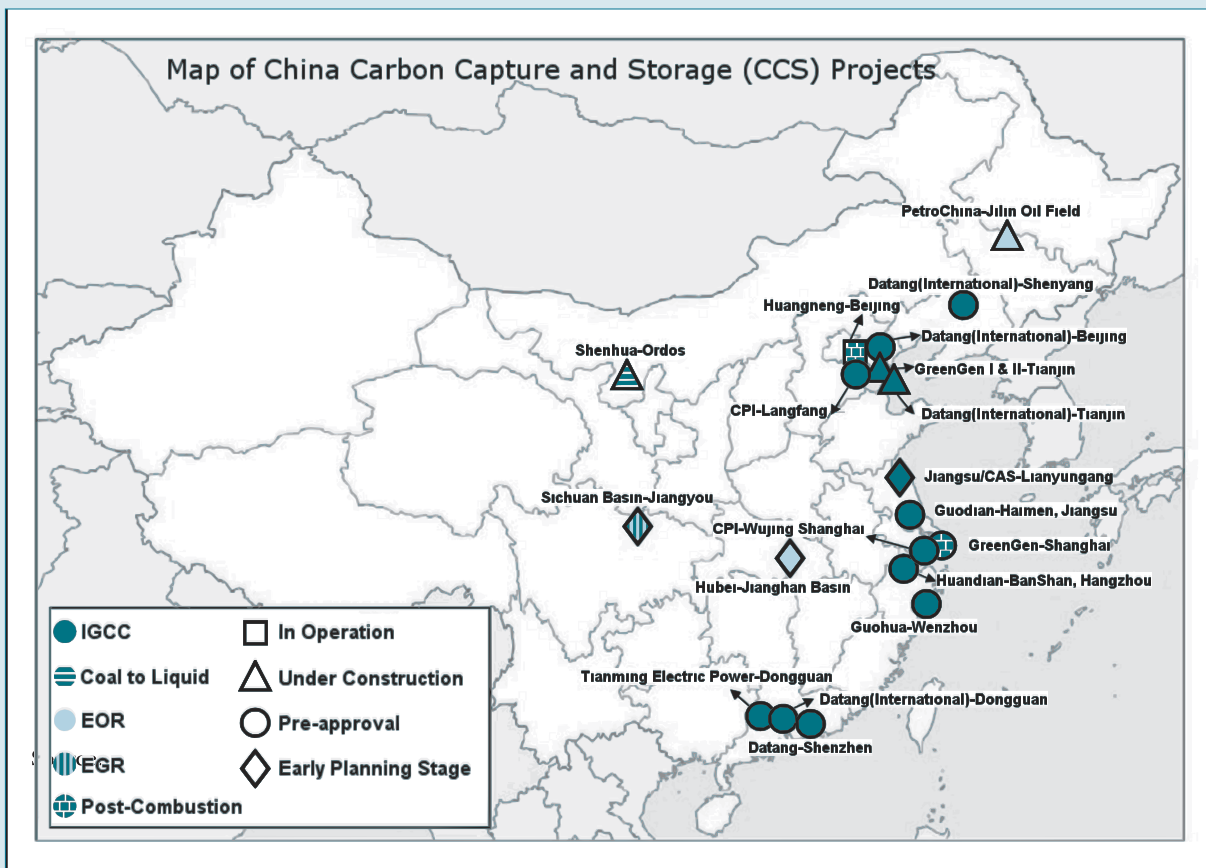
Industry Efforts:

Rapid development of several commercial IGCC projects reflects China's engineering expertise in power generation and coal gasification. This trend has been accompanied by increasing industry recognition that these gasification facilities offer near-term opportunities

for carbon dioxide capture that could be paired with future CCS demonstrations (Asia Society 2009). These gasification facilities offer important opportunities for such geologic storage tests because a portion of CO₂ must be separated out as part of the industrial process. Such storage-ready CO₂ can be used to gain experience in geologic storage in China at a relatively low cost. There are currently two announced projects that pair industrial-scale gasification with geologic storage research, one by China's biggest coal producer and another by one of its power giants.

The Shenhua Group has invested in a Direct Coal to Liquids (DCL) plant in Ordos, Inner Mongolia. This first-of-its-kind facility employs a Chinese-developed technology and is expected to begin full operation by the end of 2010. Shenhua has announced plans to inject 100,000 tons of CO₂ per year through a geologic storage demonstration at this facility. Meanwhile, since 2008 the Huaneng Group has been leading the construction of GreenGen's first IGCC power plant in Tianjin and is actively exploring the possibility for a geologic storage test in its second phase (GreenGen 2009). Research-scale post-combustion capture projects for pulverized coal plants are also underway as shown on the map below, which indicates all known existing carbon capture and CCS efforts.

Figure 1 Map Displaying CCS-Related Projects Taking Place Across China



could obstruct or delay approval of worthy CCS projects while making possible the approval of unqualified or risky projects. In contrast, early adherence by national and provincial regulators to the key criteria set forth in this brief could hasten the development of national regulation that promotes safe and effective CCS deployment. Thus, addressing regulatory structure should be an essential component of CCS development and complement the considerable scientific research, technology development, and financing planning already underway.

The remainder of this brief focuses on the development of an environmental, health, and safety regulatory framework for CCS in China. Geological and technological issues as well as the question of financing and designing liability frameworks are outside the scope of this paper, and these issues will be addressed in the forthcoming China CCS Guidelines that represent a joint effort between Tsinghua University and the World Resources Institute. These guidelines will include technical recommendations for Chinese decision makers on how to ensure safe and responsible CCS demonstrations.

II. THE CHINESE REGULATORY SYSTEM & CCS

Existing Chinese regulations will affect deployment issues including property use, siting, and safety for initial CCS pilots. China requires all industrial projects with investments of over US\$100 million to go through a project approval process. In the case of subsurface projects this involves, at a minimum, the NDRC and the Ministry of Land and Natural Resources (MLR), as well as an Environmental Impact Assessment review conducted by the Ministry of Environmental Protection (MEP) (STRACO₂, 2009). These measures provide the Chinese government an opportunity to specify environmental, health, and safety requirements for specific projects in the absence of comprehensive CCS-specific regulation.

The Legal Structure for Regulating CCS

CCS projects involve large investments and initially will most likely originate from the state-owned sector of the economy (Al-Juaied and Witmore 2009). In addition to future CCS-specific laws and standards, there is also a broader existing legal structure under which CCS as a type of industrial project will fall. This includes largely civil and administrative regulations, including those applicable to resource use, zoning, and project approval.

The mobilization of early CCS deployment will involve multiple layers of governmental decisions and actions. In the policy realm, high-level government decisions will be required that involve the President, Premier, and the State Council (of Premier

and Vice Premiers) in both their government and Communist Party leadership roles. They and other actors will also need to incorporate CCS programs that promote pilot projects in the latest Five-Year Plan, the national planning document that sets China's broad policy goals. At a lower level, company policy and investment decisions made by the mainly state-owned enterprises that dominate the energy sector will play a part.

Hand in hand with policy decisions, legislative actions will be needed to address the potential risks associated with deployment of CCS. Legal infrastructure is drafted within the State Council, Ministries, or National People's Congress Committees and passed by the National People's Congress. Laws will be supported by regulatory infrastructure established by the Ministries listed in the appendix.

At the level of individual CCS projects, provincial and local government involvement will be essential for initial approval as well as to ensure effective implementation and to facilitate community engagement throughout the project's life.

Both at the scale of individual projects and of macro-level deployment, decisions regarding approval and administration of CCS projects will cut across multiple agencies.

China's ministries, laws, and regulations can provide working models for how CCS is managed in China, as existing laws have provided the framework for CCS regulations in other countries. For example, China's Environmental Impact Assessment Law will play a direct role in CCS governance, while pipeline regulations for the oil and gas industries can be directly applied to, or used as models for, CO₂ transport activities. Appendix I provides a comprehensive description of existing laws and requirements that will apply to CCS.

III. DEVELOPING A CCS SAFETY, HEALTH, AND ENVIRONMENTAL REGULATORY FRAMEWORK IN CHINA

As Appendix I shows, China already possesses a basic body of law on which to build an effective CCS regulatory framework. One initial question facing Chinese decision makers is whether to create a CCS-specific law, or to attach new CCS provisions to existing legislation. In either case, the existing laws will play an important role in shaping the regulatory approach. Dedicated CCS regulation has the advantage of addressing the unique challenges facing CCS in a comprehensive manner. Such dedicated legislation might be established for the entire CCS process, or for CO₂ storage only. The European Union has established dedicated comprehensive legislation, while the United

States has focused on new regulations for geologic storage of CO₂. Other countries, such as Australia and Canada, have amended existing oil industry legislation to include CCS in order to maximize efficiency and use.

An advantage of dedicated regulation is that creating a new law could reduce redundancy in oversight by multiple agencies and it provides an opportunity to address the unique aspects of capture, transport, and storage in one law. On the other hand, there is also efficiency in amending existing laws to include CCS in that it would enable use of existing capacity in the various ministries and allow for focused attention to the CCS aspect within that agency's purview. It is too early to evaluate the relative success of the approaches taken in other countries. A third option that may be worth considering in China is to establish a pilot regulatory framework that would be applied to the first demonstration projects, and then improved and finalized with experience.

Review of Existing Ministries and Laws

Existing laws and regulations would affect many facets of CCS projects and present a foundation on which to build an effective environmental, health, and safety regulatory framework.

Environmental standards: With respect to capture issues, China already has robust regulations for plant construction and air pollution control that will impact all CCS capture plants and form part of CCS-specific regulations. One of the environmental impacts of equipping plants with capture technology is new pollutant emissions from the CO₂ capture unit (most often amine or ammonia). This could be regulated under the current Law on the Prevention and Control of Air Pollution.

Geological storage: Existing laws regulating the underground storage of hazardous waste, radioactive pollution, and dangerous chemicals are good initial references for designing regulations for CO₂ storage. The Law on the Prevention and Control of Radioactive Pollution may be the best parallel for comprehensive CCS regulations. It resembles those being drafted in other countries in that it governs radioactive pollution from source to final deposit, including transportation. The existing Chinese regulation incorporates standards for siting, monitoring, emergency response, and public education, which are all important to the CCS context. Two other key laws for geologic CO₂ storage, the Law on the Prevention and Control of Water Pollution and the Environmental Impact Assessment Law, will directly apply to all future CCS projects and should be incorporated into a Chinese CCS environmental regulatory framework. While unlikely that they will be developed in the near term, offshore CCS projects

in China will be subject to the CCS-specific rules that already exist under the London Convention.

Regulatory Oversight: Environmental regulations relevant to CCS will be overseen by the Ministry of Environmental Protection (MEP), while the Ministry of Water Resources (MWR) and Ministry of Land Resources (MLR) will play specific roles with respect to regulating and monitoring surface, groundwater, and subsurface impacts. While these national-level agencies will be responsible for drafting national regulations, provincial branches of the national agencies will likely enforce the regulations for individual projects. These branches have the ability to make approval decisions at a local level as well as to write local provisions to national legislation, although their authority can vary depending on the province.

Health and Safety: Substantial health and safety rules also exist that can inform or be directly applied to CCS regulations. The Chinese National Standard for Carbon Dioxide in the Air of the Workplace applies directly to all facets of a CCS project, as does the Production Safety Law, which concerns worker training, safety inspection and approval, and emergency response. Numerous additional laws and regulations are in place to ensure the safety of existing oil, gas, and pressurized chemical pipelines. The regulations for environmental protection during storage are also applicable as health and safety regulations, as the release of any hazardous, dangerous, or radioactive products threaten human and animal wellbeing.

China's State Administration of Work Safety (SAWS) is the primary agency for enforcing health and safety regulations. The General Administration of Quality Supervision, Inspection, and Quarantine (ASQIQ) is responsible for setting official standards such as CO₂ concentrations and pipeline materials. Other agencies governing environmental regulations would also have authority over health and safety where there is overlap. Individual CCS projects would also fall under the auspices of the State Council, NDRC, and National Energy Administration (NEA), all of which will or could have important roles in individual project approval. For radioactive waste control, the State Council currently makes the authoritative decision regarding storage siting, suggesting one way forward on CCS regulation. In general, for industrial projects comparable to CCS, the NDRC with support from NEA and provincial governments will make the final decisions on project approval according to the interim measures in place for examining and approving any domestic and foreign investment projects. In addition, laws on property rights, land zoning and usage, construction, and torts all could come into play for any CCS project. Other relevant

agencies include the Ministry of Finance (MOF), Ministry of Industry and Information Technology (MIIT), State-owned Assets Supervision and Administration Commissions of the State Council (SASAC), and the National Energy Committee (NEC).

Challenges Presented by China's Regulatory Framework and Legal Structure

As noted above, China is not starting with a blank slate regarding CCS regulation. However, China's environmental regulatory development has only taken place since the late 1970s (Zhou, 2008). The country's laws and regulations therefore have more gaps than Europe and the United States, for example, and its body of environmental laws is still evolving. China's environmental agency gained enforcement powers only in the early 1990s and became a ministry in 2008 (PRC 1993; Xinhua News Agency 2008).

China's relatively limited history of environmental regulation will influence the development of specific CCS requirements. As mentioned above, an initial challenge will be how to design laws or regulations within the existing legislative and regulatory framework and to either draft a single law specific to CCS projects with regulations laid out beneath it or attach new CCS-specific regulations to existing laws. Even if the Chinese government chooses to use a similar set of guiding principles to those adopted in other countries, the actual regulations may look quite different, as gaps in existing laws and regulations may require greater detail on issues ranging from environmental health and safety to property use. Another issue will be how to address the use of authorities not originally intended to regulate CCS activities and how to proceed when multiple ministries have responsibilities. An example of such a dilemma is the overlap between the underground mineral rights governed by Ministry of Land Resources (MLR) and the groundwater protection responsibility of Ministry of Environmental Protection (MEP) (NPC 1996; State Council 2000).

Authority and regulatory structure also divide by industry. Many of China's major state-owned industries originally had ministry status. The major energy companies derive from ministries specifically devoted to each fuel source or use—power, oil, and coal. The metals companies are derived from ministries that covered major industrial production (CISIA 2008; CNMIA 2009). Over the past 30 years, policies have evolved to clarify ownership and to establish national-level independent regulatory and policy-making agencies. But this complex legacy has resulted in regulations and policies that are often industry-specific (State Grid 2009; Li 2001). As a result,

existing regulations that may apply to CCS will vary depending on which sector uses the technology. In designing regulations, policy makers will need to build on this diverse background in a way that harmonizes the underlying regulations, adding content where needed, but fostering unified standards.

To some extent, the approach to CCS regulation recommended in the next section of this document is similar to that already used in the oil and gas sector, but it is quite different from those applied in the power or coal industries. As shown in Figure 2, underground storage is an iterative process that requires effective modeling and continuous data collection. Chinese experience with this type of iterative regulation has so far involved a fairly limited circle of industrial operators in the oil and gas sector. China will need a regulatory system that ensures flexibility as well as health, safety, and efficacy to encompass the diverse opportunities for cross-sectoral capture and storage.

The development of an environmental, health, and safety regulatory framework for CCS in China will also impact the future decisions of key CCS stakeholders, including foreign investors. Foreign and international organizations such as the Global Carbon Capture and Storage Institute (GCCSI), Major Economies Forum (MEF), World Bank, and Asian Development Bank are all considering financing CCS projects in China. Their understanding of the legal conditions in place will impact their involvement in projects, as regulations directly affect issues such as liability and project risk, which are fundamental to financial decisions. Chinese enterprises are also hesitant to work together on CCS pilots in part because of uncertainty surrounding responsibilities, liabilities, and other regulatory issues. The creation of an environmental, health, and safety regulatory framework would be a key step in removing this barrier.

Filling the Regulatory Gaps

The primary gaps in existing legislation in China with regard to CCS technological issues (as opposed to public policy issues, such as community engagement guidelines) relate to carbon dioxide storage. This section briefly summarizes gaps in relation to CO₂ capture, transport, and storage, with further detail provided on storage aspects of the CCS regulation process in section IV.

Capture: The key capture issue not addressed by existing legislation in China concerns increased water consumption at plants with capture facilities. The most important regulatory design issue for capture in China will therefore be the approval, monitoring, and regulation of CCS capture plants in relation to their increased demands on local water supply.

Transportation: Regulation of CO₂ transportation should not pose many new regulatory problems, given that adaptation of existing oil, gas, and chemical pipeline laws to CCS should be feasible. Standards are also available in the United States and other nations with decades of experience in EOR. China will need to consider whether to adopt specific standards or to outline criteria for CO₂ purity and CO₂ pipeline materials within existing broader pipeline legislation. Beyond that, China will need to clarify governance of pipeline construction, right-of-way, and quality, the legislative capacity for which is already largely in place.

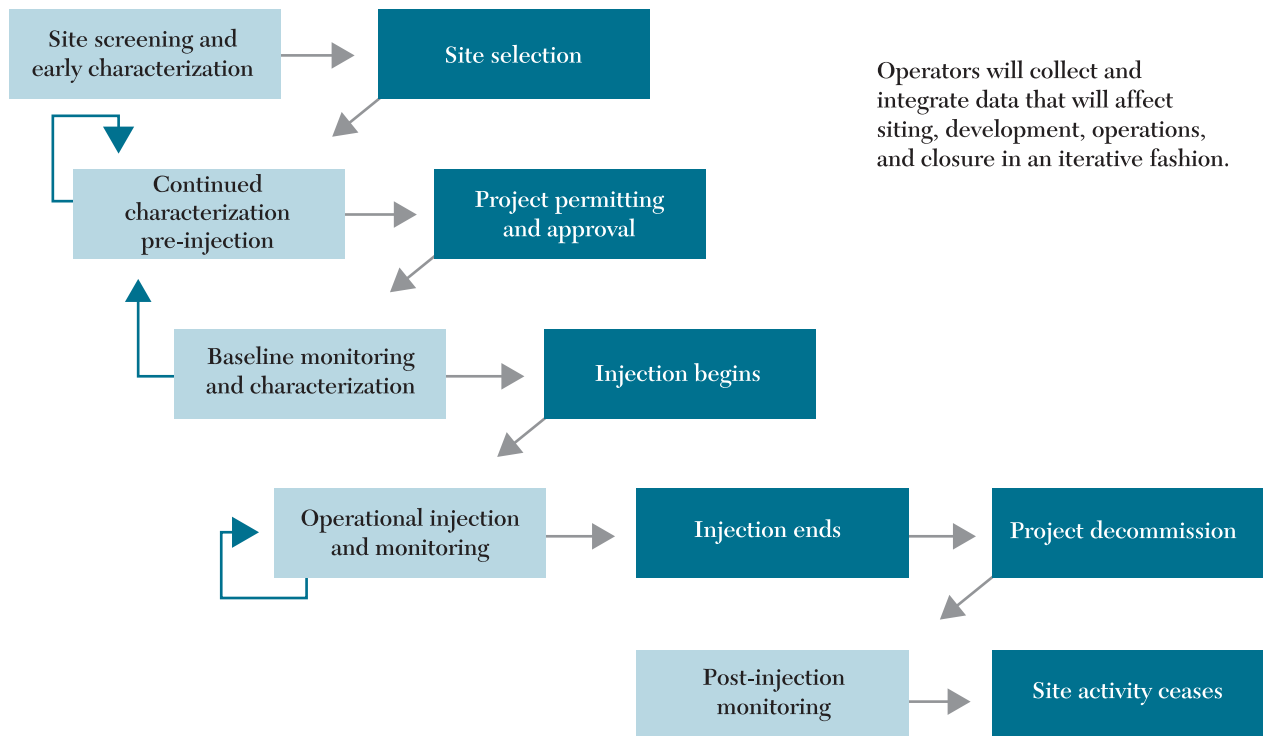
Geological storage: Storage of CO₂ fundamentally differs from that of other materials, such as hazardous waste, dangerous chemicals, and radioactive pollution, for which underground storage regulations already exist. In designing a regulatory framework for storage, China will seek to follow other countries in developing regulations that minimize risk throughout the lifecycle of a CCS project. Figure 2 describes the integrated steps necessary for geologic storage. The criteria presented below adhere to key principles identified in WRI's work on

universally applicable CCS guidelines and which underlie emerging environmental, health, and safety regulatory frameworks in countries around the world.

IV. KEY CRITERIA FOR AN ENVIRONMENTAL, HEALTH, AND SAFETY REGULATORY FRAMEWORK FOR GEOLOGICAL STORAGE

The following eight criteria are designed to guide the development of an effective regulatory framework governing the long-term geological storage of carbon dioxide. They recognize that geology, even within a specific location, can be heterogeneous and that uncertainties in operating in the subsurface need to be managed through integrated monitoring and risk analysis. The eight criteria are presented below in relation to existing Chinese regulatory systems and laws and the gaps therein. Whether China dedicates a CCS-specific law, or chooses to include CCS in other existing regulations, these criteria should be incorporated to ensure safe and effective long-term storage. While the criteria focus in particular on regulation of the geologic storage process, some of the principles highlighted are applicable to the broader CCS process.

FIGURE 2 Integrated Steps Necessary for Geologic Storage of CO₂



Source: WRI 2008

These criteria are drawn from WRI's *Guidelines for Carbon Dioxide Capture, Transportation and Storage* (see <http://www.wri.org/publication/ccs-guidelines>), which in turn were based on a comprehensive stakeholder process and in-depth analysis of international CCS regulations. These criteria also underlie emerging environmental, health, and safety regulatory frameworks in countries around the world. The criteria do not address standards for injection and monitoring well construction or protocols for worker safety during operations, as most experts believe standards for these aspects of CCS will be derived from existing industry practices.

While this paper provides a summary overview of key criteria for policy makers and other stakeholders, Tsinghua University and WRI are also developing a set of Guidelines for CCS in China, which will provide detailed technical guidelines and supporting information. WRI has also developed an online tool to compare how global CCS regulations are addressing key issues, which decision makers may find useful as China develops its CCS regulatory framework (see <http://www.wri.org/project/carbon-capture-sequestration/proposal-matrix>).

1. Site selection should be based on site-specific geologic data.

Site selection that assures the safe long-term storage of CO₂ underground is the single most important issue. Essential geologic characteristics include the following: first, the presence of a caprock that is laterally extensive, relatively thick, and without penetrations or faults that may serve as conduits for CO₂ to move outside the injection reservoir; second, a reservoir formation with a storage capacity that is greater than the anticipated volume of CO₂; and third, both reservoir and caprock formations capable of withstanding the increased pressures from CO₂ injection without fracturing.

Current legislation for underground storage of other substances in China does include some provisions that may inform future CCS rules. Both the hazardous and radioactive waste storage regulations include broad, essential geological characteristics that should be sought in storage siting for CCS, and the measures in place for storing dangerous chemicals require qualitative and quantitative analyses of storage capacity and reliability. However, none of the laws require sites to meet specific, quantifiable parameters. CCS regulations should be similar to ensure flexibility, while simultaneously ensuring environmental protection.

Approval processes already exist for the permitting of mineral exploration, mining, and geological surveying. Exploration

and extraction regulations do involve a review of geological factors. China can look to these for building rules governing the site selection and characterization process for CCS. Current laws also establish limitations regarding a site's proximity to water, mineral resources, population centers, and other restricted areas. Similar constraints should be adopted for CCS.

Also key to CCS legislation is that each site be evaluated individually. The radioactive pollution law could serve as a basis, as the State Council is responsible for approving each storage site with consent from the local government. For CCS, sites could similarly be judged individually by the MLR and/or NDRC with approval from the local provincial authority.

2. Monitoring plans should be adapted and designed for the geology at a specific site.

A monitoring area must reflect site-specific geological conditions and be based on subsurface modeling and CO₂ injection simulation that employs site-specific data (WRI 2008). This area may change through the course of a CCS effort and should be periodically re-evaluated. Since it is not possible to establish a standard suite of default monitoring technologies for CCS, the development of a site-specific monitoring plan based on the unique local geologic conditions and informed by site-specific data is critical to successful and safe storage. Different technologies will be used at different sites and should be selected based on the specific geological conditions.

Monitoring will be a new process for Chinese regulation. While it is required for both hazardous waste and radioactive pollution storage, the scope is vastly different for CCS. First, the physical and chemical properties of the stored substances are very different, as are their impacts. CO₂ is dynamic rather than static after injection, so monitoring legislation will need to be flexible in terms of the area that should be monitored, the evolution of monitoring during injection, and the exact tools required. Broad criteria such as monitoring for leakage, plume movement, and groundwater quality might be included, but monitoring plans will need to be individualized and tied to site-specific characterization, modeling, and risk assessments.

Monitoring will likely involve multiple regulatory agencies. The MEP will be the most important agency monitoring ground and surface water, amongst others. SAWS could be involved in the monitoring of infrastructure, and the MLR could be involved in tracking geological indices.

3. A model and simulation of the injection should be conducted and data routinely collected and reported to the regulator.

Operational monitoring requires essential data and information. For example, an operator should report the composition of the injected fluid, the volume injected, the flow rate, and reservoir pressure. A model and simulation of CO₂ injection should be required, and that model must be integrated with data collected during operational monitoring as well as site characterization (or exploration). This integrated planning is important to the overall success of CCS operations, because by updating the model periodically with monitoring data, over time the model can better resemble geologic conditions in the field and better predict CO₂ behavior in the subsurface.

Though there is precedent for environmental monitoring at storage sites, because most existing storage activities are for static compounds, modeling and simulation will be a new practice for Chinese regulations. Currently, physical and chemical characteristics of dangerous chemicals to be stored must be submitted for approval, but do not need to be monitored during or after placement. Chinese legislation will need to specify the purpose of models and simulations to predict movement, and ensure that they are recalibrated from characterization and monitoring data.

The MEP and maybe MLR will be the most active agencies involved in reviewing modeling and simulations.

4. A comprehensive risk assessment should be conducted based on site-specific data.

The operator must locate all potential leakage pathways such as faults and fractures as well as all man-made well bores; identify all potential hazards and impacts such as leakage into and acidification of drinking water aquifers; and evaluate these risks using modeling based on site-specific data. A site-specific risk assessment that is informed by data collected during geological site characterization and operations is essential in ensuring successful site selection and operation. Similarly, having plans in place to manage any unexpected movement of CO₂ is critical to responsible CCS operations.

Current legislation requires environmental, resource, and economic impact statements. Safety appraisals are also required in the case of dangerous chemicals, but these impact statements and appraisals are not substitutes for the risk assessments necessary for CO₂ geological storage regulations. For one, they are not necessarily comprehensive: they do not consider all possible complications or impacts in the same

way that CCS projects look not only at risks associated with injection but also at the effects of CO₂ in the subsurface and at the consequences of potential accidents. Also, current impact statements for industrial projects in China are not directly connected to monitoring schemes, whereas the monitoring plan for CCS projects should be designed around the identification of site-specific risks. Therefore, current impact statements and appraisals should be either incorporated into, or remain in addition to, a comprehensive risk assessment.

The MEP would likely be the lead agency in reviewing the risk assessment with SAWS. The MLR and MWR may also potentially play a role.

5. The area to be evaluated and monitored should extend beyond the injected CO₂ plume.

Potential impacts of a project extend beyond the boundary of the injected CO₂ and include any area of elevated pressure in the surrounding formation fluid. This expanded project footprint should be the area of consideration for modeling, monitoring, and risk assessments.

Since current monitoring requirements do not extend beyond the boundaries of the stored substance and facilities, such an approach will be new for Chinese legislation. The MEP and maybe MLR will need to be involved in approving and enforcing monitoring over the entire project footprint.

6. The regulatory framework should be reviewed regularly and adapted as new information becomes available.

A regulatory framework for CCS should allow flexibility to adapt as collected data informs the operators' understanding of the subsurface. National regulations may also need to be revisited as more industrial-scale experience is gained. One approach is to require a formal review of the environmental regulatory framework on a periodic basis. Another is to issue a pilot regulatory framework that applies to demonstration projects and is updated and finalized prior to wide-scale commercial deployment of the technology.

Current coal mining standards in China are reviewed at set intervals. Similar review procedures could be adapted as legislative procedure for CCS regulations. Also, as Chinese laws tend to be concise and use general terms, while standards and specific regulations provide the details, a law could be written that provides general performance standards and guidelines with detailed standards evolving over time with new knowledge of best practices around the world. Enforce-

ment measures must also be adopted, with penalties for non-compliance with regulations.

7. A plan for the post-closure stewardship of the site and transfer of responsibility should be clearly articulated.

A regulatory framework must specify how the site will be monitored after an operator stops injecting CO₂, closes the injection wells, and completes the required post-closure monitoring. Importantly, responsibility for a site should transfer from the operator to the competent authority (or government) at some point in time and the criteria for transfer should be clearly articulated. China's existing law on the prevention and control of radioactive pollution does not provide specific regulations regarding post-closure management.

The time period covered by CO₂ storage regulations may be considerably longer than the hundreds of years existing regulations cover for storing other substances. Clearly stating the requirements for closure, transfer, and the liability along the way will be essential. Leaving liability solely with the private sector will make deployment of CCS technology unlikely (STRACO₂ 2009). Normally the government bears very little liability in comparison to the private sector, and that liability normally falls on the individual officials involved in any errors. Hence, for CCS to be more attainable, the government will need to assume more liability and likely act as the receiving entity after project transfer.

Most environmental violations result in the liable party being responsible for the remediation and cleanup of any accidents in addition to a fine. China will need to set the penalties for violation of CCS regulations higher than the cost of following the law.

Agencies such as the MEP, MLR, SAWS, and NDRC will all likely have an active role in approving the closure, post-closure monitoring, and transfer of the site from the operator to long-term holding agent.

8. Public engagement is necessary.

Public engagement that is transparent and open at all levels of society, from local to national, should be required as part of a comprehensive CCS regulatory framework. Such engagement should go beyond exchanging information to include consultation or negotiation with the local community where siting is proposed.

China's current regulatory framework includes provisions for public participation as part of the Environmental Impact Assessment Law, and such assessments will be a necessary step for all CCS projects. Placement of storage sites is also likely to require local government approval, which is influenced by the opinions of the local community. Some laws, such as the radioactive waste disposal law, call for public education to take place as part of the site selection process. For CCS, public engagement should be emphasized throughout, from the inception of the project through post-closure management. The capacity for ensuring such engagement is already in place among the MEP, NDRC, and local governments.

V. CONCLUSION

Coal is expected to account for 50 percent of China's total power generation in 2030 and academic models show that a reduction in China's CO₂ emissions will require commercial deployment of CCS technology, beginning in the next few years, growing in importance between 2020 and 2030, and reaching significant deployment post 2030. If CCS is to be a major part of a low-carbon strategy, environmental, health, and safety regulations are essential and must be planned early on in the development process. For example, regulations should be required to ensure that CCS projects, if deployed, are sited in areas where the CO₂ will remain contained in the subsurface, that projects are operated responsibly to avoid accidental release of CO₂, and that there is long-term stewardship of CCS sites.

This brief demonstrates that the political institutions exist to support a CCS regulatory framework in China, along with some potentially adaptable laws and regulations. However, elements of CCS regulation not closely related to current industrial activities, primarily those related to geological storage, will likely require new regulations or standards. These will need to be in place before large-scale commercial CCS initiatives can move forward.

Further, China's experience in environmental regulation is relatively new and investments in adequate regulatory capacity will be essential to safe and effective CCS operation. One approach for regulating CCS in China is to develop and implement a pilot regulatory framework for the first demonstrations, which can be revisited prior to wide-scale deployment of the technology. Such an adaptive approach has the advantage of building on lessons learned during CCS demonstrations in China and elsewhere around the world.

This paper outlines eight criteria that should be considered by any country in developing an environmental regulatory framework for geologic storage. To be successful, a number of different ministries and stakeholders will need to develop a shared understanding for how China might enable CCS development and coordinate where responsibilities overlap. In addressing the details of such a structure, both this policy brief and the more comprehensive Tsinghua-WRI *CCS Regulatory Guidelines* can provide useful input.

China is only beginning to address the regulatory, legal, and financial challenges involved in CCS demonstration and deployment. At present these issues fall within the purview of the State Council's Climate Change Leading Group. For effective deployment in the energy sector, the State Council will need to consider how to involve the Energy Leading Group as well, and ensure coordination between the two Leading Groups. One key gap is that both these Leading Groups are staffed at the Ministry level, and there do not appear to be any full-time staff in the State Council itself working on CCS policy coordination. State Council-level staffing as well as the use of the Leading Groups will be critical for effective coordination.

NOTES

1. Long-term stewardship includes establishment of (1) a framework for liability and (2) a plan for routine monitoring and maintenance at the CCS site in the post-closure phase of a project.
2. See <http://www.wri.org/project/carbon-capture-sequestration/proposal-matrix>.
3. The 2050 China Energy and CO₂ Emissions Report is a major effort of the Development Research Center of the State Council, the Energy Research Institute under the National Development and Reform Commission, and the Tsinghua University Nuclear and New Energy Research Institute. The China Human Development Report 2009/10 was commissioned by UNDP China and coordinated by Renmin University of China. These reports involve modeling contributions from the Energy Research Institute, the Development Research Center, the Chinese Academy of Social Sciences, Tsinghua University, and Renmin University.
4. See page 59 of the China Human Development Report 2009/10 for estimates of GHG reductions from CCS deployment and page 763 of the 2050 China Energy and CO₂ Emissions Report for the assumptions, including CCS, in the "enhanced low carbon" scenario, charted on page 759. We are grateful to David Fridley of Lawrence Berkeley National Laboratory for his model without CCS, which he is still in the process of developing, which finds that emissions peak and then the curve flattens, but does not decline. These findings are also broadly consistent with Guan et al.'s (2008) conclusion that up through 2030 CCS could reduce the growth of emissions but would not enable China to reach an actual peak. However, Guan and colleagues did not map out a post-2030 scenario; all of the models by Chinese scholars as well as David Fridley date the peak at different points, but consistently post-2030.

Appendix 1.

Agency / Ministry	State Council	National Development and Reform Commission (NDRC)
Duties	<ul style="list-style-type: none"> Executive branch of the Chinese government in charge of overseeing all ministries and agencies Approves licenses for the underground storage of radioactive waste 	<ul style="list-style-type: none"> Overall economic planning ministry Has internal Departments of Climate Change, Energy Research, Industry, and Environment that will also play a role in CCS decision making Has both macro policy and project approval functions
Overlaps	<ul style="list-style-type: none"> Stands above all other ministries and agencies Overlaps with the NDRC on some major decisions 	<ul style="list-style-type: none"> Project approval overlaps particularly with NEA and MLR Funding overlaps with MOF Climate policy driven by both domestic concerns and international negotiations strategy
Focus	<ul style="list-style-type: none"> Approval 	<ul style="list-style-type: none"> Energy Policy, Approval
Potential Role in CCS	<ul style="list-style-type: none"> For projects over US\$500 million, they have the right to verify the approval decision of the NDRC Could be involved with storage approval 	<ul style="list-style-type: none"> Overall project approval for all large projects
Existing Laws & Regulations	<p>– Storage –</p> <p><u>1. Prevention and Control of Radioactive Pollution (Environment/Health/Safety)¹</u> – Governs radioactive pollution from the source to final deposit, including transport. Includes provisions for public education on radioactive waste storage. Regulation covers pollution and prevention standards, monitoring and supervision, operating procedure, and emergency response from the source to storage. Regulations for siting include geological standards and proximity restrictions to resources, organisms to which waste could be harmful. Separates the governance duties of the national and local governments. <i>May be the best reference for drafting comprehensive CCS regulations that include transport, storage siting, monitoring, environmental assessment, public education, and local cooperation.</i></p>	<p>– All Phases –</p> <p><u>1. Approving Domestic and Foreign Investment Projects (Administrative)²</u> – States the application materials and process necessary for all projects greater than US\$100 million. These include: company registration, project plan, EIA, investor agreement, financial investment report, economic, social, and resource impact assessment. <i>Given their size, all CCS projects would be subject to this approval process. Measures stipulate that special processes can be created meaning they could design one especially for CCS. Approval will be informed by other environmental, health, and safety regulations.</i></p>

1. **Law of the People's Republic of China on the Prevention and Control of Radioactive Pollution** (passed by NPC, 2003) (中华人民共和国放射性污染防治法); GB 14500-2002: Regulations for radioactive waste management (issued by Standardization Administration of China, 2002) (国标 14500-2002: 放射性废物管理规定).

2. Interim Measures for Examining and Approving Foreign Investment Projects (set by NDRC, 2004) (企业投资项目核准暂行办法); Interim Measures for Examining and Approving Enterprises' Investment Projects (set by NDRC, 2004) (企业投资项目核准暂行办法).

Agency / Ministry	Ministry of Environmental Protection (MEP)
Duties	<ul style="list-style-type: none"> Regulates pollution, including air pollutants, groundwater protection, and landfill and hazardous waste regulations Requires and evaluates Environmental Impact Assessments (EIAs)
Overlaps	<ul style="list-style-type: none"> EIA process can conflict with NDRC and MLR project approvals Water quality protection interfaces with MLR allotments
Focus	<ul style="list-style-type: none"> Enforcement
Potential Role in CCS	<ul style="list-style-type: none"> Environmental regulator for CCS projects
Existing Laws & Regulations	<p>– All Phases –</p> <p><u>1. Water Pollution Control (Environmental/Health)</u>³ – These regulations include articles on preventing pollution of drinking water sources (surface and underground), specifically covering: underground engineering facilities, underground prospecting/mining, other underground activities. There are also articles that address pollution liabilities, disputes and exploitation. The regulations do not apply to brine, mineral, or geothermal groundwater. <i>Because it does not apply to brine, the regulations do not cover saline aquifers, but would apply to the leakage of CO₂ from the storage reservoir into drinking water sources.</i></p> <p><u>2. Environmental Protection Law (Environmental)</u>⁴ – Foundation of all Chinese environmental laws and regulations. Puts forth that it is illegal to willfully harm the environment. Primarily enforced through other laws on air, water, solid waste, etc. Stipulates that the Environmental Impact Assessment must be followed. <i>May be the basis for other environmental laws under which CCS projects will be governed.</i></p> <p><u>3. Environmental Impact Assessment (Environmental)</u>⁵ – This law establishes EIA procedures. The report of the environmental impacts of a construction project shall include the following elements: project introduction, description of the surrounding environment, prediction and appraisal of the environmental impacts that may be caused by the project, measures for protecting the environment as well as a technical and economical demonstration, an analysis of the economic benefits and costs of the environmental impacts that may be caused by the project, suggestions for carrying out environmental monitoring of the project, and conclusion of appraisal of the environmental impacts. EIA approval requires public participation in reviewing both plans and projects. The law itself is general in its requirements. MEP then has more specific requirements for public participation in projects. EIA approval is required for project approval. <i>CCS projects will require EIAs. The EIA law may provide the reference for developing procedures for CCS post-closure stewardship.</i></p> <p>– Capture –</p> <p><u>4. Law and Standards on the Prevention and Control of Air Pollution</u>⁶ (Environmental) – These regulations have specific articles that prevent and control atmospheric pollution resulting from coal burning, including limits for: SO₂, NO_x, and particulate matter. The Law on Prevention and Control of Air Pollution also has an article encouraging development and deployment of clean coal technologies. <i>A government classification of CO₂ could provide a legal basis for its emission control and accelerate CCS deployment. CO₂ is not currently classified as a hazardous gas, pollutant, or greenhouse gas. A CCS plant would be held to these regulations for SO₂ and other regulated pollutants.</i></p> <p><u>5. Solid Waste Pollution Law (Environmental)</u>⁷ – The legal basis for regulating solid waste production, disposal, and pollution. Controls solid products or bottled gases that would be abandoned or discarded by the facility. Defines the stakeholders and legal liabilities. <i>Since many CCS capture facilities will be producing industrious and hazardous solid waste as a byproduct of their routine operations, this law will apply.</i></p>

3. **Law on Prevention and Control of Water Pollution** (passed by NPC, last amended in 2008) (水污染防治法); Implementing Rules on Law on Prevention and Control of Water Pollution (set by State Council, 2000) (水污染防治法实施细则); Groundwater Quality Standards (set by MEP, 2007) (地下水质量标准); Regulations on the Administration of the Prevention and Control of Pollution in Protected Areas for Drinking Water Sources and Groundwater (provided by the Former Administration of Environmental Protection and the Ministries of Health, Construction, Water Resource, and Land and Resources, 1989) (饮用水水源保护区污染防治管理规定).

4. **Environmental Protection Law of the People's Republic of China** (set by NPC, 1989) (中华人民共和国环境保护法).

5. **Environmental Impact Assessment Law** (passed by NPC, 2003) (环境影响评价法).

6. **Law on Prevention and Control of Air Pollution** (passed by NPC, last amended in 2000) (大气污染防治法); Implementing Rules on Law on Prevention and Control of Air Pollution (issued by State Council, 1991) (大气污染防治法实施细则); Emission Standards of Air Pollutants for Thermal Power Plants (issued by MEP, 2004) (火电厂大气污染物排放标准).

7. **Law of the People's Republic of China on Solid Waste Pollution** (set by NPC, 2004) (中华人民共和国固体废物污染环境防治法[2004 修订]).

Agency / Ministry	Ministry of Environmental Protection (MEP) (cont.)
Existing Laws & Regulations (cont.)	<p>– Storage –</p> <p><u>6. Standard for Underground Storage of Hazardous Waste (Environmental/Health)</u>⁸ – The Standard includes provisions requiring conformance with national and local plans. The siting requirements include geologic characteristics and provide protection for human health and natural resources. For instance, the site must be 800m to the leeward side of the nearest residence. An environmental risk assessment is required as part of the site selection permitting process. The landfill site cannot be located in the following zones: city industrial, agricultural development planning, agricultural protection, natural protection, scenic resort, archaeological site, drinking water resource, long-term water supply, mineral resource reservation, and other protected areas. This Standard sets monitoring requirements for landfill sites, including groundwater and air sampling. The local environmental protection department is responsible for oversight, including periodic inspections and review of monitoring results. <i>This standard provides a reference for developing regulations and standards for storage site selection, which should also conform to local plans, include an environmental risk assessment, and avoid protected zones. Additional research in this area is found in Industrial Wastes Underground Injection Technology Demonstration and Relevant Environmental Regulations Research (2005.5-2010.12) supported by the Ministry of Environmental Protection and DuPont. This standard sets a precedent for the role of local environmental protection in oversight of monitoring underground storage.</i></p> <p><u>7. Management of Dangerous Chemicals Production and Storage Construction Projects (Environmental/Safety)</u>⁹ – Includes liquefied or compressed gases. Requires a safety appraisal of storage sites that includes: identification of dangerous factors; quantitative and qualitative analyses of storage technology, capacity, methodology, facilities, and safety; interaction of project and surrounding communities, including risk level; and effects on natural conditions. Included in documentation are: a feasibility study report; physical and chemical analyses of chemicals to be stored; technical requirements for packing, transport, and storage; safety appraisal; and emergency measures. <i>It is not clear if compressed CO₂ would fall into this category and will depend on the legal classification of CO₂. However, the law and regulations provide a basis for application materials and process that would be needed for receiving permission to store CO₂ at a particular storage site.</i></p> <p><u>8. Marine Environmental Protection (Environmental)</u>¹⁰ – Marine Environmental Protection Law is applicable to all EIA's done for projects involving marine waters. Sets the rules for the protection of the marine environment and the prevention and control of pollution damage due to the actions of vessels, waste dumping, land based pollutants, etc. <i>This would apply to CCS projects conducting offshore geological storage or transporting CO₂ via ship across open seas.</i></p> <p><u>9. State Council #1</u></p>

8. Standard for Underground Storage of Hazardous Wastes (set by Former Administration of Environmental Protection, 2002) (危险废物填埋污染控制标准).

9. Safety Management Regulation for Dangerous Chemicals (set by the Former State Administration of Environmental Protection, 2005) (废弃危险化学品污染环境防治办法); Measures for the Safety Review of Dangerous Chemicals Production and Storage Construction Projects (set by State Administration of Work Safety and State Administration of Mine Safety, 2005) (危险化学品生产储存建设项目安全审查办法).

10. Marine Environmental Protection Law of the People's Republic of China (set by NPC, 1982) (中华人民共和国海洋环境保护法[1999 修订]).

Agency / Ministry	Ministry of Land and Resources (MLR)
Duties	<ul style="list-style-type: none"> • Governs land use • Sets land use laws, including underground mineral rights • Project approvals for geological exploration and siting • Governs all underground resources including oil, coal, and water
Overlaps	<ul style="list-style-type: none"> • Land planning functions interact with NDRC's industrial planning and MOHURD's land zoning • Project approvals interact with NDRC's project approval • Land and water resource protection interact with MEP and MWR
Focus	<ul style="list-style-type: none"> • Approval, Enforcement
Potential Role in CCS	<ul style="list-style-type: none"> • Energy facility and pipeline siting • Subsurface and surface property rights • Involved in issuing geological exploration and storage permits • Monitoring of geological indexes
Existing Laws & Regulations	<p>– Transport & Storage –</p> <p><u>1. Property Rights Law (Administrative/Legal Structure)</u>¹¹ – These laws and regulations have specific articles stating State ownership of: mineral resources; inland waters; maritime areas; urban land; rural land and the land on the outskirts of the city and all natural resources such as forests, mountains, grassland, unclaimed land and beaches with the exception of the resources that are collectively owned. The collective units own lands, forests, mountains, grasslands, unclaimed land, and beaches according to law. Law is also administered by the State Administration for Industry & Commerce (SAIC) and Ministry of Housing and Urban-Rural Development (MOHURD). <i>CO₂ transport pipeline siting and storage would raise the issues related to property rights. For rural land, property rights may lie with the collective units and not the State.</i></p> <p>– Storage –</p> <p><u>2. Coal Law (Administrative/Legal Structure)</u>¹² – The coal law controls mining operations, including safety procedures. Law is also administered by the State Administration of Coal Mine Safety. <i>CO₂ storage may be located in coal mining areas. This law requires the project operator to get permission from the coal mining enterprise and related coal administrative departments.</i></p> <p><u>3. Land Administration & Mineral Resources Law (Administrative/Legal Structure)</u>¹³ – The law provides for use rights, rules governing leasing, and property investments involving shareholding. The law establishes protections for agricultural land and for rural land use–right holders. It governs ownership according to both legal rights and planned uses. Contains procedures for permitting, registration, and management of geological survey including for exploration of mineral resources, oil, and natural gas. <i>The law establishes protection for both farmland and mineral rights that need to be considered in CCS projects. However, the law does not address underground uses that might impact on mineral resources. Provides a basis to draw from in designing a process for obtaining storage exploration permits.</i></p> <p><u>4. Urban and Rural Planning Law (Administrative/Legal Structure)</u>¹⁴ – Sets the rules for land zoning in different localities. Law also administered by MOHURD and local city governments. <i>CCS capture facilities and storage facilities will need to abide by the land use plans of their region.</i></p> <p><u>3. MEP #6</u></p>

11. **Property Rights Law** (passed by NPC, 2007) (物权法).

12. **Coal Law** (enacted by NPC, 1996) (煤炭法).

13. **Land Administration Law** (enacted by NPC, latest amended in 2004) (中华人民共和国土地管理法; Implementation Regulations for Land Administration Law (set by State Council, 1998) (中华人民共和国土地管理法实施条例); Geological Exploration Management Ordinance (set by State Council, 2008) (地质勘查资质管理条例); Geological Exploration Registration Rules (set by State Council, 2006) (地质勘查资质注册登记办法); **Mineral Resources Law** (passed by NPC, latest amended in 1996) (中华人民共和国矿产资源法); Implementation Rules for Mineral Resources Law (set by State Council, 1994) (中华人民共和国矿产资源法实施细则); Measures for the Registration Administration of Mineral Resources Exploration (set by State Council, 1998) (对矿产资源开发登记管理办法).

14. **Urban and Rural Planning Law of the People's Republic of China** (set by NPC, 2007) (中华人民共和国城乡规划法).

Agency / Ministry	State Administration of Work Safety (SAWS)
Duties	<ul style="list-style-type: none"> Oversees and drafts policy on worker and construction safety Oversees and directs work safety inspection and testing
Overlaps	<ul style="list-style-type: none"> Overlaps with MLR and MEP on the regulation and supervision of dangerous chemicals
Focus	<ul style="list-style-type: none"> Enforcement
Potential Role in CCS	<ul style="list-style-type: none"> Will inspect and approve of work conditions for CCS projects Possible role in the approval of storage sites Pipeline construction and safety governance
Existing Laws & Regulations	<p>– All Phases –</p> <p><u>1. Production Safety Law (Safety)</u>¹⁵ – Sets the basis for the training of workers, safety approval of facilities, safety inspection, management responsibilities, and emergency response. <i>All aspects of a CCS project, especially the capture facilities, will be held to these same standards for work safety.</i></p> <p>– Transport –</p> <p><u>2. Protection of Oil and Natural Gas Pipelines (Safety/Administrative)</u>¹⁶ – The Temporary Provisions for Safety Supervision and Management of Petroleum and Natural Gas Pipelines have a chapter that sets requirements on pipeline siting, route investigation, and design. It also establishes procedures for investigating and addressing pipeline accidents. <i>These regulations provide a reference for framing legislation related to CO₂ pipeline route selection.</i></p> <p><u>3. Regulations for Pressurized Pipelines in Chemical Companies (Safety)</u>¹⁷ – These regulations provide detailed provisions for pressurized pipelines, including standards for: manufacturing protocols, pressure limits, construction, operation, monitoring, and emergency response. <i>As CO₂ is transported in a super-critical state with high pressure, these regulations will be relevant to CO₂ pipeline standards.</i></p> <p><u>4. Provisions for Safe Supervision and Management of Petroleum and Natural Gas Pipelines (Safety)</u>¹⁸ – This regulation establishes the requirements for pipelines: steel manufacture, construction, operation, and testing. <i>As CO₂ is transported in a super-critical state with high pressure, these regulations will be relevant to CO₂ pipeline standards.</i></p> <p>– Storage –</p> <p><u>5. MEP #7</u></p> <p><u>6. MLR #2</u></p>

15. **Production Safety Law of the People's Republic of China** (set by NPC, 2002) (中华人民共和国安全生产法).

16. **Regulations for Protection of Oil and Natural Gas Pipeline** (issued by State Council, 2001) (石油天然气管道保护条例).

17. **Regulations Governing Pressurized Pipelines In Chemical Companies** (set by Former Ministry of Chemical Industry, 1995) (化工企业压力管道管理规定); Procedures for Test of Pressurized Pipelines In Chemical Companies (set by Former Ministry of Chemical Industry, 1995) (化工企业压力管道检验规程).

18. Temporary Provisions for Safe Supervision and Management of Petroleum and Natural Gas Pipelines (set by former State Committee of Economy and Trade, 2000) (石油天然气管道安全监督与管理暂行规定).

Agency / Ministry	General Administration of Quality Supervision, Inspection, and Quarantine (AQSIQ)	State Oceanic Administration (SOA)
Duties	<ul style="list-style-type: none"> Sets, manages, and administers national standards Oversees the Standardization Administration of China 	<ul style="list-style-type: none"> Subordinate to MLR Supervises and manages China's sea areas Enforces coastal environment protection
Overlaps	<ul style="list-style-type: none"> No overlaps 	
Focus	<ul style="list-style-type: none"> Enforcement 	<ul style="list-style-type: none"> Enforcement
Potential Role in CCS	<ul style="list-style-type: none"> Sets standards for liquid CO₂ in chemical, industrial, and food/beverage uses Works in standards setting for pipeline Inspects any imports to be used for CCS 	<ul style="list-style-type: none"> Undersea geological storage transport
Existing Laws & Regulations	<p>– All Phases –</p> <p>1. <u>Carbon Dioxide in the air of workplace (Health)</u>¹⁹ – Sets standard for CO₂ concentration in the air at work sites producing or handling CO₂. <i>Would be applicable to and enforced by all sites along a CCS project chain.</i></p> <p>2. <u>Standard for Commercial Liquid Carbon Dioxide (Safety)</u>²⁰ – This standard states the required purity levels for liquid CO₂ in chemical and industrial use. CO₂ volume should be 99% of the total, with a water weight below 0.4%. <i>Sets purity constraints by volume for industrial CO₂ use. Could be a reference for purity decisions on CO₂ in CCS.</i></p>	<p>– Transport –</p> <p>1. <u>Regulations Governing the Laying of Submarine Pipelines (Environmental/Administrative)</u>²¹ – These regulations have detailed provisions for permit application and approval procedures for sitting and constructing submarine pipelines, including the rights and liabilities of industry. These regulations include provisions for protection submarine pipelines as well as the economic and legal liabilities of pipelines damage. These regulations also provide construction procedures when there are conflicts with other engineering projects. <i>Existing provisions can provide a reference point for framing legislation related to CO₂ pipeline route selection. These regulations will be relevant for developing measures for CO₂ pipeline protection.</i></p>

19. National Standard GB16201-1996: Health standard for carbon dioxide in the air of workplace (set by Standardization Administration of China [SAC] under AQSIQ, 1996) (国标 16201-1996: 车间空气中二氧化碳卫生标准).

20. National Standard GB6052-1993: Commercial Liquid Carbon Dioxide (set by SAC under AQSIQ, 1993) (国标 6052-1993: 工业液体二氧化碳).

21. **Regulations for Governing the Laying Of Submarine Cables and Pipelines** (issued by State Council, 1989) (铺设海底电缆管道管理规定); Implementation Rules for Regulations for Governing the Laying of Submarine Cables and Pipelines (issued by SOA, 1992) (铺设海底电缆管道管理规定实施办法); Regulations for Protections of Submarine Cables and Pipelines (issued by SOA, 2004) (海底电缆管道保护规定).

Agency / Ministry	Ministry of Finance (MOF)	Ministry of Industry and Information Technology (MIIT)	National Energy Administration (NEA)	State-owned Assets Supervision and Administration Commission of the State Council (SASAC)	National Energy Committee (NEC)
Duties	<ul style="list-style-type: none"> Controls government budget Decision making for any government-funded projects 	<ul style="list-style-type: none"> Regulates industry Oversight role in industrial project and demonstration approvals 	<ul style="list-style-type: none"> Sets energy policy Approves energy projects Officially not a full Ministry – complex relationship with NDRC (Downs, 2008) 	<ul style="list-style-type: none"> Manages state-owned enterprises (SOEs) 	<ul style="list-style-type: none"> Lead decision maker on national energy and energy development strategy issues Reviews energy security and major energy issues Plans domestic energy development and international cooperation on energy issues
Overlaps	<ul style="list-style-type: none"> Interacts with NDRC in particular on design of government-funded projects – for energy can also involve NEA 	<ul style="list-style-type: none"> Energy industry mainly differentiated with NEA, but there are some overlaps 	<ul style="list-style-type: none"> Significant overlap with NDRC departments on both policy and project approvals Projects also subject to MLR and MWR constraints Major energy companies have significant autonomy 	<ul style="list-style-type: none"> SOEs under its management include PetroChina, Shenhua, and the State Grid 	<ul style="list-style-type: none"> Newly formed agency composed of the heads of many national ministries, agencies, and the state council The NEA is responsible for carrying out NEC decisions Will overlap with NDRC, MIIT, SASAC, and others
Focus	<ul style="list-style-type: none"> Policy 	<ul style="list-style-type: none"> Policy 	<ul style="list-style-type: none"> Energy Policy 	<ul style="list-style-type: none"> Administration 	<ul style="list-style-type: none"> Energy Policy
Potential Role in CCS	<ul style="list-style-type: none"> Approval for government financing Part of larger legal structure around CCS 	<ul style="list-style-type: none"> May approve for non-energy industrial source projects (such as cement) Part of larger legal structure around CCS 	<ul style="list-style-type: none"> Possible lead for establishing capture requirements 	<ul style="list-style-type: none"> One of the groups that will need to approve investment decisions for SOEs Part of larger legal structure around CCS 	<ul style="list-style-type: none"> The possible final decision maker for whether to fully deploy CCS with government backing, and if so, to what extent
Existing Laws & Regulations	None	None	None	None	None

Agency / Ministry	Ministry of Water Resources (MWR)	Provincial Governments and Branches of National Agencies
Duties	<ul style="list-style-type: none"> Ground and surface water protection Water allocation 	<ul style="list-style-type: none"> Administers national laws at a local level Can create province-level provisions for activities like resource extraction or use
Overlaps	<ul style="list-style-type: none"> Interactions with MEP and MLR approval processes Overlaps with MLR in controlling water as a resource 	<ul style="list-style-type: none"> Can write local provisions (not laws) as additions to national legislation Overlaps with NDRC and MLR in project siting
Focus	<ul style="list-style-type: none"> Enforcement 	<ul style="list-style-type: none"> Approval, Enforcement
Potential Role in CCS	<ul style="list-style-type: none"> Approves increases in water use for capture Monitors surface and groundwater quality 	<ul style="list-style-type: none"> Approves siting of storage projects within its jurisdiction Local branches of national agencies administer laws locally
Existing Laws & Regulations	<p>– Storage –</p> <p><u>1. Water Law (Environmental)</u>²² – The Water Law regulates that water resources including the groundwater are owned by State. The government administers a licensing system as well as requires compensation in some cases for use of water. <i>Because the boundaries of water rights are not defined clearly by existing laws, there are often water disputes between different administrative regions. The articles for groundwater pollution prevention are designed to avoid toxic and hazardous waste water discharge. To address liability in the event that the responsible company no longer exists, it calls for the government to establish the regulation system which is similar to the U.S. Superfund program, but such a mechanism has not been yet established.</i></p> <p><u>2. MEP #3</u></p> <p><u>3. MLR #2</u></p>	<p>– Storage –</p> <p><u>1. MEP #3</u></p> <p>– Administrative/Legal Structure –</p> <p><u>2. NDRC #1</u></p> <p><u>3. MLR #3</u></p> <p><u>4. MLR #4</u></p>
Other Existing Laws & Regulations Administered By Other Agencies Not-Listed	<p>– All Phases –</p> <p><u>1. Construction Law (Administrative/Legal Structure)</u>²³ –Governs licensing, qualifications, contracting, supervision and management of construction projects. The Law is administered by MOHURD. <i>As construction projects, CCS capture and storage facilities will be bound by the rules of this law while being constructed.</i></p> <p><u>2. Tort Law (Legal Structure)</u>²⁴ –Includes chapters on liability of environmental pollution and ultrahazardous activity. With respect to environmental pollution causing harm to an individual or his property, the principle is that the polluter is liable for all damages. In the case of multiple polluters, the liability is assessed according to the seriousness of each polluter’s actions. Exceptions and reduced liability include damages as a result of force majeure, victim’s actions, and third-party actions. With respect to ultrahazardous activities, damages resulting from high-pressure activities are liable. No definition for high pressure is provided. <i>In the event of accidents during a CCS project, damages to citizens would potentially be civilly liable. The inclusion of liability for third-party actions would be applicable to the destruction of pipelines by other party’s knowingly or in negligence.</i></p> <p><u>4. MEP #3</u></p> <p>– Transport –</p> <p><u>5. MLR #1</u></p> <p>– Storage –</p> <p><u>1. London Convention (Environmental/Safety)</u>²⁵ – Allows for offshore geological storage of CO₂ if injection is into a geological formation beneath the seafloor, the injected CO₂ stream is of high purity with few contaminants, and other wastes are not added to the injected CO₂. Injection is regulated according to the Risk Assessment and Management Framework for CO₂ Sequestration in Sub-Seabed Geological Structures covering site characterization, exposure assessment, effects assessment, risk characterization, and risk management. <i>As a signatory to the London Convention, all offshore CCS geological storage activities in China would be subject to the regulations stipulated by the OSPAR agreement.</i></p> <p><u>6. MLR #2</u></p> <p><u>7. MLR #4</u></p>	

22. **Water Law** (passed by NPC, 2002) (水法)

23. **Construction Law of the People’s Republic of China** (set by NPC, 1997) (中华人民共和国建筑法).

24. **Tort Law of the People’s Republic of China** (set by NPC, 2009) (中华人民共和国侵权责任法).

25. **London Convention** (Signatory, 1972, Ratified Amendments 1996, 2007) (overseen by the International Maritime Organization [IMO]) (伦敦公约).

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