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Permitting Issues Related to Carbon Capture and Storage for Coal-Based Power Plant Projects in Developing APEC Economies

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Executive Summary

Developing Asia-Pacific Economic Cooperation (APEC) economies are among the most rapidly growing economies in the world, necessitating a major expansion in electric power generation in the next several decades. Much of this new power generation will likely rely on fossil fuels, especially coal. Concern about global climate change and the growth of carbon dioxide (CO_2) emissions from the region's rapidly expanding coal-fired power generation sector raises the question of when capture and storage of CO_2 emissions from these plants may be implemented. Carbon capture and storage (CCS) technologies, which can be coupled with CO_2 utilization such as enhanced oil recovery (EOR), offer a viable technology solution to address the dramatic growth of CO_2 emissions from the rapidly expanding coal-fired generation sector of many developing APEC economies.

This study examines CCS legal and regulatory regimes for nine developing APEC economies: People's Republic of China, Indonesia, Republic of Korea, Malaysia, Mexico, the Philippines, Chinese Taipei, Thailand and Viet Nam. These APEC economies were selected for this study based on four criteria: (1) the economy is considered a developing economy; (2) the economy consumes a significant amount of coal as fuel for electricity generation; (3) the economy possesses potential CO_2 storage capacity, and (4) the economy has a likely need for CCS to achieve greenhouse gas emissions reductions and / or the presence of policies that offer an enabling environment for CCS.

Given the importance of CCS regulatory frameworks, there is a clear need for capacity building to prepare for the possible adoption of CCS in developing APEC economies. In line with these broader goals, the objectives of this project are:

- Review the work in progress in the region and around the world on relevant legal, regulatory, and permitting issues and frameworks;

- Identify issues likely to arise under a permitting regime for CCS projects in developing APEC economies, and

- Recommend capacity building efforts needed to advance CCS regulatory framework development and commercial readiness in developing APEC economies.

This study pursues these objectives through review of the state of CCS regulation in leading Organisation for Economic Co-operation and Development (OECD) jurisdictions, consultation with regulators and other stakeholders in each of the APEC developing economies included in the study, and collaboration with international organizations involved in capacity building in the region. In particular, the APEC study team cooperated with the Asian Development Bank (ADB) and the Global CCS Institute, both of which are actively engaged in advancing CCS regulation in the region of Asia.

Recommendations presented in the study concerning CCS regulatory regimes are based on review of CCS-specific laws and regulations in leading OECD jurisdictions, specifically Australia, Canada, the United States and the European Union, as well as evaluation of the particular economies' laws and regulations that could govern CCS. For each study

economy, detailed assessments of existing laws and regulations that would be relevant to a CCS project were conducted. The assessments examined existing laws and regulation that could be extended or adapted to address various aspects of the CCS chain (e.g. capture, transportation, injection, geologic storage and stewardship). Economy-specific assessments facilitated identification of issues likely to arise under a permitting regime and enabled economy-specific recommendations concerning law reforms and capacity building efforts.

Regulatory assessments were supported by extensive stakeholder consultations in each economy. For the nine economies included in this study, over 250 stakeholders from government, industry and civil society participated in meetings and reviewed the regulatory assessment of their respective economy. Similar to the regulatory assessments, stakeholder consultations were essential to identify issues likely to arise in each APEC economy and in the development of recommendations to address them.

For Indonesia, the Philippines, Thailand and Viet Nam, this study relied on regulatory assessments and stakeholder consultations conducted as part of the concurrent ADB study, "*Determining the Potential for Carbon Capture and Storage in Southeast Asia*," located in the ADB report. Both studies used a common methodology for legal and regulatory issues and were supervised by the same attorney.[1] For this APEC study, additional regulatory assessments were conducted for the People's Republic of China, Republic of Korea, Malaysia, Mexico and Chinese Taipei. The assessments comprehensively address economy-specific issues and recommendations.

Status of CCS-Related Laws in Developing APEC Economies

None of the nine developing economies in this study currently regulate any aspect of CCS (e.g. CO_2 capture, transport, injection or storage). Oil and gas and environmental protection laws provide a degree of guidance for CCS projects in all nine economies. In general, small-scale (< 1 million metric tons) test injections of CO_2 could probably go forward with regulatory oversight under existing laws. In economies such as Indonesia, Mexico and Thailand that have well developed laws regulating oil and gas operations, fully-integrated demonstration scale projects that have an oil and gas component (e.g. EOR or enhanced gas recovery (EGR)) could potentially go forward with modest adjustments to existing regulations. Early commercial and widespread deployment would require adoption of dedicated regulation or adaptation of existing regulations. Each APEC economy possesses laws that could be applied to CCS. In all likelihood, CCS permitting regimes would rely largely on existing laws and any new regulation would supplement or integrate existing regulation.

The determination of what constitutes an essential element of a CCS permitting regime will depend on many factors including technology, project scale, cost, policy and social factors. It should be emphasized that regardless of these potential factors, geologic storage integrity and environmental and public safety are essential principles for

[1] Asian Development Bank's Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

regulation in any context. Based on review of CCS laws of leading jurisdictions, the following seven principles should be reflected in any CCS regulatory regime:

- Comprehensiveness
- Safety and environmental integrity
- Public outreach and consultation
- Socio-economic policies
- Streamline regulation and coordination among regulatory agencies
- Flexibility to address site-specific conditions
- Efficient use of resources and protection of property rights

In addition to these principles, there are six categories of substantive issues that should be addressed in CCS regulation: environmental impact; capture; transportation; storage; legal and financial, and public engagement. Within these categories, the study identifies and discusses some two-dozen distinct elements. The study also includes exhaustive discussion of these elements based on examples from leading OECD jurisdictions that have developed CCS regulations.

A Path for CCS In Developing APEC Economies

The application of CCS in coal-fired power plants in developing APEC economies will require a strategy tailored specifically to the conditions of each economy. Such a strategy must address certain threshold issues for the adoption of CCS and present a feasible commercial path for the technology that these economies could pursue. The report identifies three threshold issues – cost, public acceptance and long-term liability – that must be addressed to facilitate CCS adoption.

There is a strong nexus between these threshold issues and regulatory regimes. The cost of CCS to consumers will be determined through power tariffs. Public acceptance of the technology will largely be shaped by the cost of electricity and the success of public engagement efforts. The perceived strength of the regulatory regime for addressing environmental integrity and safety issues would likely be a critical factor in public evaluation of the technology. Public acceptance issues increase the need for standards reflecting best practices in safety and environmental integrity, public engagement and education. Closely related to these issues is who will be responsible for the long-term stewardship of stored CO_2.

A commercially viable path must be identified by each economy without raising the cost of electricity for the poorest members of society. The financing strategy for each economy need not be identical, and differences among them point to different approaches. Based on our assessment of current and planned activities in the field of CCS among the study economies, the nine APEC economies can be characterized following one of two paths that could support adoption of CCS as part of coal-fired power generation — technology innovators or CO_2 users.

Technology innovators are focused on developing technologies for capture, transportation or storage. The People's Republic of China, Republic of Korea and Chinese Taipei are technology innovators. CO_2 users have economic uses for commercial volumes of CO_2, primarily for enhanced oil and gas recovery, and include the

People's Republic of China, Indonesia, Malaysia, Mexico, Thailand and Viet Nam. In our assessment, only China falls into both categories and only the Philippines does not clearly fit within either category.

Collaboration between industrial stakeholders such as oil and gas companies that may be able to utilize CO_2 for EOR and the power sector will be essential to the development of coal-fired power project with CCS. A theme of the study is that international collaboration should foster consensus among stakeholders in APEC developing economies, including officials responsible for policy development, technical personnel, key state-owned enterprises that could deploy CCS technology, and research institutions that advise and support government and industry. Public engagement efforts should reflect best practices in public education and outreach, and provide the public with a role in shaping CCS project developments. Finally, regulation and collaborative efforts should support a commercial path for CCS that foster innovation in delivering lower cost technology and benefits through CO_2 utilization wherever possible.

Future capacity building efforts by APEC and other international organizations should strengthen efforts among developing APEC economies to become CCS technology providers and/or CO_2 users, based on the strategy identified by each particular APEC developing economy. For economies adopting a technology innovation strategy, capacity building efforts that focus on demonstration projects and offer real world experience in implementing the practical technical and non-technical issues would be particularly appropriate to advance CCS research programs and helps position developing economies for export opportunities. These initiatives would help develop CCS technology as well as the associated regulation. For economies that adopt a CO_2 use strategy, the greatest opportunities are likely to exist in EOR and EGR applications. APEC has initiated a project to improve CO_2 EOR assessments and study regulation specifically for CCS involving EOR and EGR. This approach to regulation, which pursues an immediate application for CO_2 in the developing economy, would be both practical and appropriate to the needs of developing APEC economies that are oil and gas producers.

1. Introduction

1.1. Study Objectives

Rapid economic and energy demand growth in a number of developing Asia-Pacific Economic Cooperation (APEC) economies necessitates major expansion in electric power generation. Concern about global climate change and the growth of carbon dioxide (CO_2) emissions from the region's rapidly expanding coal-fired power generation sector raises the question of when capture and storage of CO_2 emissions from these plants may be implemented. Carbon capture and storage (CCS) technologies are the only current option to substantially reduce CO_2 emissions (up to 90%) from fossil fuel power plants. While still in the early stage of global development and demonstration, CCS could be a viable technology solution to address the dramatic growth of CO_2 emissions from the rapidly expanding coal-fired generation sector of many developing APEC economies.

APEC economies considering a large-scale (> 1 million tonnes (Mt)) CCS demonstration project or commercial adoption will require a legal regime that establishes a sound permitting system. Lack of institutional support for new energy and environmental control technologies is a pervasive barrier to their adoption and diffusion. For CCS, the lack of a regulatory and permitting regime creates uncertainty for the private sector and could pose a significant barrier to obtaining public acceptance and political and financial support for these projects. Therefore, regulation is important to providing certainty and transparency for project developers, investors, lenders and other stakeholders.

Given the importance of CCS regulatory frameworks, there is a clear need for capacity building to prepare for the possible adoption of CCS in developing APEC economies. In line with these broader goals, the objectives of this project are:

- Review the work in progress in the region and around the world on relevant legal, regulatory, and permitting issues and frameworks;

- Identify issues likely to arise under a permitting regime for CCS projects in developing APEC economies, and

- Recommend capacity building efforts needed to advance CCS regulatory framework development and commercial readiness in developing APEC economies.

1.2. Acknowledgements

Throughout this project, we sought opportunities to collaborate with other organizations to leverage complimentary activities. Specifically, this project relies on regulatory assessments and stakeholder engagement results for Indonesia, the Philippines, Thailand and Viet Nam that were part of a concurrent study conducted by the Asian

Development Bank (ADB), *Determining the Potential for Carbon Capture and Storage in Southeast Asia*[2] The Global CCS Institute (GCCSI), which funded the ADB study, organized meetings with national stakeholders in Malaysia and Mexico, provided contacts in other APEC economies and reviewed earlier drafts of this study. The GCCSI also reviewed the regulatory assessments developed and used in this APEC study as well as the ADB study. The BP Clean Energy Research and Education Centre at Tsinghua University, working with the World Resources Institute (WRI) on China's CCS regulatory framework development, organized a meeting to review the national regulatory assessment prepared as part of this project for the People's Republic of China. Sinotech Consulting organized meetings with stakeholders in Chinese Taipei.

Over 250 stakeholders from government, industry and civil society in this study's nine developing APEC economies participated in meetings and reviewed the regulatory assessment of their respective economy. These stakeholders, who generously provided their time and insights, were a central part of our effort.

Douglas Macdonald of AB Process Consultants, Ian Torrens of Leonardo Technologies, and staff at the Commonwealth of Australia's Department of Resources, Energy and Tourism and the Energy Pipelines Cooperative Research Centre provided comments on an earlier draft of this study. Diane Oh assisted with legal research and regulatory assessment preparation for the People's Republic of China, Mexico and Chinese Taipei. Parag Patel assisted in researching the laws of Organisation for Economic Co-operation and Development (OECD) economies.

2. Study Methodology

2.1. Criterion for Inclusion of APEC Economies in Study

This APEC study includes the following nine developing APEC economies: the People's Republic of China, Indonesia, Republic of Korea, Malaysia, Mexico, the Philippines, Chinese Taipei, Thailand and Viet Nam. These APEC economies were selected based on four criteria: (1) the economy is defined as a non-Annex I country under the United Nations Framework Convention on Climate Change (UNFCCC) or is otherwise considered a developing economy; (2) the economy consumes a significant amount of coal as fuel for electricity generation; (3) the economy possesses potential CO_2 storage capacity, and (4) the economy has a likely need for CCS to achieve greenhouse gas emissions reductions and / or the presence of policies that offer an enabling environment for CCS.

Among APEC economies, 15 economies are non-Annex I countries under the UNFCCC or otherwise considered developing economies. Although these economies are commonly regarded as "developing", several are at advanced stages of development. The 15 economies are set forth in the table below.

[2] ADB, Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

Consistent with the purpose of this study, only those economies that consume coal for electricity generation were included. Of the 15 economies, this requirement excluded Brunei Darussalam, Papua New Guinea and Singapore. While Chile, Peru and the Philippines use coal for electricity generation, they consume relatively low amounts compared to other APEC economies.

The third selection criterion is the general availability of potential geologic CO_2 storage capacity. Application of this criterion was determined based on a literature search on geologic storage potential in APEC economies. Also, an earlier APEC study, *Assessment of Geological Storage Potential of Carbon Dioxide in the APEC Region*, evaluated geologic storage potential across APEC economies and concluded that among developing economies the greatest storage potential is located in the People's Republic of China, Indonesia, the Republic of Korea, Malaysia, Mexico, the Philippines, Chinese Taipei, Thailand, and Viet Nam.[3] Based on this earlier APEC study, Chile, Hong Kong, China, Peru and Singapore were excluded from our effort.[4] Subsequent APEC research also suggested that the Republic of Korea, the Philippines and Chinese Taipei could have limited capacity.[5]

Finally, for economies with limited storage capacity, we also considered their ability to benefit from CCS technology, as reflected by the magnitude of their CO_2 emissions and coal consumption, and the presence of an enabling environment to support CCS deployment. The People's Republic of China, the Republic of Korea and Chinese Taipei have a demonstrated need for CCS to reduce their CO_2 emissions as they are highly industrialized, large coal consumers with significant CO_2 emissions. Furthermore, these governments are pursing comprehensive greenhouse gas regulation featuring carbon emissions trading which could create incentives for CCS adoption. In the case of the Philippines, stakeholder engagement as part of a concurrent ADB study revealed that government officials have a strong interest in considering the development of CCS regulation; therefore, the Philippines was included in this APEC study.[6]

In the cases of Chile, Hong Kong, China, Peru and Singapore, China, limited storage potential coupled with low volumes of coal consumption and overall CO_2 emissions favored their exclusion from this study. Moreover, these economies are pursuing greenhouse gas emissions strategies that focus on energy efficiency and, in the case of

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[3] Building Capacity for CO_2 Capture and Storage in the APEC Region: A Training Manual for Policy Makers and Practitioners. APEC Working Group Project EWG 03/2004T (March 2005).

[4] Little published research concerning storage capacity in these economies exist other than the APEC research cited in this proposal.

[5] Asia-Pacific Economic Cooperation (APEC), "CO2 Storage Prospectivity of Selected Sedimentary Basins in the Region of China and South East Asia", APEC Energy Working Group Project EWG 06/2003, 2005; see also Stefan Bachu, Bill Gunter and Mike Gerbis, "CCS Capacity Building in APEC Emerging Economies: Sharing the Canadian Experience in Training," Sixth Annual Conference on Carbon Capture & Sequestration, Pittsburgh, Pennsylvania, May 7-10, 2007.

[6] Asian Development Bank's Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

Chile and Peru, forest-sequestration, which would not provide an enabling environment for CCS.

Significantly, all of the economies identified for inclusion in the study also host oil and gas production, a strong indicator that the economy possesses well-characterized geologic formations that could be capable of storing CO_2 with supporting infrastructure that could be utilized for CCS projects. Depleted oil and gas reservoirs may also be candidates for enhanced oil recovery (EOR) or enhanced gas recovery (EGR) using CO_2 captured from coal-fired power plants or industrial facilities. It is important to note that oil and gas activity has been a key factor in the success of CCS demonstration projects in other APEC economies.[7]

Study Selection Criteria

	Coal Consumption (thousand short tons/year)	CO2 Emissions (thousand tons/year)	Domestic Oil/Gas Production	Priority for inclusion in Study
Brunei Darussalam	0	7,605	•	
Chile	7,379	71,705	•	
People's Republic of China	3,474,665	6,538,367	•	•
Hong Kong, China	13,593	39,963		
Indonesia	71,072	397,143	•	•
Republic of Korea	113,293	503,321	•	•
Malaysia	7,338	194,476	•	•
Mexico	19,890	471,459	•	•
Papua New Guinea	0	3,666	•	
Peru	16,349	42,988	•	
Philippines	10,357	70,196	•	
Singapore	6.6	54,191	Refining only	
Chinese Taipei	66,240	275,577	•	•
Thailand	35,605	277,511	•	•
Viet Nam	21,223	111,378	•	•

Source: US Department of Energy, Energy Information Agency; Carbon Dioxide Information Analysis Center.

[7] See C. Hart, "Advancing Carbon Sequestration Research in an Uncertain Legal and Regulatory Environment: A Study of Phase II of the DOE Regional Carbon Sequestration Partnerships Program," Cambridge, Massachusetts: John F. Kennedy School of Government, Harvard University (2009); and C. Hart, "Putting It All Together: The Real World of Fully Integrated CCS Projects - A Study of Legal, Regulatory and Financial Barriers in Phase III of the US Department of Energy Regional Carbon Sequestration Partnerships Program," Cambridge, Massachusetts: John F. Kennedy School of Government, Harvard University (2011).

2.2. Stakeholder Consultations

Stakeholder consultations were held in each subject APEC developing economy. Stakeholder meetings would typically last a half-day and be followed by individual meetings with key stakeholders. Participants in these meetings included regulators from ministries responsible for the power sector, oil and gas operations, and the environment, as well as subject matter experts from government and academia (national geologic surveys, science and technology ministries), industry groups (especially power sector, oil and gas), and in some cases included civil society (non-governmental organizations).

As noted previously, this APEC project relied on regulatory stakeholder engagements conducted in Indonesia, the Philippines, Thailand and Indonesia as part of a concurrent ADB study of CCS potential in these economies. Stakeholder engagements for both studies followed the same methodology and shared a common legal and regulatory expert. The stakeholder consultations conducted for both studies are set out in Exhibit A.

The purpose of the stakeholder consultations was to collect viewpoints from a broad group of representatives from regulatory agencies, industry, academia, civil society and other stakeholders and to identify key issues of concern regarding CCS deployment in developing APEC economies. These meetings also helped ensure that this final study reflects the priorities and conditions of each APEC developing economy, is accurate and comprehensive, and that its conclusions and recommendations are feasible and supported by key stakeholders.

Stakeholder consultations also served to build capacity among key constituents in economies where little prior knowledge about CCS previously existed. Meetings included general technical presentations, an overview of essential CCS permitting requirements and best practices from selected OECD economies (Australia, Canada (Alberta), the United States (US) and the European Union (EU)), and discussion of the particular economies' laws and regulations that could govern CCS. In advance of the final stakeholder meeting in each economy, a draft regulatory assessment for the particular developing APEC economy was circulated for review and discussion.

2.3. Regulatory Assessments

As part of this study, we conducted in-depth assessments of regulatory issues relating to CCS in each subject developing economy. The regulatory assessments are intended to provide a foundation for recommendations concerning permitting regimes and future CCS regulatory development. Each assessment was prepared based on research of laws and regulations, which was reviewed by stakeholders (including representatives from regulatory agencies and industry) and discussed at stakeholder meetings.

The assessments examined existing laws and regulation that could be extended or adapted to address various aspects of the CCS chain (e.g. capture, transportation, injection, geologic storage and stewardship). The assessments also considered financial incentives and liability provisions in existing law to the extent they could apply to CCS projects. The assessments analyzed gaps within the existing laws and assessed where

greater clarity would be desirable if existing laws were used to regulate a CCS project in the subject economy.

For this APEC study, we conducted regulatory assessments for the People's Republic of China, Republic of Korea, Malaysia, Mexico and Chinese Taipei, which are located in the appendices. We relied on assessments for Indonesia, the Philippines, Thailand and Viet Nam that were prepared as part of the concurrent ADB study, "*Determining the Potential for Carbon Capture and Storage in Southeast Asia*," which are located in the ADB report. Both studies used a common methodology and were supervised by the same attorney.[8]

[8] Asian Development Bank's Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

3. Status of CCS-Related Laws in Developing APEC Economies

None of the nine developing economies in this study currently regulate any aspect of CCS (e.g. CO_2 capture, transport, injection or storage). The only economy that possesses any law on CCS is the Republic of Korea, where the Ministry of Land, Transport and Maritime Affairs has issued a ministerial order to allow offshore (subsea) CO_2 storage subject to the development of standards and other requirements. Korea's CCS Master Plan calls for development of regulations by 2014. Although China has not yet adopted CCS laws, draft regulations have been prepared by WRI in collaboration with Tsinghua University with the participation of government, industry and academic institutions. In other study economies, efforts to promote CCS regulatory framework development are also being supported by the GSSCI and the IEA. Chapter 6 of this study describes these efforts in greater detail.

Oil and gas and water protection laws provide a degree of guidance for CCS projects in all nine economies. In general, small-scale (< 1 Mt) test injections of CO_2 could probably go forward with regulatory oversight under existing laws. In economies such as Indonesia, Mexico and Thailand that have well developed laws regulating oil and gas operations, fully-integrated demonstration scale projects that have an oil and gas component (e.g. EOR or EGR) could potentially go forward with modest adjustments to existing regulations. Indonesia, for example, possesses detailed regulations concerning waste injection associated with oil and gas, which could provide a foundation for CCS regulation. Early commercial and widespread deployment would probably require adoption of dedicated regulation or adaptation of existing regulations. The table below summarizes the general stages of regulatory readiness for the various types of CCS project activities.

Regulatory Readiness

Small-scale Test Injection	Fully integrated Small Research-scale Demonstration Projects	First Commercial Project (1 million tons/year or more)	Widespread Commercial Adoption
Regulate under existing environmental or petroleum laws	Adjustments to existing environmental and petroleum regulations	Develop dedicated CCS regulations or amend existing environmental and petroleum laws	Develop dedicated CCS regulations addressing full range of capture, transport, storage, post-closure liability and financial issues

While none of the study economies currently regulate CCS, all possess laws that could apply to CCS, be adapted, or provide a model for new regulation. The table below indicates the status of law and regulation for eight key CCS issues in each economy.

Eight Key Issues in Study Economies

	China	Indonesia	Korea	Malaysia
Classification of CO_2	Not specified. Environmental laws contain definitions that could be used to classify CO2 as pollutant or waste.	Not classified. Environmental Law contains definitions of "hazardous and toxic waste" that could categorize CO_2 as waste	Ministry of Land, Transport and Maritime Affairs (MLTMA) issued order allowing offshore sequestration and to impose charges or recover costs for the source of CO_2. Requires verification of the purity of CO_2 and could require treatment as a waste.	Not classified. Environmental Quality Act contains definitions for "pollution" and "pollutants" that could potentially apply to CO_2.
Jurisdiction over Pipelines and Reservoirs	State Council, National Development and Reform Commission, Ministry of Environmental Protection, Ministry of Land Resources	State Oil Company, with oversight from Ministry of Environment and DG Migas.	Ministry of Knowledge Economy, Ministry of Environment, MLTMA	State, delegated to Petronas.
Pore Space Ownership	State	State	Public or private, subject to government zoning and land laws.	Federal government, delegated to Petronas for oil-bearing reservoirs. Individual states generally have authority over onshore surface.
Regulatory regime related to storage and transportation	Law on the Protection of the Oil and Natural Gas Pipelines could be adapted for CO_2 or serve as a model.	Oil and gas and environmental laws	MLTMA specifically allows offshore storage of CO_2 subject to development of regulations. High-Pressure Gas Safety Control Act. MLTMA sets standards for transportation of substances by vessel or ocean pipeline.	Petronas Production Management Unit and Ministry of Natural Resources and Environment (MNRE)'s Department of Environment would likely have jurisdiction.
Long-term Management & Liabilities	Civil Law and environmental laws require compensation and remediation for damage to land.	Various polluter pays statutes	Various polluter pays statutes	Civil law and environmental laws impose liability for damage and require remediation.
Financial Assurance for Long-term Stewardship	Law on the Prevention and Control of Atmospheric Pollution provides a system of collecting fees for discharge of pollutants, which could serve as possible model.	Oil and gas regulation and production sharing contracts require operators to reserve funds for decommissioning. Environmental law requires guarantee funds to protect the environment.	MLTMA order allows charges or recover costs for CO_2 storage.	National Environment Fund could serve as model for CCS liability fund. Fund defrays costs of monitoring and remediation, partly funded by fees collected from industry.
Third Party Access Rights to Pipelines	Not specified.	Production sharing contracts contain provisions. DG Migas resolves disputes.	Not specified	Petronas Carigali owns all upstream oil and gas pipelines.
Regulatory Compliance & Enforcement Scheme	Mineral Resources Law and various environmental protection laws	Ministry of Energy and Mineral Resources' DG Migas and Ministry of Environment	Various Environmental Protection and marine management laws.	Petronas is responsible for planning, investment and regulation of all up-stream oil and gas activities. MNRE's Department of Environment regulate environmental compliance.
Public Participation	Law of the People's Republic of China on the Environmental Impact Assessment calls for public participation in "appropriate ways." It requires projects that could have an adverse environmental impact to seek the opinion of the public.	Environmental Impact Assessment, pro-community provisions in production sharing contracts, customary law	Environmental Impact Assessment, Framework Act on Environmental Policy and Framework Act on National Land. Official Information Disclosure Act requires disclosure of information to public.	MNRE issues guidelines for conducting EIAs. While not strictly requiring public hearings, guidelines describe the purpose of scoping the IEA to include understanding public opinion.

	Mexico	Philippines	Chinese Taipei	Thailand	Viet Nam
Classification of CO_2	Not classified. General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) defines "waste" broadly that could potentially apply to CO_2.	Defined as naturally occurring under Clean Air Act, but could be classified as "waste" under Law on Environmental Protection or "pollutant" under Clean Water Act.	Not specified. Greenhouse gas emissions are restricted by national policy. Environmental laws contain definitions that could be used to classify CO_2 as pollutant or waste	Not classified. National Environmental Protection and Promotion Act, contains definitions of "pollutant" and "waste" which could potentially apply, as well as Hazardous Substances Act.	Not classified. Law on Environmental Protection and Law on Water Resources, define "Waste" and "Pollution of Water Resources" that could potentially apply to CO_2.
Jurisdiction over Pipelines and Reservoirs	Secretariat of Energy (SENER), Secretariat of Environment and Natural Resources (SEMARNAT)	Department of Energy, Department of Environment and Natural Resources	Ministry of Economic Affairs' Bureau of Energy, Environmental Protection Agency	State Oil Company, with oversight from Ministry of Energy's Department of Mineral Fuels and Mineral of Natural Resources and Environment.	State Oil Company, with oversight from Ministry of Natural Resources and Environment and Ministry of Industry and Trade.
Pore Space Ownership	State	State	State except if is private. Rights include reasonable use of subsurface. Minerals remain state property.	State	State
Regulatory regime related to storage and transportation	General Law for Prevention and Integral Waste Management provides for injection of substances in underground geologic formations. If applied to CO_2, transport, storage or reuse would require license from SEMARNAT ad use of best practices and technology.	Clean Water Act and Water Code regulate injections near water sources	Petroleum Administration Act provides basis to regulate pipelines. Environmental laws, especially Ocean Pollution Control for offshore storage, provides basis for regulating storage.	Oil and gas and environmental laws	Oil and gas and environmental laws
Long-term Management & Liabilities	Civil Code, LGEEPA and other environmental laws provide for general civil liability for causing damage to the environment.	Various polluter pays statutes	Civil Code and the Basic Environment Act impose liability for pollution and environmental harm.	Various polluter pays statutes	Various polluter pays statutes
Financial Assurance for Long-term Stewardship	If CO_2 were treated as a "pollutant" under General Law for Prevention and Integral Waste Management, storage operators required to provide guarantees and remain liable for the site a minimum of 20 years after site closure for dangerous substances.	Environmental Guarantee Fund and Environmental Monitoring Funds required for certain environmental sensitive projects.	If CO_2 sequestered offshore, Ocean Pollution Control Act could impose financial assurance requirements. Operators submit emergency response plan and a letter of financial guarantee or liability insurance policy.	Environment Fund could serve as model for financial assurance mechanism.	Well decommissioning requirements and Oil and Gas Prospecting and Exploration Fund could provide a model for financial assurance mechanism.
Third Party Access Rights to Pipelines	PEMEX owns, operates and regulates all oil and gas pipelines. SEMARNAT and the Ministry of Transportation and Communications regulate pipelines that transport dangerous and toxic substances.	Not specified	Petroleum Administration Act requires operators to allow access to pipelines.	Energy Regulatory Commission regulates downstream gas pipelines. Oil and gas concession agreements contain provisions	Ministry of Industry and Trade regulates pipelines.
Regulatory Compliance & Enforcement Scheme	SEMARNAT and SENER. For CCS related to oil and gas operations, PEMEX would have operational and certain regulatory responsibility.	Various environmental protection laws	Environmental protection laws. Mining Act and Petroleum Administration Act could also be relevant.	Department of Mineral Fuels and Various Environmental Protection Laws	Ministry of Industry and Trade and Ministry of Natural Resources and Environment
Public Participation	LGEEPA provide certain rights to the public to participate in the EIA review process. The Federal Transparency Law requires federal agencies to provide public access to information.	Environmental Impact Assessment	Environmental Impact Assessment Act requires public disclosure and participation in review of Environmental Impact Assessment. Freedom of Government Information Law requires public disclosure.	Constitutional protections and Environmental Impact Assessment	Public "right to know" laws and Environmental Impact Assessment

4. CCS Regulatory and Permitting Best Practices

This section examines CCS legislation adopted in leading jurisdictions to evaluate emerging best practices in developing CCS legal and regulatory frameworks. In assessing best practices, we considered the laws of by Australia, Canada, the US and the EU, as well as the UNFCCC's modalities and procedures for CCS under the Clean Development Mechanism (CDM).[9] Our focus is on CCS-specific laws in these jurisdictions in order to provide a diverse set of examples upon which developing APEC economies and others can draw for examples and guidance. While APEC economies are likely to follow their own paths that reflect domestic conditions, examples from other economies reveal a consistent set of principles and issues that should be considered by any APEC economy considering CCS regulations.

While laws concerning reporting of greenhouse gas emissions, cap and trade or carbon taxes are highly relevant to supporting CCS development and deployment, we do not address these laws in detail.

In this section, we identify seven key principles of regulatory and permitting regimes based on these first-mover OECD economies. In the next section, we consider specific permitting issues and their appropriateness to developing APEC economies.

4.1. CCS Law and Regulation in OECD Economies

This section provides an overview of CCS regulation in leading OECD jurisdictions. We focus on regulations concerning CO_2 storage as this phase involves the greatest environmental risk and presents the most challenging regulatory issues. In Chapter 5 of this study, we look beyond laws governing storage and also consider regulations concerning other important aspects of CCS, such as capture, transportation, financing and liability for long-term storage.

Australia: Australia has developed CCS legal and regulatory frameworks at the Commonwealth and state levels. At the Commonwealth level, Australia has adopted a legal regime governing exploration, injection and storage aspects of geologic storage in offshore waters. This legislation addresses long-term stewardship of the storage site by indemnifying the site operator for liabilities arising in connection with its operation under a valid license where such liability occurs or accrues after completion of the closure assurance period.[10] If the operator ceases to exist, the Commonwealth assumes liability for the storage site directly.[11] Onshore CCS in Australia is governed primarily by state law

[9] Draft modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities, FCCC/SBSTA/2011/4.

[10] Section 400, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[11] Section 401, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

and Victoria, Queensland and South Australia have all adopted relevant legislation. Western Australia has developed regulation specifically for the Gorgon CO_2 Injection Project (Gorgon Project) and New South Wales and Western Australia are presently developing general CCS legislation.

Canada: The Canadian province of Alberta adopted comprehensive CCS legislation as parts of its Mines and Minerals Act, which provides a permitting regime for exploration, injection and storage, clarifies Crown ownership of pore space rights, and provides for long-term liability transfer to the Crown based on regulatory compliance. The provinces of British Columbia and Saskatchewan have modified existing oil and gas laws to enable CO_2 storage; however, these provinces has not developed comprehensive CCS regulations to the extent of Alberta.

United States: The US regulates CCS under the Safe Drinking Water Act's Underground Injection Control (UIC) program on the premise that injection of CO_2 could affect underground sources of drinking water. The US Environmental Protection Agency (EPA) adopted Class VI under the UIC program specifically to regulate dedicated CO_2 injection and long-term storage. Class II of the UIC program regulates CO_2 injection for oil and gas operations. Class VI provides requirements for site selection, operations, monitoring and closure. Notably, federal CCS regulation does not address pore ownership or liability. Property rights, and by extension pore ownership, is governed by state law. Several states have adopted their own CCS regulations, some of which address pore ownership and include provisions concerning long-term liability.

European Union: The EU adopted framework legislation for CCS that sets a number of requirements for permitting, well closure and transfer of liability to Member States. In order to be operative, the framework must be implemented into the laws of Member States, which requires Member States to provide detailed substantive legislation or regulation in line with EU directives. Currently, none of the Member States have complied with the directive but efforts are underway. In addition to the EU framework, the United Kingdom has enacted laws specifically providing financial and regulatory incentives for CCS under its Electricity Market Reform.

Clean Development Mechanism: The CDM's modalities and procedures for CCS provide rules for the development of regulation for developing countries seeking CDM treatment for a CCS project. The CDM modalities and procedures are consistent with regulatory best practices as reflected in the legislation of jurisdictions described here. The text box below summarizes the CDM modalities and procedures for CCS.

CDM Modalities and Procedures for CCS

The Conference of the Parties (COP) serving as the Meeting of the Parties (MOP) to the Kyoto Protocol at its seventh session designated CCS as an eligible practice under the CDM and adopted modalities and procedures for CO_2 capture and storage in geological formations as CDM project activities.

The modalities define CCS to mean "the capture and transport of carbon dioxide from anthropogenic sources of emissions, and the injection of the captured carbon dioxide into an underground geological storage site for long-term isolation from the atmosphere," where "geographical storage site" is defined as a geological formation that consists "a paired geological formation, or a series of such formations, consisting of an injection formation of relatively high porosity and permeability into which carbon dioxide can be injected, coupled with an overlying cap rock formation of low porosity and permeability and sufficient thickness which can prevent the upward movement of carbon dioxide from the storage formation."

Storage Site Characterization, Risk and Safety Assessment and Monitoring Plan

The Executive Board of the CDM is required to adopt standards and procedures for CCS activities. In order to determine whether the geological formation meets the requirements, project participants must follow a four-step scheme:

- Data and information collection, compilation and evaluation;
- Characterization of geological storage site and surrounding domains;
- Characterization of dynamic behavior, sensitivity and risk assessment; and
- Establishment of a site development and management plan.[12]

Additionally, project participants must carry out a risk and safety assessment in accordance with the international good practice. The risk and safety assessment must cover risks associated with the entire CCS project chain and specifically identify any potential effects on drinking water, seawater, human health and ecosystem health under two scenarios: seepage and mass release of carbon from a storage site. In assessing the potential risk associated with a CCS project, project participants should take the following steps:

- Hazard characterization;
- Exposure assessment;
- Effects assessment; and
- Risk characterization.[13]

The risk and safety assessment must also offer a remedial plan in the event of any unintended physical leakage or seepage of carbon from the storage site.

A monitoring plan is required that confirms injected CO_2 is contained within the geological storage site and the project boundary, ensures good site management is taking place, detects any seepage or impurities, updates numerical models through monitoring results, provides measurements of

[12] Appendix B, Paragraph 4, Decision -/CMP.7, Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities.

[13] Appendix B, Paragraph 2, Decision -/CMP.7, Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities.

geological, geochemical and geomechanical parameters, and provides measurements of the temperature and pressure of the carbon dioxide at the top and bottom of the injection well.

Host Country Legal Regime

The draft modalities require the host country of a CCS project to possess laws and regulations that:

- Set licensing criteria, including for site selection, characterization and development;
- Define rights to store carbon dioxide in subsurface formations;
- Provide sufficient redress for adversely affected parties;
- Provide sufficient remedial measures; and
- Establish mechanisms to address liability.[14]

The modalities require clear documentation of liability obligations associated with the CCS project and sufficient financial resources to cover the cost of remediation, of seepage, and of monitoring, verification and certification for at least 20 years following the closure of CCS site.

Responsibility for Net Reversals

Verification and certification by an operational entity are to determine any unintentional transboundary effects, whether seepage occurred and in the case of seepage, to determine whether the remedial plans a part of the risk and safety assessment were implemented and its effectiveness. Verification and certification must also determine if the storage site has been successfully closed and the amount, if any, of net reversal of storage.[15]

Upon finalization of a certification for a given verification period, the CDM Registry Administrator, operating under the Executive Board, will issue the verified quantity of certified emission reduction from anthropogenic emissions (CERs) to the parties' account, less CERs for administrative expenses and 5% to be placed in a reserve account of the CDM registry to compensate for any net reversal of storage. Upon the finalization of the last certification report, the CDM Registry Administrator will deposit the remaining CERs in the reserve net reversal of storage account minus any actual net reversal into the parties' registry account. If the net reversal exceeds the amount of CERs in a parties' reserve account, the CDM Registry Administrator shall cancel any pending CERs and then request project participants to transfer CERs, emission reduction units (ERUs), assigned amount units (AAUs) or removal units (RMUs) equivalent to the outstanding amount to a cancellation account. If project participants fail to transfer CERs, AAUs, ERUs or RMUs sufficient to cover net reversal of storage, the Executive Board shall either require the host Party to transfer the required units if it has accepted the obligation to address a net reversal of storage, or will instruct the international transaction log to identify the quantity of CERs issued in respect of the CCS project in each national registry and place those units into a holding account ineligible for transfer on a pro-rata basis up to the amount of such net reversal.

[14] Annex, Section F, Decision -/CMP.7, Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities.

[15] "Net reversal of storage" is defined by the draft modalities to mean, "For a verification period during the crediting period, the accumulated verified reductions in anthropogenic emissions by sources of greenhouse gases (GHGs) that have occurred as a result of a registered CDM project activity are negative (i.e. the seepage from the geological storage site of the CCS project activity exceeds the remainder of the emission reductions achieved by the CCS project activity)." Annex, Section A, Decision -/CMP.7, Modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities.

4.2. Seven Guiding Principles

Based on our review of CCS laws of leading OECD jurisdictions, the following seven principles should be reflected in any CCS regulatory regime:

- Comprehensiveness;
- Safety and environmental integrity;
- Public outreach and consultation;
- Socio-economic policies;
- Streamline regulation and coordination among regulatory agencies;
- Flexibility to address site-specific conditions; and
- Efficient use of resources and protection of property rights

4.2.1. Comprehensiveness

CCS regulation should be comprehensive, which has several aspects. Most importantly, regulation should cover all critical aspects of CCS and address threshold issues that must be resolved for any project to be considered. Another important aspect of comprehensiveness is that all laws that could potentially be relevant to CCS should be included in the review process and amended appropriately.

CCS involves four stages that should be addressed through regulation: capture; transportation; storage; and post-injection and closure. These stages implicate a broad range of laws and regulations. A regulatory process aimed at developing laws and guidance for CCS should review all potentially applicable laws, gaps in existing laws, and potential conflicts. These include laws concerning property rights and land use, environmental protection, water resources, minerals exploration and exploitation, transportation, health and safety, and intellectual property rights. A comprehensive process that addresses all aspects of the CCS value chain is most likely to produce law and policy that will facilitate the adoption and diffusion of CCS technology. Incomplete or conflict legislation could present deployment barriers.

There are several threshold issues that are fundamental to the success of a project, which comprehensive CCS regulation should address. Threshold issues include: pubic acceptance; retail cost of electricity for projects with CCS, and liability associated with long-term storage of CO_2. These issues can be addressed either within CCS regulation or other laws or regulation. Because these issues have proven to be difficult to address, they are sometimes omitted from regulation, in favor of focusing on more technical issues. Further in this chapter we address public consultation and socio-economic issues. In section 5.5.2, we discuss liability for long-term storage of CO_2. We also suggest possible strategies for APEC economies to address these threshold issues in the concluding chapter of this study.

Several jurisdictions have adopted CCS regulation that reflects the principle of comprehensiveness. For example, the EU directive on the geological storage of CO_2

('CCS Directive') provides a framework within which Member States are to adopt implementing legislation for a permitting regime that addresses CO_2 capture, transportation, storage, post-injection and site closure, and transfer of liability for long-term storage. With respect to the post-closure period, the directive requires Member States to accept liability based on all available evidence showing stored CO_2 will be "completely and permanently contained," a default monitoring period of 20 years has elapsed, financial security requirements satisfied, and the site has been sealed and injection facilities removed.[16] The directive addresses capture by requiring new power plants over 300 megawatts (MW) to consider whether CCS is economically feasible as a condition of permitting, imposing purity requirements for CO_2, amending regulation to allow for transportation via pipelines, and making recommendations for the amendment of other EU legislation concerning the transport of CO_2.[17] The EU Emissions Trading Scheme (ETS) further addresses CCS by setting caps on emissions and providing a financial incentive to deploy CCS or other low-carbon technologies. The New Entrants Reserve (NER) 300 program of the EU ETS also funds CCS demonstration plants in the EU by setting aside and auctioning 300 million EU Emissions Allowances (EUA).[18] With respect to public acceptance, another threshold issue, the EU directive requires the dissemination of information to the public and review of all projects at the community level.[19]

The table below summarizes the comprehensive elements of CCS legislation in four leading OECD jurisdictions and the requirements of the CDM modalities and procedures for CCS. The table reflects a consensus that certain issues should be addressed by regulation. The specific issues presented in the table below are explored in depth in the next chapter, which analyzes essential permitting regimes.

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[16] Article 18, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[17] Articles 12, 21, 31 and 33, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[18] Directive 2009/29/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community. With respect to NER 300, see Article 10a(8) of Directive 2009/29/EC and Commission Decisionof 3 November 2010 laying down criteria and measures for the financing of commercial demonstration projects that aim at the environmentally safe capture and geological storage of CO2 as well as demonstration projects of innovative renewable energy technologies under the scheme for greenhouse gas emission allowance trading within the Community established by Directive 2003/87/EC of the European Parliament and of the Council (2010/670/EU).

[19] Articles 26 and Preamble paragraphs 11 and 15, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

Legislation in Selected OECD Jurisdictions

Jurisdiction	Australia Commonwealth	Alberta, Canada	United States	European Union	CDM
Primary CCS Legislation	Offshore Petroleum and GHG Storage Act	Mines and Minerals Act	Class VI UIC Rule	EU CCS Directive	CDM Modalities
ENVIRONMENTAL					
GHG Reporting	◆	◆	◆	◆	◆
CO_2 Classification				◆	
CO_2 Purity	◆	◆	◆	◆	◆
H_2O Use, Waste, Air Emissions				◆	◆
CAPTURE					
CCS Ready				UK	
Technology Forcing		◆		◆	
TRANSPORTATION					
Siting & Construction	◆		◆	◆	◆
Pricing & Access	◆			◆	
STORAGE					
Exploration Permit	◆	◆	◆	◆	
Storage Permit	◆	◆	◆	◆	◆
Characterization	◆	◆	◆	◆	◆
Well Construction	◆	◆	◆		◆
Operating Requirements	◆	◆	◆	◆	◆
MRV	◆	◆	◆	◆	◆
Plugging/Closure	◆	◆	◆	◆	◆
Remediation	◆	◆	◆	◆	◆
LEGAL					
Subsurface Rights	◆	◆	State Law		◆
CO_2 Stewardship	◆	◆		◆	◆
Financial Assurance	◆	◆	◆	◆	◆
Information	◆	◆		◆	
FINANCING					
CCS Incentives	◆	◆	◆	◆	◆
CCS Tariffs				UK	
Public Engagement					◆

4.2.2. Safety and Environmental Integrity

The safety and environmental integrity of CCS operations should be the guiding priority of regulation. Public acceptance and successful implementation of individual CCS projects, and ultimately commercial diffusion of the technology, depend upon it. Leading examples of CCS regulation reflect several general principles that promote safety and environmental integrity including: science-based regulation, continuous improvement, a role for all relevant agencies, and public dissemination of information.

CCS regulation should be based on science and fact-based assessments, which has several aspects. Permitting regimes must be based on a geologic site assessment and a rigorous monitoring plan that continue through injection and for a period after injection ceases. Leading examples of regulation in Australia, the EU and US all possess these basic elements.

Importantly, a science-based approach helps ensure that decision-making concerning environmental safety is grounded in technical factors versus political considerations. Site characterization and selection are critical steps in order to ensure environmental safety of a CCS operation. As part of this step, multiple potential sites should be identified and pre-screened against agreed criteria before proceeding to more in-depth and costly characterization. Consideration of multiple sites reduces the risk that stakeholders will become locked-in to a single site, which may prove to be unsound for technical, economic or public acceptance reasons.

Regulations should be designed to ensure that all stakeholders – government, industry, academic and expert organizations, and civil society – benefit from the lessons that early stage CCS projects necessarily involve. One way that regulations accomplish this is by integrating continuous improvement concepts through periodic project review. For example, US regulation under Class VI of the UIC program requires owners and operators to periodically review (at least every five years) the project area (known as the "area of review") and if needed, take corrective action to ensure that testing, monitoring, and remediation plans reflect any advances in science and technology.[20] Site-specific review includes analysis of actual CO_2 plume migration against modeled projections. Depending upon the results of the periodic assessments, the regulator can require changes to the monitoring plan or operation of the facility. This type of iterative review and revision of regulatory requirements, computational models and project operations help ensure that all parties have current knowledge of CO_2 plume movement and maintain the safety and environmental integrity of the project. The CDM modalities for CCS similarly require periodic review of models against actual monitoring, and corresponding changes to site management and operation plans.[21]

[20] 40 C.F.R. § 146.84(e), § 146.90(j), and § 146.94(d).

[21] Appendix B, Paragraph 11, Draft modalities and procedures for carbon dioxide capture and storage in geological formations as clean development mechanism project activities, FCCC/SBSTA/2011/4.

All agencies that regulate aspects of CCS should be included in the development of regulation, have full access to information concerning CCS research and demonstration projects, and coordinate their various regulatory roles. Cooperation among agencies in sharing information and participation in decisions concerning issues relevant to their jurisdiction is critical to the safe operation of a project and ultimately the success of the technology itself. A broad group of agencies have potential roles in regulating or facilitating CCS including: regulators concerned with environment, health and safety; water; oil and gas; power generation, and science and technology, to name a few. For the nine APEC developing economies included in this study, the appendices identify specific government agencies and their potential roles in CCS regulation.

While engagement by various government agencies should be encouraged and facilitated by regulation, at the same time the efforts of these various agencies should be coordinated by a lead agency. This is the approach taken, for example, in Australia by Victoria's Greenhouse Gas Storage Act, which appoints the Department of Primary Industries as lead agency, and requires it to consult with and obtain the recommendation of ministries responsible for environmental protection and water.[22] Engagement by relevant agencies, however, should not result in redundant or conflicting regulation. This issue is addressed further below on the principle of streamline regulation.

Finally, pubic dissemination of information is a critical aspect of safety and environmental integrity. Broad and timely dissemination of information enables academic and other expert organizations, civil society such as NGOs, and the local community to play a full role as project partners.

4.2.3. Public Outreach and Consultation

Public support for CCS is essential for its successful adoption and diffusion and is one of the threshold issues for individual project implementation. Gaining public support requires information sharing about the project as well as public engagement and consultation. Experience with other technologies and CCS demonstration projects to date strongly suggests that the consultation process should be initiated early in a project's planning and involve an open dialogue with stakeholders broadly drawn from government, industry, expert organizations, civil society groups such as NGOs, and most importantly, the local community in the project area.

Public engagement models range from public opinion surveys, to information dissemination, and active participation from key stakeholders and experts in project design and implementation. The prevailing view of best practices is that public engagement should be a two-way process that develops trust by actively inviting public involvement to shape and improve the project.[23] While experience suggests that public

[22] Section 41, Victoria Greenhouse Gas Storage Act 2008.

[23] See, e.g., World Resources Institute, CCS and Community Engagement: Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects (2010). National Energy Technology Laboratory (2009), Public Outreach and Education for Carbon Storage Projects. Washington, D.C.: US Department of Energy; Commonwealth Scientific and

engagement is generally more successful the earlier, more open, and more interactive the process, law and regulation typically only require minimal public dissemination of information, often as part of a zoning, environmental impact assessment or public hearing process.

Most jurisdictions require environmental impact assessments (EIAs) to be conducted for projects that could potentially cause significant environmental impacts. Regulations governing the preparation of EIAs typically require public participation during the approval process (e.g. one or more public hearings concerning the project). The EIA process can be critical to assuring the social acceptance and environmental integrity of CCS projects; however, a meaningful and effective public consultation process will involve more extensive public outreach than required for compliance with existing environmental and zoning laws.

While reliance on zoning and environmental impact assessment laws may be adequate for purposes of legal compliance for conventional coal-fired power plant, projects with CCS involve new technologies that are generally unfamiliar to the public and a more comprehensive public engagement strategy is advisable. Moreover, enforcement of zoning and environmental impact assessment laws is often weak in developing APEC economies. Accordingly, regulators should consider supplementing existing laws with public education and consultation activities and monitor projects at the national level to ensure compliance. These additional measures are appropriate for a new technology that is unfamiliar and presents novel risks.

Projects funded through the CDM or multi-lateral development banks will require additional and more intensive public engagement than typically required by national legislation. For example, the CDM requires an assessment of local and environmental impacts and stipulates that the project proposal be made publicly available and is subject to public comment on a global scale. The CDM Designated Operating Entity reviews the stakeholder consultation process, responds to public concerns and then assesses whether to recommend approval to the CDM Executive Board.[24]

Several OECD jurisdictions require public engagement beyond the minimal information and hearing approach and enforcement of existing environmental laws is generally more rigorous in OECD jurisdictions than APEC developing economies. For example, in Australia, Queensland's Greenhouse Gas Storage Act 2009 requires project developers to consult owners and occupiers of land on which CCS activities are being planned or are likely to be carried out.[25] It further empowers the approving Minister to take the public interest into consideration in deciding whether to approve a project.[26]

Industrial Research Organisation (CSIRO), Communication and Engagement Toolkit for CCS Projects (2011).

[24] Sections 128-129, Clean Development Mechanism Validation and Verification Manual, Version 1.2.

[25] Sections 85 and 166, Queensland Greenhouse Gas Storage Act 2009.

[26] Section 419, Queensland Greenhouse Gas Storage Act 2009.

Also in Australia, Victoria's onshore CCS regulation ensures that public consultation will occur in the event that an Environmental Effects Statement is not required. For example, permit holders must conduct community consultation throughout the life of the permit and obtain approvals to inject greenhouse gas substances.[27] The legislation further requires those carrying out any GHG storage activity to enter into a compensation agreement with other users of the land. If this agreement is not completed, a government tribunal will determine the amount of compensation that is payable in relation to proposed work. While these arrangements are primarily intended to define liability for damages to property, loss of value or amenity, they also effectively require consultation from landowners and users.[28]

In accordance with Community legislation, the EU requires information dissemination concerning geological CO_2 storage in general and inspections of CCS project specifically.[29] The EU adheres to the principles of the Aarhus Convention, which requires dissemination of information to the public in a timely manner with as few barriers as possible.[30]

Leading OECD jurisdictions also specifically authorize government agencies to use and release information submitted by CCS projects during the planning, development and monitoring stages to the public. For example, in Australia, Queensland's Greenhouse Gas Storage Act specifically provides that reported information may be used by the permitting agency for any reason related to the Act or carrying out its responsibilities.[31] Similarly, Victoria's onshore CCS law specifies that information provided by a permit holder may be released to the public immediately, after two years, and after five years, except information about the holder's technical qualifications, advice received and

[27] Section 46, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

[28] Sections 48-49, 104-105, 118, 200-201, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

[29] Articles 26 and 15, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[30] The Aarhus Convention is formally called the Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters. See Council Decision 2005/370/EC of 17 February 2005 on the conclusion, on behalf of the European Community, of the Convention on access to information, public participation in decision-making and access to justice in environmental matters (OJ L 124, 17.05.2005). The Convention ensures that all natural or legal persons have access to administrative or judicial procedures to challenge acts and omissions by EU institutions which contravene provisions of EU law relating to the environment. Procedures for redress and the provision of information shall "provide adequate and effective remedies" and shall "be fair, equitable, timely and not prohibitively expensive."

[31] Section 262, Queensland Greenhouse Gas Storage Act 2009.

financial resources. Victoria's law also provides for notice, hearing and appeal process for information release decisions.[32]

4.2.4. Socio-Economic Policies

CCS is currently an expensive technology for power plant applications when compared to conventional power plants, but CCS can be competitive on a cost of electricity basis with other low-carbon technologies.[33] Passing the additional costs to consumers will be highly regressive, especially in developing economies where retail electricity rates are already high relative to income and the poorest segments of society still lack access to affordable electricity. For these economies, access to electricity is critical to development and a better quality of life for its citizens.

The higher cost of electricity from power plants with CCS and its impact on the poor should be addressed in CCS or related legislation. Failure to address this issue will likely undermine the potential for CCS deployment in a developing economy. Some OECD economies with carbon regulation have addressed its impact on the poor. For example, Australia's Carbon Pricing Mechanism (AusCPM) (a collection of laws that provide a comprehensive carbon pricing mechanism to meet Australia's national emissions reductions targets) helps low income households adjust to related cost of living increases by adjusting marginal tax rates.[34] It also provides household assistance payments to the elderly, veterans, and those receiving medical assistance.[35]

In a developing economy context, socio-economic policies could be linked to the provision of international financing. Under the UNFCCC, ongoing discussions on "nationally appropriate mitigation actions" (NAMAs) could include payments to help offset the additional cost of CCS and insulate the poorest segments of society from being impacted by cost increases. CDM offset revenues could also contribute to reducing cost impacts on the poor.

4.2.5. Streamline Regulation and Coordinate among Regulatory Agencies

Streamlining regulation and improving coordination among regulatory agencies – without compromising safety or environmental integrity – is a critical aspect of best practices in

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[32] Section 236-250, Victoria Greenhouse Gas Geological Sequestration Act 2008.

[33] See Electric Power Research Institute, Program on Technology Innovation: Integrated Generation Technology Options, Report No. 1022782, Technical Update (June 2011).

[34] Clean Energy (Tax Laws Amendments) Act 2011; Clean Energy (Income Tax Rates Amendments) Act 2011.

[35] Clean Energy (Household Assistance Amendments) Act 2011. http://www.climatechange.gov.au/government/clean-energy-future/legislation.aspx (accessed November 28, 2011).

CCS regulation and can promote greater certainty for project developers, improve financing opportunities, and ultimately facilitate successful commercial deployment. Streamlining regulation has several aspects: competing jurisdiction, conflicting rules, and appropriate level of regulation.

The potential for different government agencies to exercise overlapping or competing jurisdiction over the various aspects of CCS projects is commonplace. This concern has proven to be a significant issue for large-scale demonstration projects in the US[36] and has been raised by various stakeholders in the APEC developing economies who participated in consultations undertaken in connection with this study.

Several leading OECD jurisdictions have addressed the issue of competing jurisdiction in their own legislation. The Commonwealth of Australia issues licenses for offshore CCS activities through the Commonwealth Minister or in the National Offshore Petroleum Titles Administrator (NOPTA) and the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA). A number of jurisdictions follow a similar model where greenhouse gas storage regulatory responsibility is delegated to the same body that regulates oil and gas where such activities are likely to occur together. In addition to the Australian Commonwealth, this is the case in the Australian states of Victoria, Western Australia, South Australia, and the Canadian provinces of British Columbia and Alberta.

Delegation to a particular agency, such as an oil and gas regulator, should not preclude consideration of environmental and other issues. A critical aspect of best practices requires that agencies coordinate and are not excluded from the process of ensuring that a project is properly permitted and regulated. Queensland's Greenhouse Gas Storage Act contains detailed provisions for coordination among agencies if there is overlapping authority over a project.[37] Victoria's Greenhouse Gas Storage Act requires the approving agency — in assessing whether storage of greenhouse gases presents a risk to the environment and the adequacy of risk management plan and long-term monitoring and verification plan — to consult and obtain the recommendation of ministries responsible for environment protection and water. The act also allows the executing agency to refer the matter to an independent panel for its recommendation, which provides a neutral expert to assist the government agencies involved in regulating a CCS project.[38]

Western Australia's Barrow Island Act contains similar requirements for the approving agency to consult the ministries responsible for land use and conservation, but also requires the project developer to consult these ministries as well as the ministry for indigenous peoples issues in order to obtain an injection permit.[39] Western Australia's law

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[36] See C. Hart, Putting It All Together - The Real World of Fully Integrated CCS RD&D Projects: A Study of Phase III of the DOE Regional Carbon Sequestration Partnerships Program. John F. Kennedy School of Government, Harvard University (2011).

[37] Chapter 4, Queensland Greenhouse Gas Storage Act 2009.

[38] Section 171, Victoria Greenhouse Gas Geological Sequestration Act 2008.

[39] Section 13, Barrow Island Act.

further provides that all entities operating a gas processing facility must join the Barrow Island Coordination Council, which plays a critical role in coordinating activities among stakeholders and plays a governance role along the lines of a public/private or self-governing organization model.[40]

Competing jurisdictions also necessarily increase the likelihood of competing bodies of law or regulation governing a project. Victoria's Greenhouse Gas Storage Act addresses this issue by specifying that its exploration, injection and monitoring permitting regimes override requirements under the Planning and Environment Act. Moreover, it waives the requirement to obtain a planning permit if an Environmental Effects Statement is prepared and ministries responsible for environment and greenhouse gas storage approve the waiver.[41] Such an approach should only be taken if the CCS regulatory regime is adequate in scope and rigor to waive other regulations.

A third approach to streamlining regulation without compromising environmental integrity or safety is to adjust the rigor and level of regulation to the risks posed by the activity. In the context of CCS, several jurisdictions provide for reduced regulatory requirements for small-scale (< 1 Mt) test injections or other assessment activities that do not pose significant risk. This approach not only helps facilitate research and development efforts, but also helps focus regulatory resources appropriately on large-scale injections, and thus could enhance overall regulatory effectiveness.

Several jurisdictions have adopted phased permitting requirements, which typically involve an assessment permit featuring relaxed requirements to conduct exploration and possibly small-scale injection in order to prove initial geologic storage assessments. The EU's directive on geologic storage requires exploration and injection permits, and only regulates CO_2 injection volumes greater than 100,000 tonnes. Injection volumes less than 100,000 tonnes undertaken for research, development or testing of new products or processes, are not regulated at the EU level and their regulation is at the discretion of Member States.[42] The Australian Commonwealth's offshore regulatory regime provides for an assessment permit to conduct exploration, an injection license to carry out greenhouse gas injection and storage activities, and a research consent to conduct scientific investigation.[43] Queensland, Victoria and South Australia similarly provide for differentiated exploration and injection permits.[44] In Canada, Alberta provides for an evaluation permit and a storage lease. Alberta's evaluation permit allows operators to drill

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[40] Section 15, Barrow Island Act.

[41] Sections 189 and 190, Victoria Greenhouse Gas Storage Act.

[42] Article 2(2), Directive of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[43] Parts 3.2, 3.4 and 3.7, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[44] See Section 19 and 71, Victoria Greenhouse Gas Geoloical Sequestration Act 2008; Chapters 2 and 3, Queensland Greenhouse Gas Storage Act 2009; Sections 21 and 34, South Australia Petroleum and Geothermal Energy Act 2000.

approved wells and inject substances to evaluate the suitability of subsurface reservoirs for CO_2 storage, whereas the storage lease allows for CO_2 storage according to an approved plan.[45]

Differentiated permitting requirements for test injection and exploratory assessment can take many forms. A common feature of streamlined permitting schemes is a quantified limit, which in the case of CCS, would likely be a CO_2 volume limit. A volume limit may be further differentiated based on formation type, site pressure or other site-specific conditions. Such a limit could be adjusted as knowledge about a particular formation and experience with CO_2 injections in the formation increases. Volume limits should be based on the need to advance research coupled with an assessment of possible risks to people, water resources, flora and fauna. CCS assessment models have been developed by research laboratories specifically to assist regulators understand potential risks based on site-specific considerations.[46]

4.2.6. Efficient Use of Resources and Protection of Property Rights

CCS regulation should ensure that exploitation of oil, gas, minerals and other subsurface resources such as geothermal resources are coordinated with greenhouse gas storage and not adversely affected by it. One approach to accomplish this is to consider greenhouse gas storage rights together with mineral extraction rights under the same law, by the same regulator, or institutional arrangements for coordination among agencies. The Australian Offshore Petroleum and Greenhouse Gas Storage Act provides an example of some of these practices. It contains procedures to facilitate petroleum exploitation and greenhouse gas storage in the same area and checks to ensure that new petroleum or storage titles do not adversely impact existing titleholders. It sets out detailed criteria to determine whether resources are adversely affected. If a proposed new petroleum exploration or exploitation or greenhouse gas storage operation significantly adversely impacts existing activities, the responsible Commonwealth Minister can deny a permit for the new activity, order suspension of activity or take other mitigation measures.[47]

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[45] Sections 3(3) and 9, Alberta Carbon Sequestration Tenure Regulation.

[46] See Curtis M. Oldenburg and Steven L. Bryant, Certification Framework for Geologic CO_2 Storage, Sixth Annual Conference on Carbon Capture and Sequestration, National Energy Technology Laboratory, Pittsburgh, PA, May 7-10, 2007 available at www.netl.doe.gov/publications/proceedings/07/carbon-seq/data/papers/tue_062.pdf; Curtis M. Oldenburg, Steven L. Bryant, Jean-Philippe Nicot, and Ying Zhang, Certification Framework for Geologic Carbon Sequestration Based on Effective Trapping, Seventh Annual Conference on Carbon Capture and Sequestration, National Energy Technology Laboratory, Pittsburgh, PA, May 5-8, 2008; Curtis M. Oldenburg, Steven L. Bryant, Jean-Philippe Nicot, Certification Framework for Geologic Carbon Sequestration Based on Effective Trapping (2009).

[47] Sections 25-29, 316, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

The province of Alberta in Canada also addresses competing uses of resources by integrating its greenhouse gas storage regulation into its Mines and Minerals Act.[48] Similarly, British Columbia's Petroleum and Natural Gas Act and Saskatchewan's Oil and Gas Conservation Act have been amended to provide the means to regulate CCS.[49] South Australia adopts the same approach for onshore CCS.[50] Integrating CCS regulation into petroleum regulation may be especially appropriate in jurisdictions in which CCS is likely to be conducted as part of an EOR operation or CCS occurs in areas in which oil and gas or other mineral extraction is present.

In the US, protection of mineral and other resources in relation to CCS activities has been carried out through property law. For example, the states of Wyoming, Montana, and North Dakota vest ownership of subsurface pore space in the surface owner, and grant dominance to any mineral rights holders in both the surface and subsurface estate so that pre-existing mineral rights are superior to storage rights in the event of a conflict.[51] Other property and tort laws would also generally reinforce the protection of rights of other land users.

4.2.7. Flexibility to Address Site-Specific Conditions

Regulation should be designed to provide flexibility to tailor requirements to a particular project based on site- or project-specific data. At the same time, regulation should specify a level of guidance that provides project developers with a degree of certainty. Examples of regulation that provide flexibility to take site-specific conditions into account include government agency discretion to tailor requirements based on site characterization, default provisions that can be varied where justified, and project-specific agreements.

All of the OECD jurisdictions reviewed in this study require geologic assessments and numerical simulations or models to establish a basis for regulators to approve the suitability of a site and inform the site monitoring, emergency response and remediation plans. The requirement of site-specific characterization provides the foundation for regulators to define specific requirements appropriate to a site. For example, Australian offshore regulation requires prospective project operators to develop a site plan, which forms part of the license application and sets out projections of CO_2 movement based on geologic assessments.[52] On the basis of the site plan, a license may be issued which

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[48] Alberta's Carbon Capture and Stroage Statutes Amendment Act, 2010 amends the Mines and Minerals Act, adding a new Part 9 – Sequestration of Carbon Dioxide, and makes conforming amendments to the Energy Resources Conservation Act.

[49] British Columbia's Oil and Gas Activities Act (Bill 20- 2008), amending the Petroleum and Natural Gas Act; Saskatchewan Oil and Gas Conservation Act.

[50] South Australia Petroleum and Geothermal Energy Act 2000.

[51] Wyoming Statutes 34-1-152 and 34-1-202(e); Montana Senate Bill 498, Section 1(2)(a) and 1(3); North Dakota Century Code 47, 38-20-08(6) and 38-20-13.

[52] Section 24, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

specifies the injection area, volume and rate of injection, and other requirements.[53] US regulations similarly base regulation on the site assessment and set minimum criteria for project siting, granting regulators discretion to tailor specific requirements.[54] For example, the regulator has discretion to require a secondary confinement zone for the site, and to vary other aspects such as monitoring requirements (e.g., for corrosion and surface air and/or soil fluxes) and arrange for financial assurance provisions.[55]

A number of regulations possess default provisions for post-injection site care requirements that allow the regulator to adjust the specific requirements based on site-specific conditions. The US CCS regulation under Class VI of the UIC program, for example, adopts a default rule of 50-years of monitoring after injection ceases, with discretion of the administrator to impose a shorter or longer period.[56] Similarly, Australia's offshore CCS legislation process involves a staged process. The first stage involves the injection licensee obtaining a site-closing certificate, which will be subject to whether injected CO_2 is behaving as predicted and poses no significant risk to the integrity of the geologic formation, the environment, or human health and safety, together with provision of funding for longer-term monitoring. At this point the licensee surrenders the title and statutory obligations cease. The second stage is a minimum 15-year period known as the closure assurance period. Issuance of a site-closing certificate is the basic enabling requirement. It is only after the end of the closure assurance period, and subject to whether the injected CO_2 is still behaving as predicted and poses no significant risk to the integrity of the geologic formation, the environment, or human health and safety, that the Australian Government would accept long-term liability for stored CO_2. Regulators may extend the closure assurance period if necessary. Completion of the closure assurance period triggers the Commonwealth's indemnification of the site operator for liabilities arising in connection with the operation of the facility where such liability occurs or accrues after the closure assurance period.[57]

Another approach that provides flexibility for addressing project-specific circumstances is regulating through contract or project-specific legislation. The Gorgon Project in Western Australia provides an example of how basic project-specific legislation coupled with a contractual arrangement between government authorities and the project can be tailored to site- and project-specific conditions. This approach allows project-specific contingencies to be identified and addressed that otherwise could not be contemplated under generic legislation. Project-specific regulation can work to the advantage of both the project developer and the community. In the Gorgon Project, the contract between the government and the project developer takes into account the commercial viability of the

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[53] Section 358, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[54] 40 CFR 146.83.

[55] 40 CFR 146.85.

[56] 40 CFR 146.93(b)(2).

[57] Section 400, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

gas processing plant that will produce CO_2 for storage, which protects the developer.[58] The contract also requires the operator to hire from the local community if economically feasible.[59]

Project-specific contractual provisions can also bring transparency to the process by making it clear how such provisions are intended to apply to the project, as opposed to a statutory approach that is general in nature. The application of general statutes to a project may not be readily apparent and a tailored approach enables governance regimes to be strengthened by taking advantage of local governance arrangements. For example, the Gorgon Project requires the creation of the Barrow Island Cooperation Council, membership in which is compulsory for all gas processing facilities on the island.[60] The Council is funded by industry and provides a single point of contact and interaction for the regulator. The Council plays an important role in coordinating monitoring, planning and emergency response for Barrow Island.

[58] Section 17, Gorgon Gas Processing and Infrastructure Project Agreement, Schedule 1 to the Barrow Island Act 2003.

[59] Section 15, Gorgon Gas Processing and Infrastructure Project Agreement, Schedule 1 to the Barrow Island Act 2003.

[60] Section 13, Gorgon Gas Processing and Infrastructure Project Agreement, Schedule 1 to the Barrow Island Act 2003.

5. Essential CCS Permitting Regimes

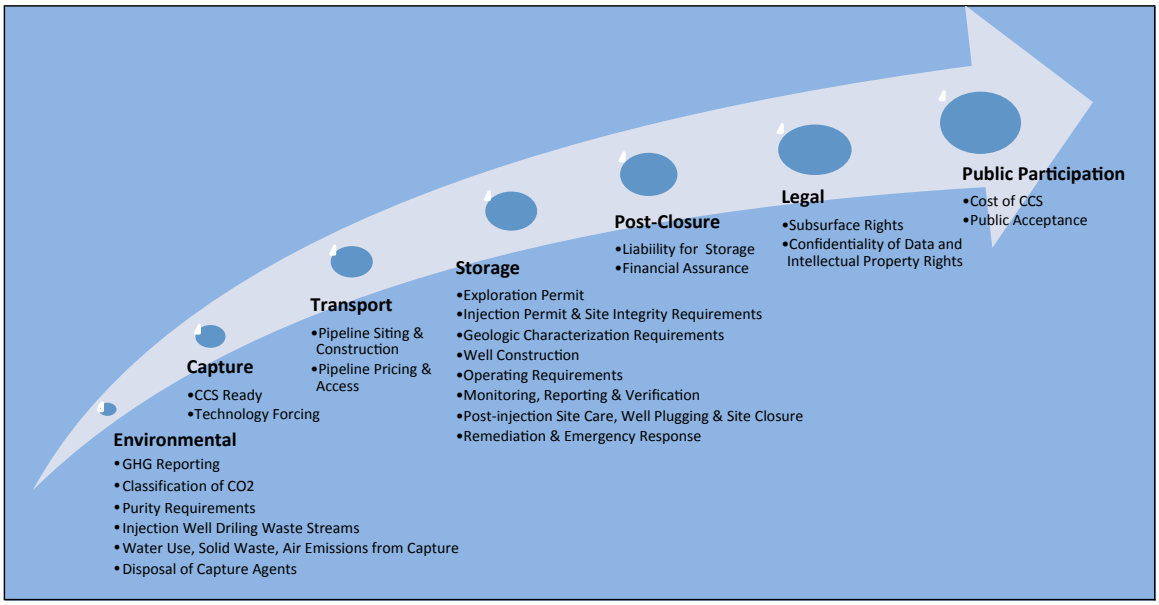
This chapter sets out the essential elements of a CCS permitting regime. It is based on our review and analysis of legislation and permitting regimes in leading jurisdictions and assessment of current needs of the APEC developing economies included in this study, It is also informed by our own regulatory assessments for each APEC economy included in this study and subsequent stakeholder meetings with government, industry, academic and experts groups, and civil society. While this section offers recommendations, it is not intended to be prescriptive. It presents the various issues that regulators have addressed in CCS regulation for leading OECD jurisdictions and is meant to inform APEC developing economies. Local stakeholders and officials must make any final determination of CCS regulatory elements for their own economy.

We recognize that determination of what constitutes an essential element of a CCS permitting regime will depend on many factors including technology, project scale, cost, policy and social factors. With respect to technology, consistent with this study's focus, we assume CO_2 will be captured from a coal-fired power plant, transported via pipeline and stored in either saline formations or depleted oil or gas fields. The scale of a CCS project will also be a factor in determining what regulatory elements are essential. For example, a small pilot plant presents fewer regulatory issues than a fleet of commercial-scale facilities, and the regulatory regime for the former could be comparatively modest. Policy context and objectives should also be considered, such as laws that may require CCS for compliance with greenhouse gas emissions reductions or to obtain emissions reduction credits under the CDM. Our own analysis assumes that one or more commercial plants are contemplated to be built on a voluntary basis; not mandatory adoption of CCS on an economy-wide basis. Finally, social considerations should also influence the determination of what is essential. For example, public acceptance could require that the additional cost of CCS be addressed as part of the permitting process.

It should be emphasized that regardless of these potential factors, geologic storage integrity and environmental and public safety are essential principles for regulation in any context.

There are six categories of issues that should be addressed in CCS regulation: environmental impact, capture, transportation, storage, legal and financial, and public engagement. There are many issues within these categories that are relevant to more than one category. The issues presented in the environmental impact, legal and financial and public engagement categories are, for example, relevant to all phases of a CCS project. In this chapter, we present some two-dozen distinct elements that could be included within a CCS regulatory regime, which are presented graphically in the diagram below.

Key Elements of Regulatory and Permitting Practices



This chapter also addresses transboundary issues and development of international CCS standards. For most of the APEC developing economies in this study, storage may occur in offshore oil and gas fields that may be in close proximity to, or even shared with, other economies. In such circumstances, a CCS project would require institutional arrangements that can facilitate joint storage or coordination of the potential impact of CCS on petroleum resources.

The development of international standards would support APEC economies in their efforts to develop CCS regulations. For example, the APEC economies surveyed in this study with an active oil and gas production all rely on international standards to govern that industry. International standards for the oil and gas industry are developed by such organizations as the International Organisation for Standardisation (ISO), the International Electrotechnical Commission (IEC), British Standards Institution (BSI), the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM) and the Society for Petroleum Engineers (SPE).[61] These organizations have played an important role in shaping regulation in the oil and gas industry and will play a critical role in the regulation of CCS. ISO is presently in the process of developing standards for geological storage of CO_2.

Each APEC economy possesses laws that could be applied to CCS. In all likelihood, CCS permitting regimes would rely largely on existing laws and any new regulation would supplement or integrate existing regulation. Law and regulation concerning environmental protection, public consultation (typically through environmental impact assessments), oil

[61] See International Association of Oil & Gas Producers, Catalogue of International Standards Used in the Petroleum and Natural Gas Industries, Report No. 362, February 2012 update.

and gas laws, and property regimes provide relevant guidance in each economy. The appendices to this report contain assessments of five out of the nine economies featured in this study, and the ADB's forthcoming study, *Exploring the Potential for CCS in Southeast Asia,* contains assessments for the remaining four economies. These assessments, which were completed using the same methodologies under common supervision, provide detailed economy-specific analysis.

5.1. Environmental Impact Issues

Environmental impact covers a broad range of issues in the context of a CCS project, including gas reporting, classification of CO_2 as a waste or some other designation that could trigger special handling or more stringent liability treatment, the generation of waste streams from drilling injection wells and operating a CCS project, such as increase fly ash, and increased water usage. In this section we address each of these issues.

5.1.1. GHG Reporting

Reporting greenhouse gas emissions provides a foundation for all other greenhouse gas regulations. Developed economies that are party to the Kyoto Protocol have an obligation to reduce greenhouse gas emissions and submit an annual inventory of anthropogenic emissions by sources and removals by sinks.[62] Parties in turn adopt regulation at the national level, which require that large industrial sources and other sources of greenhouse gases report their emissions.

In the context of CCS, a greenhouse gas reporting regulation could comprise two elements – CO_2 emissions from large point sources and CO_2 injected and released (if any) from a storage site. Both elements provide important information for developing CCS regulations. Reporting on CO_2 sources is the first step in evaluating the technical and economic viability of CCS. Greenhouse gas reporting provides information that enables matching between sources and sinks, as well as planning the most economic transportation system for CO_2, such as shared pipeline networks. Reporting injection amounts and any releases from a CCS monitoring regime is important not only for greenhouse gas accounting but also to help ensure the integrity and safety of storage. This information should be reported in a timely manner and be made publicly available in order to allow regulators, the community and other stakeholders to monitor the project and evaluate data. The US has developed comprehensive requirements for reporting emissions by sources and sinks that could provide a model for other economies. The US reporting system that governs CCS is described in the text box below.

For APEC developing economies, current data on sources of CO_2 are essential for planning a project and identifying economically viable storage sites. Most of the APEC economies in this study have at least some information concerning CO_2 sources. The level of information required for CCS purposes does not, in our view, warrant annual reporting in the absence of a general regulatory requirement to report greenhouse gas

[62] Article 7(1), Kyoto Protocol to the United Nations Framework Convention on Climate Change.

emissions. However, information on sources should be made more widely available to enable industry and research organizations to evaluate options for CCS. For any CCS project, we believe that periodic reporting of injection volumes and releases of CO_2 – the second element of reporting - is essential to properly monitor the site and ensure its integrity and safety.

US Greenhouse Gas Reporting Rules for CCS

The US EPA's Mandatory Reporting Rule (MRR) under the Clean Air Act requires annual reporting of greenhouse gas emissions by a broad range of emitters in various sectors, including power generation and carbon-intensive industries. The MRR generally imposes reporting obligations on any facility emitting at least 25,000 metric tons of CO_2 equivalent (CO_2e).[63] Additionally, subpart RR of the MRR requires facilities that inject CO_2 for geologic storage to report volumes received and injected on an annual basis, and to detect and quantify any releases. Subpart UU of the MRR requires reporting by all other facilities that inject CO_2 underground, including enhanced oil and gas recovery. Subparts RR and UU require facilities conducting geologic CO_2 storage to develop and implement an EPA-approved site-specific monitoring, reporting and verification (MRV) plan, and to report the amount of CO_2 stored using a mass balance approach. Subpart RR exempts certain projects that inject CO_2 for research and development.[64] In addition, subpart PP imposes reporting requirements on facilities that capture CO_2 in order to supply it for commercial applications or to store or otherwise inject it underground. Operators engaged in CO_2 injection are obligated to provide information under the EPA's UIC program relating to injection volumes on a semi-annual basis.

5.1.2. Defining CO_2 as a Waste or Commodity

Environmental laws typically define such concepts as "waste", "pollutant", "contaminant" and/or "hazardous substance" and list the substances determined by regulatory authorities to fall within these categories, which is the case in OECD and APEC developing economies reviewed in this study. Depending upon the jurisdiction, courts may also be empowered to determine that a substance comes within a particular category and mandate its regulation.

In contrast, it is also possible that industrial or other laws can define a substance as a commodity – a good or service having economic value. There has been significant discussion globally on whether CO_2 should be defined as a commodity to clarify that it will not be treated as a waste; however, it is not clear whether simply defining CO_2 as a commodity alone would preclude it from possible treatment as a waste. It could, in fact, trigger obligations to comply with commodities regulations, such as those relating to the sale of goods or regulation of commodities markets. This approach should be considered in light of a jurisdiction's existing regulation governing commodities.

The designation of CO_2 when captured or stored as either a "waste" or a "commodity" has far reaching implications for CCS operations. The designation of CO_2 as a waste or other

[63] US Environmental Protection Agency, Mandatory Reporting of Greenhouse Gases; Final Rule, 74 Fed. Reg. 209 (October 30, 2009).

[64] US Environmental Protection Agency, Mandatory Reporting of Greenhouse Gases: Injection and Geologic Sequestration of Carbon Dioxide; Final Rule, 75 Fed. Reg. 75060 (December 1, 2010).

similar category typically triggers special treatment under environmental laws, which may include special requirements for reporting, handling and heightened liability associated with CO_2 capture, transport and storage. Depending upon how CO_2 is classified, these special regimes can potentially increase the legal risks associated with handling CO_2, which could increase costs or discourage the private sector participation in projects with CCS.

Regulators in APEC developing economies should assess whether CO_2 in CCS applications would be treated as a pollutant or hazardous substance under their existing regulations. The decision whether to regulate CO_2 under these regulations should be informed by whether the risks to human health and the environment associated with CCS are appropriately addressed under existing regulation for these classes of substances.

The potential adverse effects from high concentrations of CO_2 resulting from leaks from a storage site, a pipeline or other transport, or from the chemicals used during capture processes, must be regulated under a regime that ensures proper site selection and characterization, monitoring and safety measures, and mitigation planning. Regulating CO_2 under pre-existing regimes that are not designed for CCS may not address these risks adequately.

The characteristics of CO_2 and the safety record of handling and using CO_2 in industrial settings are directly relevant to the determination of how CO_2 should be regulated. CO_2 is a non-toxic and nonflammable substance that occurs naturally in the environment. In normal concentrations CO_2 in not harmful; it is produced by humans and is essential for photosynthesis in plants. In relatively pure CO_2 streams containing no hazardous contaminants, CO_2 only presents risks to human health in concentrations higher than that of ambient air, which is comprised of approximately 0.037% CO_2. Research on the impact of exposure levels of CO_2 on human health show that concentrations of approximately 5% for extended periods can cause adverse physiological effects, concentrations of 10% can cause unconsciousness within minutes, accompanied by convulsions at concentrations of 15%, and concentrations of 30% can result in death within minutes. The effects of CO_2 concentrations on ecosystems are less well understood, but concentrations above 20% for extended periods of time are believed necessary for adverse impacts to occur.[65] In a properly monitored and regulated industrial setting, CO_2 concentrations would not reach these levels. For example, US Occupational Safety and Health Act regulations set workplace limits for CO_2 exposure to an average of less than 5,000 parts per million (0.5%) for a 40-hour workweek.[66]

Carbon dioxide is used for various industrial applications, including food preservation and beverage carbonation, EOR, fire suppression and chemical production. Experience in these industries confirms CO_2 can be handled safely in a properly regulated setting. For

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[65] Sally M. Benson, Robert Hepple, John Apps, Chin-Fu Tsang, and Marcelo Lippmann, Lessons Learned from Natural and Industrial Analogues for Storage of Carbon Dioxide in Deep Geological Formations, Lawrence Berkeley Nat'l Lab. Report LBNL-51170 (2002) *available at* http://repositories.cdlib.org/lbnl/LBNL-51170/.

[66] Occupational Safety & Health Administration, Carbon Dioxide (Revised Sept. 20, 2001), *at* http://www.osha.gov/dts/chemicalsampling/data/CH_225400.html.

example, the US oil and gas industry has used CO_2 in EOR for over 40 years and the industry operates over 3,600 miles of CO_2 pipeline today.[67] A review of government safety records shows a total of eight accidents associated with the operation of these pipelines during the period 1968 to 2000, none of which resulted in fatalities or injuries.[68]

In the context of CCS, CO_2 could pose a risk to human health or the environment in the event of pipeline or injection well rupture, resulting in a high velocity release of CO_2. These risks should be addressed through regulation concerning the design, construction, operation and monitoring of pipelines and CO_2 injection operations. Monitoring, warning and emergency response systems are essential measures for responding to any potential leak of CO_2 before concentrations can reach harmful levels.

During the injection and storage phase, CCS poses the risk of CO_2 leaking from a geologic formation. Undetected, a slow CO_2 leak could result in accumulation in low-lying areas, as CO_2 is heavier than air, potentially posing a risk to humans, flora or fauna. Injection of CO_2 in the subsurface may also cause acidification of drinking water, displace brine which could then come into contact with drinking water, or carry with it metals and other substances that can contaminate drinking water. Finally, without proper siting and characterization, injection of CO_2 or other substances into the subsurface could potentially cause seismic events.[69]

The potential risks of leakage, water contamination, and induced seismic events should be addressed during site selection and in CCS project design, operation, and monitoring. Traditional regulatory regimes for waste or hazardous substances are poorly equipped to address these risks. For example, the site characterization and selection process should identify and evaluate all active faults in the area of the storage formation. For a project located in an area that is seismically active, seismic monitoring should be part of the monitoring plan. Classifying CO_2 as a waste, however, would not address issues concerning seismicity or provide requirements for mitigating the risk.

If regulatory authorities determine it is appropriate that CO_2 not constitute a "waste," regulators should consider excluding CO_2 from the definition of waste explicitly. The EU took this approach when it affirmatively excluded CO_2 from the definition of "waste" and further determined that its dedicated CCS regulation would "ensure a high level of protection of the environment and human health from the risks posed by the geological

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[67] Paul. W. Parfomak, Peter Folger and Adam Vann, Carbon Dioxide (CO_2) Pipelines for Carbon Sequestration: Emerging Policy Issues, Congressional Research Service (July 31, 2009).

[68] Sally M. Benson, Robert Hepple, John Apps, Chin-Fu Tsang, and Marcelo Lippmann, Lessons Learned from Natural and Industrial Analogues for Storage of Carbon Dioxide in Deep Geological Formations, Lawrence Berkeley Nat'l Lab. Report LBNL-51170 (2002) *available at* http://repositories.cdlib.org/lbnl/LBNL-51170/.

[69] Non-CCS injections of CO_2 for purposes of gas recovery have produced small-scale seismic events. See, e.g., Ohio Department of Natural Resources, Preliminary Report on the Northstar 1 Class II Injection Well and the Seismic Events in the Youngtown, Ohio, Area (March 2012).

storage of CO_2".[70] In excluding CO_2 from regulation governing waste, CCS operations must be conducted in accordance with dedicated CCS regulation and the CO_2 stream must "consist overwhelmingly of carbon dioxide."[71]

In many of the APEC developing economies in this study, definitions of concepts such as "waste" or "pollution" are broad enough to include CO_2 in the context of underground injection. At the same time, many of these regulatory regimes would require CO_2 to be explicitly included as a scheduled substance to bring it within their regulation. For these economies, adopting regulation to clarify the status of CO_2 would be appropriate.

5.1.3. CO_2 Purity Requirement

Closely related to CO_2 classification are requirements concerning the purity of the CO_2 stream. During the capture, transport and injection phases, other substances can become mixed with CO_2. Because the CO_2 stream can potentially release into the ambient environment, be exposed to workers, or, once injected, come into contact with drinking water sources, it should contain other substances at levels that do not pose a risk to human health or the natural environment. The CO_2 stream also comes into contact with pipeline and well equipment; external substances that corrode metals or degrade cement can undermine the integrity of equipment, thus resulting in accidental release of CO_2 and substances in it.

For CO_2 captured from coal-fired power plants, impurities contained in the coal or created during the combustion process will be found in the CO_2 stream. Most of these impurities will be removed through clean up of gas streams to control for sulfur dioxide (SO_2), nitrogen dioxide (NO_x), particulates and mercury; however, the level and types of impurities will differ depending upon the coal quality, type of power plant and pollution abatement equipment. The text box below describes the leading CO_2 capture technologies and how they result in different types of impurities.

[70] Preamble paragraph 46 and Article 35, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006. The EU amended its legislation governing "waste" as contained in Directive 2006/12/EC and other related regulation to exclude CO_2 captured and transported for the purposes of geological storage.

[71] Article 12(1), Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

Concentration of Impurities in Dried CO_2 for Coal-fired Plants (% by volume)

	SO_2	NO	H_2S	H_2	CO	CH_4	$N_2/Ar/O_2$	Total
Post-combustion capture	<0.01	<0.01	0	0	0	0	0.01	0.01
Pre-combustion capture (IGCC)	0	0	0.01-0.6	0.8-2.0	0.03-0.4	0.01	0.03-0.6	2.1-2.7
Oxy-fuel	0.5	0.01	0	0	0	0	3.7	4.2

Source: Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

Various CCS processes can also impart impurities and other wastes. Furthermore, the presence of impurities and water can cause corrosion of capture facilities and pipelines, which can lead to leaks of CO_2 or other chemicals. Corrosion can be mitigated by selecting chemical sorbents with low corrosion rates or by adding corrosion inhibitors such as sodium metavanadate ($NaVO_3$), which absorbs water, and copper carbonate ($CuCO_3$), which reacts with acids. In the storage phase, tracer elements in small quantities may be added during injection to track the migration of the CO_2 plume in the subsurface. Tracers such as isotopes of C, O, H and noble gases present in the injected CO_2 can be used to specifically identify the CO_2, enabling researchers to isolate changes in environmental conditions due to the storage operation. Noble gases, SF_6 and perfluorocarbons may be added in small quantities. Perfluorocarbons, for example, can be detected at concentrations as low as 1 part per trillion.[72]

Carbon dioxide can be purified to the point of qualifying as food-grade for use in the beverage industry. For CCS, CO_2 purity requirements will significantly affect project economics. Requiring too stringent a level of CO_2 purity would result in CCS being prohibitively expensive. At the same time, regulation should ensure that CO_2 stream does not pose a threat to human health or the environment.

Leading OECD jurisdictions have addressed this issue in a manner that seeks to strike a balance. US federal rules governing CCS disallow use of Class VI injection wells for geologic storage where the CO_2 stream contains hazardous waste. Under the Class VI well regulation, "CO_2 stream" is defined as follows:

> Carbon dioxide stream means carbon dioxide that has been captured from an emission source (e.g., a power plant), plus incidental associated substances derived from the source materials and the capture process, and any substances added to the stream to enable or improve the injection process. This subpart does not apply to any carbon dioxide stream that meets the definition of a hazardous waste under 40 CFR part 261.

[72] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

While the US EPA prohibits the presence of hazardous wastes, it tolerates "incidental associated substances" and promotes the use of technologies that minimize impurities. The definition also allows for non-hazardous impurities added to the CO_2 stream to improve the process.

The EU adopts a comparable approach. It prohibits the addition of waste or other matter with the CO_2 stream for purposes of disposal, but allows the CO_2 stream to contain "incidental associated substances from the source, capture or injection process and trace substances added to assist in monitoring and verifying CO_2 migration." The EU limits all incidental and added substances to levels below those that would adversely affect the integrity of the storage site and relevant transport infrastructure, pose a significant risk to the environment, or breach the requirements of applicable Community legislation on wastes.[73] The EU directive further requires chemical analysis and risk assessment of the CO_2 stream prior to the grant of an injection permit.[74] Australian Commonwealth legislation governing offshore sequestration similarly defines "greenhouse gas substances" to consist "overwhelmingly" of carbon dioxide or other prescribed greenhouse gases, and allows for prescribed detection agents. Like the other jurisdictions surveyed, Australia requires reporting on the CO_2 stream composition to ensure compliance with purity requirements.[75]

For offshore CCS operations, operators would also be required to observe CO_2 purity requirements contained in the 1996 Protocol to the London Convention (the "London Protocol"), if applicable to their project. Pursuant to the London Protocol, CO_2 streams may only be disposed of in sub-seabed geologic formations if they "consist overwhelmingly of carbon dioxide." The CO_2 stream may contain "incidental associated substances derived from the source material and the capture and sequestration processes used", however no wastes or other matter may be added for the purpose of disposal.[76]

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[73] Article 12(1), Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[74] Article 12(2), Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[75] Section 23 and 292, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[76] Paragraph 4, Annex 1 to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. See International Maritime Organisation, Notification of amendments to Annex 1 to the London Protocol 1996, Ref. T5/5.01, LC-LP.1/Circ. 5, 27 November 2006.

Carbon Capture Technologies for Coal-Fired Power Plants

There are three basic systems currently available or at an advanced stage of development for capturing CO_2 in coal-fired power plants: post-combustion, pre-combustion and oxy-fuel.

Post-Combustion Capture

Post-combustion CO_2 separation and capture involves the treatment of flue gas, which is first cooled and than passed through a absorption tower, typically using an amine solvent such as monoethanolamine. Reuse of the chemical agent requires low-pressure steam to break the bonds between the absorbent and the CO_2, a highly energy intensive process, which takes place in a stripper unit. The recovered CO_2 is then compressed into a supercritical liquid state (about 100 atmospheres) to facilitate transport and storage. Removal of SO_2, NO_x, and particulates occur in separate processes, such as limestone absorbent for desulfurization and bag-type particulate removal.

Pre-Combustion Capture: Integrated Gasification Combined Cycle (IGCC)

IGCC technology converts solid fuels (e.g. coal, oil, biomass and waste) into synthetic gas (syngas) for the purposes of generating electricity and/or feedstock for the production of chemicals and fuels. In a gaseous state, CO_2, SO_2, NO_x, mercury and particulates can be more easily and cost-effectively removed. Once these substances are removed, the syngas can be used to power a gas turbine for the generation of electricity. In a combined cycle plant, waste heat from the gas turbine is then run through a steam turbine to generate additional electricity.

The process of transforming solid coal into syngas takes place in a gasifier in two distinct processes: gasification and an optional shift-reaction to increase the energy content of the product. Coal or other fuel is fed to the gasifier through one of a number of methods including fixed-bed, fluidized-bed, and entrained–flow. The feedstock is subjected to high temperatures (between 1,400° and 2,800° F) and pressure, and mixed with carefully controlled amounts of steam and air or oxygen, which is supplied by an oxygen plant. The gasification process breaks apart the chemical bonds of the coal and results in a syngas consisting of a mixture of carbon monoxide (CO), CO_2, hydrogen (H_2) and other trace substances. If the syngas is shifted in a water-gas reaction (syngas reacts with water vapor to produce hydrogen and carbon dioxide in an exothermic reaction: $CO+H_2O$ CO_2+H_2), the reaction produces H_2, which enriches the gas or liquid fuel, and CO_2 that becomes highly concentrated in high-pressure gas. The highly concentrated CO_2 can be separated from the syngas prior to being supplied to the gas turbine, where CO_2 is at lower pressure and diluted with other exhaust gases. IGCC also enables the economically efficient removal of SO_2, NO_x, mercury, and particulates from the syngas using such methods as activated carbon filtration and sorbents, resulting in much less pollution than conventional coal-fired power plants.

Oxy-Fuel Combustion

Oxy-fuel combustion technology utilizes oxygen instead of ambient air for combustion of fossil fuel. Oxy-fuel processes involve the removal of nitrogen from ambient air, producing a near pure stream of oxygen that is used as an oxidant for fossil fuel combustion. The cost of operating the air separation unit is the most significant challenge in this technology. When the oxygen-rich gas is combusted, the resulting flue gas contains high concentrations of CO_2 (generally exceeding 80% by volume), water vapor and small volume particulates, NO_x, SO_x and trace elements. These elements can be removed from the flue gas, resulting in a relatively pure CO_2 stream available for other applications or storage.[77]

[77] Mark Bohm, Scott Gold, Stefan Laux, Ben Neu, Apoorva Sharma, Knut Aasen, Application of Oxy-Fuel CO_2 Capture for In-Situ Bitumen Extraction from Canada's Oil Sands. XXI World Energy Congress, Montreal, Canada (September 12-16, 2010).

5.1.4. Injection Well Drilling Waste Streams

While drilling the injection well, drilling fluid, wastewater, produced water and drill cuttings are generated. The produced water is typically brine (a highly saline brackish water not suitable for drinking) that cannot be disposed of into the general environment without treatment. Additionally, excavation required for building the drill pad and access roads would involve removal of significant amounts of earth, which may be re-used or stored for later site remediation. Options for addressing waste streams associated with the drilling process include waste minimization, treatment and re-use, and disposal.[78] The site and drilling plan must account for waste stream volumes to be produced from drilling. Strategies to address waste streams have implications for permitting requirements and these issues should be considered early in the project design process. The table below sets out options for minimization, re-use and disposal of the major waste streams from a drilling operation.

[78] Section 4.1.4, US National Energy Technology Laboratory, Best Practices for Carbon Storage Systems and Well Management Activities (2012).

Injection Well Waste Reduction, Disposal and Re-Use Options

Water Category	Reduction Strategies	Disposal Options	Beneficial Reuse Potential
Drilling Fluids	Smaller diameter wellbores	Burial	Recycling/Reprocessing Oil- and Synthetic-Based Muds
	Multiple bores from single wellhead	Land Application	Enhanced Mud Recovery from Drilling Equipment
	Use Air	Bioremediation	
	Advanced Mud Processing Equipment Technology	Salt Cavern Disposal	
	Advanced Mud Formulas	Thermal Treatment	
		Commercial Disposal	
Waste Water	Grading to divert rain water around and away from pad	Injection well disposal	Underground injection for future use
		Evaporation	Underground injection for increased oil recovery
		Offsite commercial disposal	
Produced Water		Discharge (Generally Prohibited Except Under Effluent Limitation Guidelines for Agriculture and Wildlife Subcategory)	Underground Injection for Hydrological Purposes (i.e., Controlling Subsidence, Blocking Salt Water Intrusions, Augmenting Ground Water/Stream Flows)
		Underground injection	Underground injection for increased oil recovery
		Evaporation	Industrial use
		Offsite Commercial Disposal	Agricultural Use
			Domestic Use
			Road De-icing
			Erosion Control (following separation and treatment)
Drill Cuttings	Smaller diameter wellbores	Onsite burial	Fill material
	Closer spacing of consecutive casing strings	Landfill disposal	Daily cover of landfills
	Slimhole drilling	Slurry injection	Concrete and brick filler/aggregate
	Coiled tubing drilling	Commercial disposal options, including salt cavern disposal	Encapsulation and use as road foundation

Source: US National Energy Technology Laboratory, Best Practices for Carbon Storage Systems and Well Management Activities (2012).

5.1.5. Water Use, Solid Waste and Air Emissions Associated with Capture

CCS facilities consume additional fuel to operate the CO_2 separation and compression equipment. For coal-fired facilities, this results in an approximately 30% increase in coal consumption. Depending upon the technology used, increasing coal-consumption will in turn increase the plant's water use, and solid waste and air emissions. Project developers and regulators need to anticipate and plan for the additional water use and emissions associated with these plants.

The difference in water use and emissions vary by technology. With respect to solid waste and air emissions, the plant will increase production of slag and chemical emissions from combusting coal, but will also generate additional waste related to the use of capture agents. Issues relating to the disposal of capture agents are further discussed in the section below.

A post-combustion power plant with a CCS system will generate as much as a third more NO_x, ash, and residue from the flue gas desulfurization (FGD) unit. Emissions of ammonia will increase significantly. IGCC technology results in much smaller increases in ash and will generate additional solid sulfur waste, however other emissions will generally decrease. Both post-combustion and IGCC plants with CO_2 capture technology will reduce sulfur oxides, and IGCC can also reduce mercury emissions. The table below summarizes the changes in resource consumption, atmospheric emission and solid waste emissions based a nominal 500 MW plant equipped with CCS against the equivalent plant without CCS.

Regulators evaluating a proposed coal-fired power plant with CCS technology should consider the availability of water in the immediate area and water treatment as part of the permitting process. Water use by a post-combustion CCS plant will more than double, and for an IGCC facility increase by as much as 20%.[79] A plant that competes with existing community and industrial water use could face local opposition. Water issues should therefore be addressed early in the process when water mitigation options can be explored, adjustments to the project plan or zero water discharge technology can be adopted and, if necessary, additional supporting infrastructure to supply water can be planned.

Regulators considering a request to site any new plant would ordinarily be required to examine health, environmental and community impacts. However, as CCS is a relatively new technology, regulators are likely to pay special attention to the possible increase in waste streams, water usage and potential health impacts. This is especially important for public outreach and community engagement in connection with any project.

[79] US Department of Energy, Cost and Performance Baseline for Fossil Energy Power Plants. Volume 1: Bituminous Coal and Natural Gas to Electricity. Final Report. DOE/NETL-2007/1281.

Impacts of CCS and Energy Penalty on Resources Consumption and Emissions

	PC-CCS (kg/MWh)		IGCC-CCS (kg/MWh)		NGCC-CCS (kg/MWh)	
	Rate	Change from Reference	Rate	Change from Reference	Rate	Change from Reference
Resource Consumption						
Fuel	390	93	364	50	156	23
Limestone	27.5	6.8	_	_	_	_
Ammonia	0.80	0.19	_	_	_	_
CCS reagents	2.76	2.76	0.005	0.005	0.80	0.80
Atmospheric Emissions						
Carbon dioxide	107	-704	97	-720	43	-342
Sulfur oxides	0.001	-0.29	0.011	-0.13	_	_
Nitrogen oxides	0.77	0.18	0.10	0.01	0.11	0.02
Ammonia	0.23	0.22	_	_	0.002	0.002
Solid Waste						
Ash/Slag	28.1	6.7	34.2	4.7	_	_
FGD Residues	49.6	12.2	_	_	_	_
Sulfur	N/A	N/A	7.7	1.2	_	_
Spent CCS sorbent	4.05	4.05	0.005	0.005	0.94	0.94

Source: E.S. Rubin, C. Chen and A.B. Rao, "Cost and Performance of Fossil Fuel Power Plants with CO_2 Capture and Storage." Energy Policy 35(9) (2007): 4444-4454.

5.1.6. Disposal of Capture Agents

Chemical agents are commercially used to separate CO_2 from other gases in the capture process. Depending upon the capture process and the chemical agents used, these chemical agents or their degraded products can have detrimental impacts on human health and the environment. Furthermore, some are hazardous waste that must be handled under appropriate regulation.

We focus here on post-combustion CO_2 capture technologies based on absorption processes that are proven and commercially available to separate CO_2 from flue gases. Among commercially available process technologies, comparative assessment studies show that absorption processes based on chemical solvents have the lowest energy requirements and costs compared with other capture processes.[80] Therefore, the most commonly used sorbents for capturing CO_2 today are amines.

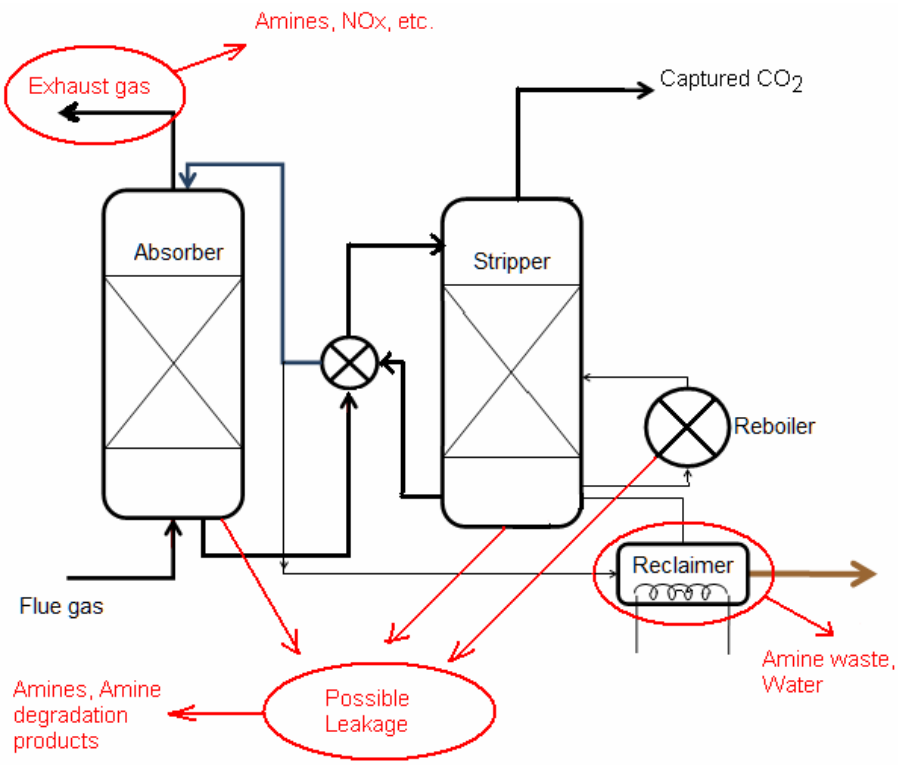
Amines are organic compounds that contain a basic nitrogen atom with a valence electron in their outer shell that is not shared with other atoms, giving them the characteristic that they can bond with other atoms, such as CO_2, through chemical or physical bonding. Amines are commonly used for separating CO_2 and hydrogen sulfide (H_2S) in natural gas processing facilities, and have been used to capture CO_2 in pilot and demonstration-scale coal-fired post-combustion plants.

In a post-combustion plant with CCS, flue gases are passed through an amine solution, which absorbs CO_2. The CO_2-rich amine is then heated to release the CO_2 and recover the amine for further use. The process is energy-intensive, especially due to the recovery process, requiring as much as 20-25% of plant electrical output.

Amine degradation during the various phases of the capture process and in the natural environment can result in the production of by-products, such a nitrosamines, which form by means of reactions with oxides of nitrogen (NO_x) and present risks to human health and the environment. During the CO_2 capture process, amines could escape into the environment through one of several pathways. The most significant is exhaust gas from the absorber unit, which will contain a small fraction of amines, and amines and amine degradation products can escape in liquid form from the absorber, stripper, reboiler and reclaimer units, contaminating soil and water. Amines typically have a very low vapour pressure so emissions to the environment tend to be as aerosols. A very small amount of amine products could potentially contaminate the CO_2 waste stream, however this has received less attention because it would be injected and ordinarily would not make contact with the ambient environment. The diagram below shows potential pathways of chemicals associated with the capture process entering the environment.

[80] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005), citing Hendriks, Carbon Dioxide Removal from Coal-Fired Power Plants, Dissertation, Utrecht University, Netherlands (1994); Riemer and Ormerod, International perspectives and the results of carbon dioxide capture disposal and utilisation studies, Energy Conversion and Management, 36(6-9), 813-818 (1995); IEA GHG R&D Programme, Leading options for the capture of CO_2 emissions at power stations, report PH3/14 (Feb. 2000).

Possible Emissions Sources of Amines and Degradation Products



Source: Renjie Shao and Aage Stangeland, Amines Used in CO2 Capture – Health and Environmental Impacts. The Bellona Foundation (2009).

Amine waste is hazardous and must be handled in accordance with regulations for hazardous waste. Amines and certain degraded amine products potentially pose risk to human health, flora and fauna when released into air, water or soil. The specific volumes and concentrations of waste and their human health and environmental impacts are the subject of ongoing study, which would need to be specifically considered for a particular CCS facility. A recent study in connection with the Kårstø post-combustion CCS plant in Norway estimates that a typical CO_2 capture plant with the capacity of 1 Mt of CO_2 annually will produce from 300 to 3,000 tonnes of amine waste per year.[81] The degradation products must be either incinerated in regulated facilities or filtered out and disposed of as toxic solid (sludge) waste.

A broad range of CO_2 capture research (e.g. absorption based on carbonates, adsorption, chemical looping, membranes, etc.) is being conducted to improve performance, lower cost and reduce environmental impact. Regulation should be flexible to allow selection of evolving technology but also raise environmental standards when technologies with superior environmental characteristics become cost effectively available.

[81] Renjie Shao and Aage Stangeland, Amines Used in CO_2 Capture – Health and Environmental Impacts. The Bellona Foundation (2009).

5.2. Capture Phase

The capture stage involves issues relating to requirements for greenhouse gas emissions reductions, including requirements to build capture ready power plants or deploy apply best available technology. The capture stage also involves other requirements such as those concerning the environmental impact of operating a CCS project (e.g. increase fly ash or water usage), which was addressed in the prior section on environmental issues.

5.2.1. CCS Ready

Until the technical and economic challenges associated with CCS-equipped power plants are overcome, some governments concerned with reducing greenhouse gas emissions have enacted "CCS ready" policies to facilitate future greenhouse gas reductions when large-scale CCS becomes more cost competitive. CCS ready policies require that new power plants prepare for future adoption of CCS technology as a condition of the permitting process. Such policies may be justified on the grounds that in light of pending or emerging greenhouse gas regulation, these plants would otherwise be forced to be close before the end of their planned period of operation.

There is currently no industry standard or internationally recognized definition of what constitutes "CCS ready." Moreover, readiness is a matter of degree, involving tradeoffs between cost, stringency and flexibility and can be very site specific. Regulation in this area should not be so specific or costly that it precludes application of a variety of technologies or fails to account for technology advances.

Although there is no common definition of "CCS ready," a GCCSI study proposed that a CCS ready plant is one that is capture, transport, and storage ready and suggested a number of elements within these phases that regulators can consider.[82] According to the study, a "capture ready" plant would take future retrofit for CCS into account in plant site selection, technology selection, capture facility design, and the provision of adequate space. At a minimum, a capture ready plant design would allow additional space for capture facilities to ensure that retrofit to CCS is physically feasible. A "transport ready" plant would identify a future transport corridor between the plant and a storage site, confirm that transport is expected to be technically and economically feasible, and may specify the design for transport facilities. A "storage ready" facility would identify one or more possible storage sites in proximity to the plant that would allow for economic transport of CO_2 and have a reasonable likelihood of being able to safely and cost-effectively store CO_2 in the volumes required to support the contemplated CCS facility. The text box below sets out the elements of CCS ready for all phases of a CCS facility according to the study.

[82] ICF International, Defining CCS Ready: An Approach to an International Definition. Global CCS Institute (2010).

Proposed International Definition of CCS Ready

A CCS Ready plant is one that is Capture Ready, Transport Ready, and Storage Ready.

Capture Ready Plant. A CO_2 capture ready plant satisfies all or some of the following criteria:

- Sited such that transport and storage of captured volumes are technically feasible;
- Technically capable of being retrofitted for CO_2 capture at acceptable economic cost;
- Adequate space allowance for future addition of CCS equipment;
- All required environmental, safety, and other approvals have been identified;
- Public awareness and engagement have been performed;
- Sources for equipment, materials, and services for future retrofit identified; and
- Capture readiness is maintained or improved over time and documented.

Transport Ready Plant. A CO_2 transport ready plant satisfies all or some of the following criteria:

- Potential transport methods are technically capable of transporting captured CO_2 from the source(s) to geologic storage ready site(s) at an acceptable economic cost;
- Transport routes are feasible, rights of way can be obtained, and any conflicting surface and subsurface land uses have been identified and/or resolved;
- All required environmental, safety, and other approvals for transport are identified;
- Public awareness and engagement related to transportation have been performed;
- Sources for equipment, materials, and services for transport have been identified; and
- Transport readiness is maintained or improved over time and documented.

Storage Ready Plant. A CO_2 storage ready plant satisfies all or some of the following criteria:

- Storage site(s) have been identified that are technically capable of, and commercially accessible for, geological storage of volume of captured CO_2, at acceptable cost;
- Adequate capacity, injectivity and storage integrity are shown to exist at storage site;
- Any conflicting surface and subsurface land uses have been identified and/or resolved;
- All required environmental, safety, and other approvals have been identified;
- Public awareness and engagement related to future storage have been performed;
- Sources for equipment, materials and services for injection/storage are identified; and
- Storage readiness is maintained or improved over time and documented.

Source: ICF International, Defining CCS Ready: An Approach to an International Definition. Global CCS Institute (2010).

As a practical matter, full geologic assessment would generally not be undertaken until required; however, a determination of storage ready could involve initial assessment of injectivity, capacity, and integrity of a geologic storage formation and design of the storage site. Requiring a high level of CCS readiness for the capture or transport phases without verifying a storage site could result in the capture plant ultimately being infeasible.

The EU has adopted CCS ready regulations for new large power plants. As a condition of granting construction and operating permits for plants of 300 MW size or greater, the EU requires developers to include suitable space on the site to capture and compress CO_2, confirm that transport and retrofitting for CO_2 capture are technically and economically

feasible, and that suitable storage sites are available. The EU CCS ready provision is set forth below:

> Article 9a
>
> 1. Member States shall ensure that operators of all combustion plants with a rated electrical output of 300 megawatts or more for which the original construction licence or, in the absence of such a procedure, the original operating licence is granted after the entry into force of Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide, have assessed whether the following conditions are met:
>
> — suitable storage sites are available,
>
> — transport facilities are technically and economically feasible,
>
> — it is technically and economically feasible to retrofit for CO_2 capture.
>
> 2. If the conditions in paragraph 1 are met, the competent authority shall ensure that suitable space on the installation site for the equipment necessary to capture and compress CO_2 is set aside. The competent authority shall determine whether the conditions are met on the basis of the assessment referred to in paragraph 1 and other available information, particularly concerning the protection of the environment and human health.[83]

CCS ready regulations may be appropriate for jurisdictions that either have or expect to impose regulations for emitters to reduce greenhouse gas emissions. However, even for these jurisdictions, CCS ready regulations should be considered carefully as they can significantly influence the cost and viability of implementing a CCS project. For example, CCS ready regulations that require new power plants to define a pipeline route or identify a specific storage formation prior to acquiring land rights can increase the cost of acquiring these rights at a later time. Thus, policymakers should evaluate which elements of CCS readiness are appropriate for their particular jurisdiction.

For APEC developing economies, which presently do not have any international commitment to reduce emissions, CCS ready regulation generally would not be an essential element of a CCS permitting regime. However, for some APEC developing economies that have rapid growth in CO_2 emissions from new coal-fired generation, CCS readiness in some form could become an element of domestic regulation. An earlier

[83] Article 33, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

APEC study evaluated the potential for building CCS ready plants in six of the nine APEC developing economies included in this study, and estimated the costs in these economies. The APEC study provided guidelines for developing economies to facilitate their pursuing CCS ready coal-fired power generation.[84]

5.2.2. Technology Forcing Standards

Technology forcing standards are requirements to adopt a certain technology based on application of a performance requirement or other test. In the area of pollution control, examples of technology forcing standards include concepts such as "best available control technology" (BACT), a less stringent variant "reasonably available control technology standard" or the most stringent variant, "lowest achievable control technology standard". These control standards determine what air pollution control technology must be used to control a specific pollutant to a specified limit.

Like the concept of CCS ready, BACT is a forward-looking regulation that raises awareness among industry and the public that changes to regulation are anticipated. Mandating that power plants employ BACT for reduction of CO_2 could drive additional investment in CCS technology. However for CCS to constitute BACT, it must be commercially demonstrated taking into account various factors including cost and technology availability. Moreover, whether CCS would be commercially demonstrated, and thus could constitute BACT, would differ based on the specific source of CO_2 or technological application. Thus, for example, CCS is generally regarded as not having yet been commercially demonstrated for any power plant applications. Moreover, commercial demonstration for power plant applications would be technology-specific. For example, what constitutes BACT would differ for conventional coal-fired plants, natural gas plants, or integrated gasification combined cycle plants. Further distinctions may be made on the basis of whether a particular facility is old or new. In contrast, CCS may possibly be regarded as being commercially demonstrated for natural gas separation plants.

BACT regulations typically take into account factors such as size of facility or total source emissions, cost, and technology status. BACT requirements generally apply to new plants and may apply to expansion of existing plants and their stringency requirements can be varied.

US regulation provides an example of how BACT could be applied to CCS technology. The US EPA has developed detailed regulations for the application of BACT and has specifically identified CCS as a potential candidate technology for the BACT requirement. The US Clean Air Act requires BACT for certain regulated substances, including greenhouse gases, under its Prevention of Significant Deterioration (PSD) permit and Title V permit programs. What constitutes BACT is determined at the time an applicant apples for a PSD permit for the construction (if the facility is new) or modification (if the facility is an existing source) of any "major emitting facility." For greenhouse gases, a major emitting facility is defined, in its most basic form, as a facility that emits, or has the

[84] Asia-Pacific Economic Cooperation (APEC), "Planning and Cost Assessment Guidelines for Making New Coal-Fired Power Generation Plants in Developing APEC Economies CO2 Capture-ready", APEC Energy Working Group Project EWG 01/2008A (2010).

potential to emit greenhouse gas emissions equal to or greater than 100,000 tons CO_2-e.[85] Facilities subject to PSD would be required to use BACT for each pollutant emitted by the facility that is subject to regulation under the Clean Air Act.

Under the Clean Air Act, each new source or modified emission unit subject to PSD is required to undergo a BACT review with respect to regulated air pollutants. Facilities subject to PSD for greenhouse gases will be required to limit their emissions based on BACT. The EPA provided guidance to state agencies setting permit requirements for greenhouse gas emitters to determine whether there are available and feasible technologies for controlling emissions. Under the guidance, permitting authorities make BACT determinations on a case-by-case basis, applying an established five-step process:

Step 1: Identify all available control technologies

Step 2: Eliminate technically infeasible options

Step 3: Evaluate and rank remaining control technologies

Step 4: Evaluate cost, environmental and energy impacts of technologies

Step 5: Select the BACT and establish enforceable emission limits

The US EPA specifically identified CCS as a control technology that should be deemed "available" under Step 1 for large CO_2-emitting facilities, including fossil fuel-fired power plants and industrial facilities with high-purity CO_2 streams, although it recognized that technological and cost considerations may presently eliminate CCS as a candidate for BACT under Steps 2 and 4.[86]

Although US EPA has not determined that CCS constitutes BACT for any power plant application, we note that the US EPA has separately proposed New Source Performance Standards for New Electricity Generating Units (EGUs). Those standards would set the CO_2 emissions rate at that of combined cycle natural gas power plants, and thus effectively require new coal-fired EGUs to deploy CCS.[87] Adoption of these standards could effectively stop the construction of new coal-fired power plants in the United States until CCS technology becomes commercially available for coal power applications.

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[85] 42 U.S.C. § 7475(a), § 7479(1). The EPA shall consider application of the PSD and Title V requirements to smaller sources by July 1, 2013. However in no event shall sources with a potential to emit less than 50,000 CO2-e tons per year be subject to PSD or Title V permit requirements for greenhouse gas emissions before 2016. 42 U.S.C. § 7475(a).

[86] US Environmental Protection Agency, Office of Air Quality Planning and Standards, PSD and Title V Permitting Guidance for Greenhouse Gases (November 2010 and March 2011) (available at http://www.epa.gov/nsr/ghgdocs/ghgpermittingguidance.pdf).

[87] US Environmental Protection Agency, Standards of Performance for Greenhouse Gas Emisisons for New Stationary Sources: Electricity Generating Units; Proposed Rule, RIN 2060-AQ91, Docket No. EPA-HQ-OAR-2011-0660 (March 27, 2012).

Like CCS ready regulations, BACT requirements for greenhouse gases are appropriate for jurisdictions that either require or expect to require reductions of these gases. For APEC developing economies, BACT regulation that could require CCS would not be an essential element of a CCS permitting regime.

5.3. Transport Phase

Carbon dioxide can be transported by pipeline, truck, rail or ship and may be transported in gas, liquid or solid form. However, the most efficient way to transport CO_2 in significant volumes is by pipeline, after compressing and cooling the gas to a supercritical or dense-phase liquid. Accordingly, this section focuses on pipeline transport.

Regulatory issues concerning CO_2 pipelines focus on siting, construction and operation in order to ensure their safety, access and pricing. For CCS projects at any scale, safety issues are paramount, whereas access and pricing generally become issues if there is widespread commercial adoption of CCS technology that would necessitate a shared pipeline network.

5.3.1. Pipeline CO_2 Specifications, Siting, Construction & Operating Requirements

There is substantial experience operating CO_2 pipelines in the oil and gas industry. In the US, more than 3,600 miles of CO_2 pipelines are currently in operation, supplying 58 Mt of CO_2 per year, largely from natural sources, to EOR projects located primarily in west Texas.[88]

CO_2 pipelines have maintained a good safety record in part due to compliance with regulation and strong industry standards. A study of US CO_2 pipeline safety reported 10 reported incidents during the 1990-2002 period, representing an incident rate of 0.00032 per km per year. These events caused property damage totaling US$ 469,000 with no injuries or fatalities. Causes of incidents were relief valve failure (4 incidents), weld/ gasket/valve packing failure (3), corrosion (2) and outside force (1).[89] For subsea pipelines, the most significant risks are human error and ship anchors being dragged across pipelines in shallow waters less than 50 m.[90]

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[88] P. DiPietro, P. Balash and M. Wallace, A Note on Source of CO2 Supply for EOR Operations, Society of Petroleum Engineers (2012); Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

[89] Gale, J., and J. Davison, Transmission of CO_2: Safety and Economic Considerations, Proceedings of the 6th International Conference on Greenhouse Gas Control Technologies, 1-4, October, 2002, Kyoto, Japan, pp. 517-522 (2002).

[90] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

Regulation focus primarily on the design and operation of CO_2 pipelines to prevent, and if necessary mitigate the effects of, corrosion, leakage and overpressure. This section we address selected issues that have contributed to the safe operation of pipelines, specifically:

- Specifications for CO_2;
- Pipeline siting;
- Pipeline construction specifications; and
- Safe operating requirements.

5.3.1.1. Specifications for CO_2

Specifications for CO_2 are desirable in order to minimize corrosion of pipelines, which in turn reduces the risk of leaks and increases the safety of pipeline transport. CO_2 specifications can also increase the operating efficiency of the pipeline. Specifications should be adopted through regulation where the pipeline is to serve multiple CO_2 sources that may supply CO_2 of varying composition. Alternatively, pipeline operators may impose requirements through contract. The section in this study on CO_2 purity addresses some of these issues, primarily in the context of risk to human health and the environment. Here we focus on CO_2 specifications from the point of view of preventing corrosion and promoting efficiency of pipeline transport.

In order to minimize corrosion, the CO_2 stream should be dry and free of H_2S and oxygen.[91] Although it is possible to design corrosion-resistant pipelines using stainless steel, such a design could increase the cost of pipelines significantly.

Impurities in the CO_2 stream will change the properties of the CO_2, which could affect the efficiency and operation of the pipeline and require engineering and design modifications.[92] Impurities will change the critical pressure of the CO_2 stream, potentially requiring the pipeline to operate at higher pressure in order to maintain the stream in a single phase. Pressure and temperature change of the CO_2 stream will cause variations in density and viscosity, potentially resulting in phase change, and lead to changes in the volume and flow of the stream, resulting in inefficiencies during the transport phase and even damage to the pipeline. For power plant operations, the variable flow of CO_2 must also be taken into consideration in the capacity (diameter), design and operation of the pipeline.

Where there is water present in the CO_2 stream, a temperature drop can also result in damage to the pipeline by stressing materials and causing formation of hydrates, which

[91] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

[92] Newcastle University, in US-China Energy Center and West Virginia University, Carbon Capture and Sequestration Options for the Shenhua Direct Coal Liquefaction Plant: Final Pre-feasibility Study Report (2009).

can block pipelines and damage equipment. Hydrates can form at approximately 10-11°C for CO_2 pipelines.[93] Inhibitors may be added to CO_2 in order to reduce the potential for hydrate formation, if permitted by regulatory authorities.

A pipeline designed to carry CO_2 with impurities would be significantly more costly, requiring additional compressor stations along the pipeline to maintain high pressure in a supercritical phase. For marine pipelines, subsea compressor stations are at the early stages of deployment for natural gas applications and will be expensive, and therefore CO_2 purity is essential.[94]

Effect of Impurities on Pipeline Capacity

Composition	Mass Flow Rate (kg/s)	Vol. Flow Rate (m3/s)	% Deviation from Pure CO_2	
			Mass Flow Rate	Vol. Flow Rate
Pure CO_2	85.68	108.10	-	-
95% CO_2 + 5% N_2	81.92	44.68	-4.39	-58.67
90% CO_2 + 10% N_2	68.65	38.08	-19.88	-64.77
95% CO_2 + 5% CH_4	82.11	45.37	-4.17	-58.03
90% CO_2 + 10% CH_4	78.01	44.56	-8.95	-58.78
95% CO_2 + 5% H_2	76.48	43.17	-10.74	-60.06
90% CO_2 + 10% H_2	56.19	33.22	-34.42	-69.27
95% CO_2 + 5% Ar	83.7	45.02	-2.31	-58.35
90% CO_2 + 10% Ar	80.68	43.63	-5.84	-59.64
90% CO_2 + 5% CH_4 + 5% N_2	77.5	43.63	-9.55	-59.64
90% CO_2 + 5% H_2 + 5% Ar	62.02	35.07	-27.61	-67.56
90% CO_2 + 5% Ar + 5% CH_4	79.32	44.10	-7.42	-59.21

Source: Newcastle University, in US-China Energy Center and West Virginia University (2009), Carbon Capture and Sequestration Options for the Shenhua Direct Coal Liquefaction Plant: Final Pre-feasibility Study Report. Note: Calculations are for a pipeline segment with its flow adjusted to operate at a pressure drop of 0.0001bar/m with an internal diameter of 15" (OD=16") and an ambient temperature of 5°C.

Requirements concerning CO_2 purity can be specified in regulation and/or contract. EU law contains a general provision specifying CO_2 quality should meet "reasonable minimum composition thresholds" and that pipelines should be constructed to safely handle such CO_2. EU legislation is, however, careful to balance the cost of cleaning up CO_2 to achieve a desired purity with the cost of constructing pipelines and providing

[93] Fradet, A., Saysset, S., Odru, P., Broutin, P., Ruer, J. & Bonnissel, M., "Technical and Economic Assessment of CO2 Transportation for CCS Purposes", Journal of Pipeline Engineering, Vol. 6(3), pp.173-180 (2007).

[94] See, e.g., "Subsea compression can boost gas flow rate," Offshore Magazine, http://www.offshore-mag.com/articles/print/volume-69/issue-5/subsea/subsea-compression-can-boost-gas-flow-rate.html (accessed May 6, 2012).

access for less than pure streams of CO_2. According to the provision, "pipelines for CO_2 transport should, where possible, be designed so as to facilitate access of CO_2 streams meeting reasonable minimum composition thresholds." [95] The provision effectively allocates the responsibility in this regard to both the capture facility, to the extent that it requires it to clean up the gas stream to meet minimum thresholds, and the pipeline operator who must accommodate CO_2 with some level of impurity.

Common practice is for pipeline operators to specify purity requirements for CO_2 in order to protect pipelines against corrosion and to comply with any applicable law. The text box below provides an example of CO_2 quality specification in a CO_2 purchase agreement.

Example of CO_2 Quality Specifications from a CO_2 Purchase Agreement

The Product delivered by Seller or Seller's representative to Buyer at the Canyon Reef Carriers Delivery Meter shall meet the following specifications, which herein are collectively called "Quality Specifications"

(a) Carbon Dioxide. Product shall contain at least ninety-five mole percent (95%) of Carbon Dioxide as measured at the SACROC delivery meter.

(b) Water. Product shall contain no free water, and shall not contain more than 0.48 g m^{-3} in the vapour phase.

(c) Hydrogen Sulphide. Product shall not contain more than fifteen hundred (1500) parts per million, by weight, of hydrogen sulphide.

(d) Total Sulphur. Product shall not contain more than fourteen hundred and fifty (1450) parts per million, by weight, of total sulphur.

(e) Temperature. Product shall not exceed a temperature of 48.9°C.

(f) Nitrogen. Product shall not contain more than four mole percent (4%) of nitrogen.

(g) Hydrocarbons. Product shall not contain more than five mole percent (5%) of hydrocarbon and the dew point of Product (with respect to such hydrocarbons) shall not exceed –28.9°C.

(h) Oxygen. Product shall not contain more than ten (10) parts per million, by weight, of oxygen.

(i) Glycol. Product shall not contain more than 4×10^{-5} L m^{-3} of glycol and at no time shall such glycol be present in a liquid state at the pressure and temperature conditions of the pipeline.

Source: Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

[95] Article 21, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

5.3.1.2. Pipeline Siting

Pipelines should be sited in a manner that promotes safety, enables access for inspection and maintenance, and takes account of geographic features, highly populated and sensitive areas, and the construction of future infrastructure. Here we focus on safety considerations.

Carbon dioxide is heavier than ambient air and accumulates in surface depressions. Pipelines should therefore be routed in a manner that prevents accumulation in the event of a leak. Routing pipelines through sparsely populated areas reduces the risk of any leak to human health or property damage, as well as reduces the risk of damage to pipelines caused by activities such as trenching for water and sewer lines, street repair and other digging that might occur around pipelines in populated areas. For example, under US regulations, CO_2 pipelines must be sited at least 200 meters (m) on both sides of the pipeline from buildings or other construction.[96] Routing pipelines through heavily populated or environmentally sensitive areas requires special attention to design factors, such as overpressure protection and to leak detection.[97] In addition, signs, fencing and burying the pipeline can help reduce the risk associated with incidents caused by outside force, such as digging equipment.

Although CO_2 itself is not flammable and a CO_2 pipeline would therefore be safer than ordinary hydrocarbon pipelines, impurities in the CO_2 could pose risks to human health that affect the routing of the pipeline under applicable transportation, environmental or zoning regulations. For example, H_2S, a by-product of petroleum production, is a highly poisonous, flammable gas that poses risks to human health in relatively low concentrations. The US National Institute for Occupational Safety and Health recommended exposure limit is 10 parts per million (ppm) for 10 minutes of exposure.[98] The presence of H_2S or other impurities could require siting of the pipeline away from heavily populated areas. In the United States and United Kingdom, for example, pipeline siting regulations vary the corridor around the pipeline based on the substance being transported.

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[96] 49 CFR 192.5.

[97] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

[98] NIOSH Pocket Guide to Chemicals, available at http://www.cdc.gov/niosh/npg/npgd0337.html (accessed March 22, 2012).

5.3.1.3. Pipeline Construction Specifications

The high pressures at which CO_2 pipelines operate require demanding specification for materials and equipment. In order to maintain CO_2 in a supercritical state, pipelines should be operated at pressures above the CO_2 critical pressure of 7.38 megapascals (MPa) or 73 standard atmospheres (atm).[99] As gas travels along the pipeline, it loses pressure due to friction against the inside of the pipe. Also, as described above, the presence of impurities in the CO_2 stream change the physical property of the gas and could require increasing the pressure to avoid phase or temperature change. For these reasons, it is recommended that CO_2 pipelines be operated at pressures greater than 8.6 MPa (85 atm).[100] Maintaining high pressures may require installation of compression booster stations at intervals along the pipeline.

Onshore pipelines are typically buried to depth of one meter. Temperature in the CO_2 pipeline is largely determined by soil temperature. Soil temperatures range based on location, from 6-8°C in the summer for northern latitudes, to as high as 20°C in southern latitudes.[101]

Offshore pipelines are usually buried in shallow water, and may be laid in trenches in deeper water.[102] For offshore pipelines, surrounding water temperatures will affect CO_2 temperature. In equatorial areas, water temperatures can reach as high as the mid-30's^{o}C during the daytime, with temperatures lower and more stable at lower depths.[103] Subsea CO_2 pipelines must be sited away from hydrothermal vents.

Within the upper part of these temperature ranges, CO_2 can undergo a phase change from liquid to gas and expand. For APEC economies located in tropical zones, both onshore and offshore pipelines would require higher operating pressures and regulations should reflect this.

Steel pipelines are rated based on specified minimum yield strength (SMYS), which indicates the minimum stress a pipe may experience that will cause permanent deformation. The SMYS is determined by the material and the thickness of the pipe wall. A maximum allowable operating pressure (MAOP) is determined as a percentage of the SMYS, which provides a design safety margin. MAOP for oil and gas pipelines are set at

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[99] Reid, R.C., Prausnitz, J.M., Poling, B.E., The properties of gases and liquids. 4th edition, McGraw-Hill, Inc., New York (1987).

[100] Farris, C.B., Unusual Design Factors for Supercritical CO_2 Pipelines. Energy Progress (1983) 3(3): p. 150-158.

[101] Skovholt, O., *CO2 Transportation System.* Energy Conversion & Management (1993) 34 (9-11): p. 1095-1103.

[102] Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

[103] NASA Earth Observatory, available at http://m.earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MYD28M (accessed May 7, 2012).

80% of SMYS in the US.[104] Pipelines are hydrostatically tested to determine the MAOP and to ensure that it can operate safely before being placed in service.

Sudden pressure drops can induce fractures. US regulation requires that CO_2 pipelines be designed to mitigate the effects of fracture propagation; therefore, materials used for CO_2 pipelines must also have the strength to prevent ductile fracture propagation.[105] It is not common practice to convert different types of pipelines to carry CO_2 and any consideration of this approach should be evaluated carefully.

In conditions where pipelines may be vulnerable to fracture propagation or the pipeline is designed in a manner in which wall thickness, toughness, yield strength or diameter render it inadequate to resist possible fracturing, installation of crack arrestors may be considered or required. Crack arrestors are designed to prevent propagating fractures from spreading beyond three pipe spools and are generally only used onshore.[106] BSI specifications contemplate use of crack arrestors, particularly where pipeline strengths may not be conservatively estimated.[107] Several US CO_2 EOR pipelines have employed crack arrestors: the Central Basin Pipeline installed crack arrestors at intervals of 400 m, and Canyon Reef Carrier installed them at intervals of 5.8 kilometers (km).[108]

Block valves that isolate sections of the pipeline to allow for maintenance and to stop leakage in the event of damage to the pipeline should be installed at intervals along the pipeline. Specification ASME B31.4 requires that block valves be placed every 12 km. BSI PD 8010 does not specify a minimum interval, but rather requires that several factors be considered, including pipeline operating pressure, route through high population density and topography.[109]

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[104] Evangelos Michalopoulos and Sandy Babka, Evaluation of Pipeline Design Factors. Gas Research Institute (2000).

[105] 49 CFR 195.111.

[106] Section 9.2.4.2, Element Energy, CO2 Pipeline Infrastructure: An Analysis of Global Challenges and Opportunities. International Energy Agency Greenhouse Gas Programme (2010).

[107] British Standards Institute, BS8010-1(2004) “Code of practice for pipelines. Steel pipelines on land” (2004).

[108] Section 9.2.4.2, Element Energy, CO2 Pipeline Infrastructure: An Analysis of Global Challenges and Opportunities. International Energy Agency Greenhouse Gas Programme (2010).

[109] Section 9.2.4.3, Element Energy, CO2 Pipeline Infrastructure: An Analysis of Global Challenges and Opportunities. International Energy Agency Greenhouse Gas Programme (2010).

Specifications used in industry for operations involving CO_2

Specification/standard	Name/title	Comments
49 CFR 195	Transportation of hazardous liquids by pipeline	Only valid for pipeline transport of supercritical CO_2
NACE TM0192-2003	Evaluating elastomeric materials in carbon dioxide decompression environments	A general test method only valid for >99% CO_2. The test is conducted below 30°C at pressures <53bar. Thus not valid for supercritical CO_2
NACE TM0297-2008	Effect of high-temperature, high-pressure carbon dioxide decompression on elastomeric materials	Only valid for >99% CO_2. Test temperatures and pressures within the supercritical range, but not valid for CO_2 with impurities
NORSOK M-CR-710 2001	Qualification of non-metallic materials and manufacturers	Valid in the supercritical range, but only for CO_2 with different amounts of CH_4
API Spec 5L and 5LD	Specification for line pipe and specification for CRA or lined steel pipe	These are only used for well and field piping
BS PD 1080	Part 1 Steel pipelines on land and 2 - subsea pipelines	Takes CO_2 as a non-flammable, non-toxic fluid which is gaseous at ambient temperature and pressure
DNV OS-F101 2007	Submarine pipeline systems	Only valid for submarine pipelines. No mention of supercritical phase CO_2 transport
BS EN 14161	Petroleum and natural gas industries, pipeline transportation systems	Not valid for CO_2 transport in a strict sense. However, the standard mentions CO_2 as a non-flammable, non-toxic fluid which is gaseous at ambient temperature and pressure
ASME B31.4 and B31.8	Transportation of liquids and gases by pipeline	B31.8 specifically excludes pipelines carrying CO_2, and whilst B31.4 does not specifically include CO_2 within the list of fluids to which the code is intended to apply

Source: Shiladitya Paul, Richard Shepherd, Amir Bahrami, and Paul Woollin, Material Selection for Supercritical CO_2 Transport, TWI. Available at http://www.twi.co.uk/services/technical-information/published-papers/material-selection-for-supercritical-co2-transport/ (accessed March 19, 2012).

Transport of CO_2 by pipeline requires special equipment and fittings. Supercritical CO_2 at high pressure diffuses into the elastomers commonly used as sealants in oil and gas pipelines, weakening or damaging valves, gaskets and coatings. A sudden pressure drop can cause elastomers to crack as CO_2 is released. Flanges must also be designed to

withstand high pressures. Flanges meeting ASME-ANSI 900 having maximum allowable operating pressure of 15.3 MPa at 38°C are generally recommended.[110]

Design Margins for Selected Gas Transmission Pipeline Codes

Code	Condition	Safety Factor on SMYS	Safety Factor on Tensile Strength	Comments
B31.4 Pipeline Transportation Systems for Liquids	Pressure hoop stress	0.72		
B31.8 Gas Transmission and Distribution Systems	Pressure hoop stress Location Class 1, Div 1 Location Class 1, Div 2 Location Class 2 Location Class 3 Location Class 4	 0.80 0.72 0.60 0.50 0.40		Code includes numerous modifications for types of facilities, crossings, encroachment, etc.
British BS 8010 Section 2.8 Pipelines on Land: Steel for Oil and Gas	Pressure hoop stress Category B substances Category C & D Class 1 Category C & D Class 2 Category C & D Class 3	 0.72 0.72 0.30 0.30		Categories are related to hazard potential of substances and location class to population densities.
Canadian CSA Z662 Oil and Gas Pipeline Systems	Pressure hoop stress Basic design factor Depending on location and type of facility	 0.80 0.50 to 0.80		Canadian code is similar to B31.8. Limit States Design (LSD) non-mandatory appendix
Dutch NEN 3650 Requirements for Steel Pipeline Transportation	Pressure hoop stress Simplified analysis procedure	0.55 to 0.72		Code is sophisticated with plastic, reliability, and probabilistic and complete risk analysis procedures.
European DRAFT CEN PrEN 1594 Pipelines for Gas Transmission	Pressure hoop stress Basic design method Alternative design method	0.67 0.67	0.42 0.53	The alternative design route requires more controls. Has LSD option.
German DIN 2470 Part 2: Steel Gas Pipelines	Pressure hoop stress	0.62 to 0.67		Variation is associated with material minimum elongation and fracture properties.

Source: Evangelos Michalopoulos and Sandy Babka, Evaluation of Pipeline Design Factors. Gas Research Institute (2000).

Beyond compliance with regulations, most US CO_2 pipeline operators follow ASME B31.8 for gas transportation and distribution systems, which is designed for gases under

[110] Mohitpour, M., H. Golshan, and A. Murray, Pipeline Design & Construction. 1st ed. 2003, New York, NY: ASME Press.

pressure.[111] ASME B31.8 employs a risk-based approach to defining requirements, based on classes of locations defined in terms of population densities along a pipeline. Adopting class locations takes into account the heightened risk of damage to a pipeline near densely populated areas, as well as the possible severity or consequences of a pipeline failure on a populated area. ASME B31.8 requires setoffs from buildings, thicker wall pipe and lower maximum allowable operating pressure in areas with high population density and other special conditions. ASME B31.8 also requires hydrostatic testing for pipelines to expose defective materials and possible leaks, and ensure that the pipeline is structurally sound to withstand operating pressures before being put in service. The pipeline's maximum allowable operating pressure is further discounted by a safety factor or margin. The safety factor or safety margin should be large enough to more than compensate for uncertainties in the values of both the load (stress) and the resistance (strength) of the system. Australian, Canadian, British, European and Dutch codes have also incorporated risk-based concepts. The table above provides an overview of how several economies incorporate risk-based concepts in pipeline design rules and requirements.

5.3.1.4. Operating Requirements

In addition to physical construction specifications, CO_2 pipelines operators must observe operating regimes for maintenance, monitoring, and inspections and training of personnel in order to ensure the safe pipeline operation.

Pipelines must also be tested periodically to ensure their integrity. In the US, pipelines are typically subject to periodic aerial inspection, patrols, and internal inspection using pipeline inspection gauges or "pigs" for cleaning and to check corrosion and leaks.

Because CO_2 is considered a suffocant and therefore dangerous in concentrated quantities, pipeline operators must demonstrate that pipelines remain safe in all operational circumstances. Pipelines should be designed to isolate or block-in sections of pipe that have lost structural integrity. Regulations typically require controlled depressuring of pipelines to facilitate routine maintenance and ensure public safety during emergency situations such as pipe leakage. Where CO_2 must be vented to depressure a pipeline, block valve and venting station siting, design and operation should ensure that vented CO_2 does not collect in low-lying areas, near high-population areas, or can form as a solid in low temperature environments. Vented CO_2 may be heated with natural gas so that it will safely loft and not pool on the ground.

CO_2 pipeline operators must install metering systems that record delivery of gases into the pipeline (this should be integrated with greenhouse gas monitoring regulations) and Supervisory Control and Data Acquisition (SCADA) systems to measure pressure drops and facilitate emergency response. US code, for example, requires installation of computational pipeline monitoring leak detection for CO_2 pipelines transporting liquid in

[111] Pipelines International, Transport of CO_2 for carbon capture and storage (March 2010). Available at http://pipelinesinternational.com/news/transport_of_co2_for_carbon_capture_and_storage/040204/# (accessed March 19, 2012).

single phase (without gas in the liquid) that comply with API 1130.[112] Carbon dioxide pipeline operators are also required to adopt an integrity management program that evolves to reflect operating experience, results of periodic integrity assessments, and other maintenance and surveillance data. The integrity management program requires operators to adopt a process for identifying which pipeline segments could affect densely populated or sensitive areas, and develop remedial plans to address integrity issues raised by the assessment. The integrity plan requires a continual process of assessment and evaluation to maintain a pipeline's integrity and identification of preventive and mitigation measures to protect high consequence areas.[113]

5.3.1.5. Environmental impact assessments and Laws

Pipelines carrying high pressure would be subject to general environmental laws, such as those relating to environmental impact assessments. Pipelines may also be regulated under transportation laws governing hazardous material due to their high pressure.

5.3.1.6. Transboundary Issues

Pipelines traversing national borders will be subject to more than one jurisdiction's regulatory regime. In such circumstances, coordination among regulatory authorities in the relevant jurisdictions would be desirable to reduce the cost of compliance and enhance regulatory effectiveness. Reliance on generally accepted industry standards for high pressure pipeline design, construction and maintenance can also assist project developers and regulators in harmonizing requirements. For APEC developing economies in Asia, transboundary issues could occur for injection in offshore oil and gas reservoirs that are along borders or are shared formations. Transboundary cooperation and international standards are discussed further below.

5.3.2. Pipeline Pricing and Access

Because of the high cost of CO_2 pipeline infrastructure, widespread CCS adoption will likely require a pipeline network that links multiple CO_2 sources with one or more storage sites. Access to CO_2 pipelines will determine access to specific storage sites; therefore, regulation of transportation is crucial for emitters who have an obligation to reduce CO_2 emissions.

Pipeline access can significantly affect the economics of a CCS project. Hydrocarbon pipelines cost approximately US$1-2 million per mile to build in the US.[114] Annual

[112] 49 CFR 195.444

[113] 49 CFR 195.452

[114] Cost data based on the 2005-2006 period. West Virginia University, US Department of Energy Office of Fossil Energy, Lawrence Livermore National Laboratory, and China Shenhua Coal to Liquid and Chemical Co. Ltd., Carbon Capture and Sequestration Options for the Shenhua Direct Coal Liquefaction Plant: Final Pre-feasibility Study Report (2009).

operating and maintenance costs for a CO_2 pipeline are reported to be about $3,250 per km of pipeline in 2004 dollars,[115] estimated to be about 6% of the total cost per tonne of transportation for a 100 km (62 mile) pipeline supplying five Mt of CO_2 per year.[116]

The most cost-effective method for reducing pipeline transport costs is shared access to CO_2 pipelines. A GCCSI study estimates that by combining CO_2 from multiple sources using single trunk pipeline for delivery to a single storage site reduces the cost to transport the CO_2 from US$1-2 per tonne for a single source plant to less than US$1 and as low as US$0.5 per tonne for three or more source plants, for a 100 km pipeline supplying 10 Mt of CO_2 per year.[117]

Experience in the US suggests that lack of a pipeline network will not be a major barrier for early CCS demonstration projects. The nine large-scale integrated CCS projects in the US Regional Carbon Capture and Storage Program generally selected storage sites within a short distance from the capture facilities The total distance of pipelines for all projects is less than 36 miles, with the shortest distance being a matter of yards. The short distances of these pipelines and the fact that all of them except possibly one would be intrastate, precluded the need for more comprehensive transportation regulation.[118]

APEC developing economies should evaluate whether CO_2 pipeline access and pricing rules are necessary or appropriate to their circumstances. In many of these economies, pipelines are exclusively operated by a single state-owned oil company, which serves oil and gas fields that are candidates for CO_2 storage. Assuming CO_2 transport and storage operations would be conducted by a monopolist oil and gas operator or with their permission, pipeline access and pricing would be fully internal to a single company and further regulation may not be necessary. On the other hand, for economies with multiple oil and gas operators or economies that anticipate opening storage operations to a larger group of operators, regulation that guarantees access may be essential. For many of the APEC developing economies, CO_2 storage sites are primarily located offshore, in some cases requiring the construction of pipelines that are several hundreds of kilometers to land-based CO_2 sources. Given these distances and the associated costs of constructing dedicated CO_2 pipelines, APEC developing economies should evaluate potential opportunities for sharing offshore infrastructure.

Legislation in the EU provides an example of access and pricing regulation for CO_2 pipelines and storage facilities. Under the EU CCS directive, Member States are required

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[115] Bock, B., et al., Economic Evaluation of CO_2 Storage and Sink Enhancement Options, TVA Public Power Institute: Muscle Shoals, AL (2003).

[116] Sean T. McCoy, The Economics of CO_2 Transport by Pipeline and Storage in Saline Aquifers and Oil Reservoirs, Ph.D. Dissertation, Carnegie Mellon University (2009).

[117] WorleyParsons and Schlumberger, Economic Assessment of Carbon Capture and Storage Technologies: 2011 Update. Canberra, Australia: Global CCS Institute (2011).

[118] C. Hart, "Putting It All Together: The Real World of Fully Integrated CCS Projects." Discussion Paper 2011-06, Cambridge, Mass.: Belfer Center for Science and International Affairs (2011).

to provide for "fair, open and non-discriminatory" access to transportation networks, taking into account factors including transport and storage capacity that is available or can reasonably be made available. A pipeline operator may deny access on the grounds of incompatibility of technical specifications that cannot be reasonably overcome, the needs of the owner or operator of the storage site or of the transport network taking into account the interests of other users, or lack of capacity. Where access is denied on the basis of lack of capacity, Member States can seek to require transport and storage operators to make enhancements to facilitate broader access provided it is economic do to so.[119] Member States are also encouraged to establish dispute settlement mechanisms regarding access to transport networks and storage sites.[120] The text box below sets out the EU directive on access to transport and storage sites.

Several of the APEC developing economies already have regulations governing oil and gas pipeline access and pricing that integrates the same principles that are relevant to CO_2 pipeline access. For example, Thailand's Energy Regulatory Commission exercises jurisdiction concerning pricing and access to downstream gas pipelines in order to promote a competitive energy market. The Energy Regulatory Commission takes into account anti-competitive practices when issuing licenses to applicants who operate businesses in the energy industry. Thailand's Energy Industry Act requires the licensed operator of an energy network system to allow other operators to connect to that system and to operate the system without unjust discrimination.[121] It prohibits anti-competitive practices among licensees and gives authority to the Energy Regulatory Commission to "stop or correct the practices that are monopolistic, reduce competition or limit competition".[122] Regulations such as these could provide APEC developing economies with guidance for developing CO_2 pipeline access regulations based on local models.

[119] Article 21, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[120] Preamble paragraph 38, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

[121] Sections 7, 80 and 81, Energy Industry Act B.E. 2550 (2007).

[122] Sections 51 and 60, Energy Industry Act B.E. 2550 (2007).

EU Access to Transport and Storage Sites

Article 21

Access to transport network and storage sites

Member States shall ensure that the operator, on the basis

1. That potential users are able to obtain access to transport networks and to storage sites for the purposes of geological storage of the produced and captured CO_2, in accordance with paragraphs 2, 3 and 4.

2. The access referred to in paragraph 1 shall be provided in a transparent and non-discriminatory manner determined by the Member State. The Member State shall apply the objectives of fair and open access, taking into account:

(a) the storage capacity which is or can reasonably be made available within the areas determined under Article 4, and the transport capacity which is or can reasonably be made available;

(b) the proportion of its CO_2 reduction obligations pursuant to international legal instruments and to Community legislation that it intends to meet through capture and geological storage of CO_2;

(c) the need to refuse access where there is an incompatibility of technical specifications which cannot be reasonably overcome;

(d) the need to respect the duly substantiated reasonable needs of the owner or operator of the storage site or of the transport network and the interests of all other users of the storage or the network or relevant processing or handling facilities who may be affected.

3. Transport network operators and operators of storage sites may refuse access on the grounds of lack of capacity. Duly substantiated reasons shall be given for any refusal.

4. Member States shall take the measures necessary to ensure that the operator refusing access on the grounds of lack of capacity or a lack of connection makes any necessary enhancements as far as it is economic to do so or when a potential customer is willing to pay for them, provided this would not negatively impact on the environmental security of transport and geological storage of CO_2.

5.4. Storage Phase

CCS storage involves a broad range of issues. Jurisdictions promoting adoption of CCS generally develop regulations and permitting regimes for storage site exploration, injection and measurement, monitoring and accounting (MVA) / verification (MVR) requirements. Standards for well construction, operation and closure should also be established. This section addresses the various issues that regulation typically covers in OECD jurisdictions that have developed CCS legislation. In addition to the discussion in

this section, we address mechanisms for securing subsurface property rights in section 5.5.1 on Subsurface Rights. The specific issues addressed in this section are as follows:

- Exploration permit;
- Injection or storage permits and site integrity requirements;
- Geologic characterization requirements;
- Well construction;
- Operating requirements;
- Monitoring, reporting and verification;
- Post-injection site care, well plugging and site closure; and
- Remediation and emergency response.

5.4.1. Exploration Permit

Exploration of potential storage sites should be regulated and coordinated by a single designated authority. Government coordination helps prevent conflicting activities and facilitates safe, rational development of storage potential. Exploration should therefore be prohibited unless a specific license is procured for that purpose.

Regulation should identify the objectives of an exploration license in order to provide guidance to applicants and license holders. These objectives should be closely linked to the geologic assessment requirements that are discussed further in section 5.4.3 titled "Geologic Characterization Requirements". For example, in Australia, Victoria's Greenhouse Gas Geological Storage Act identifies the following objectives:

- Establish characteristics and extent of any underground geological storage formation in the permit area;

- Assess the feasibility of injecting a greenhouse gas substance into an underground geological storage formation;

- Assess the suitability of an underground geological formation for permanent storage; and

- Ensure that the greenhouse gas sequestration exploration is carried out in a manner that protects the integrity of the underground storage formation and protects public health and the environment.[123]

Similar to the oil and gas industry, exploration of potential storage sites will require substantial investment; therefore, companies making those investments will reasonably expect preference for a period of time to further develop storage sites they discover. The granting of an exploration license can therefore pre-determine later storage site development and should be undertaken through a public bidding or other publicly announced process that encourages competition and optimal use of resources.

[123] Article 21, Victoria Greenhouse Gas Geological Sequestration Act 2008.

As part of the exploration licensing process, the regulator would undertake a review of applicants' technical and financial resources. Applications for an exploration license would typically include:

- Proposed work program;
- Applicant's technical qualifications and qualification of key employees;
- Financial resources of applicant; and
- Technical qualification of applicant's partners.

The exploration permit must clearly define the scope of rights being granted and the obligations imposed on the licensee. The area of exploration, both in terms of areal extent and stratum, should be clearly identified in the license. Regulation should define the period of the license, as well as terms for renewal, and the criteria for granting renewals. Exploration licenses should be time-limited to provide an incentive for the holder to pursue the approved work plan in a prompt manner. For example, Victoria's regulation grants an initial five-year right to explore.[124] In general, once an exploration license lapses without renewal, the exploration opportunity should be made available to other prospective developers.

The scope of the exploration activity to be undertaken should clearly identify that it relates to geological storage, and if rights include prospecting for minerals, the expanded set of exploration rights should be specified. For oil and gas producing economies, petroleum and storage exploration and exploitation should be coordinated as they are for several leading jurisdictions.

The Australian Commonwealth's legislation governing offshore storage of greenhouse gases provides an example of how storage and petroleum exploration might be coordinated. Under the legislation, with the consent of the regulator, greenhouse gas storage exploration permit holders also have the right "to recover petroleum in the permit area for the sole purpose of appraising a discovery of petroleum that was made as an incidental consequence of authorized storage exploration or greenhouse gas injection incidental to exploration." The legislation clarifies that any petroleum recovered by the permit holder in the permit area does not become its property.[125]

Different jurisdictions have established different rules on whether an exploration permit entitles a holder to conduct test injections. Australian Commonwealth offshore greenhouse gas storage legislation is an example of a permissive rule. Under Australian law, the holder of an exploration permit possesses the authority:

- To inject, on an appraisal basis, a greenhouse gas substance into a part of a geological formation, so long as the relevant well is situated in the permit area;

- To store, on an appraisal basis, a greenhouse gas substance in a part of a geological formation, so long as the injection of the stored greenhouse gas

[124] Article 30, Victoria Greenhouse Gas Geological Sequestration Act 2008.

[125] Article 290, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

substance takes place at a well situated in the permit area; and

- To inject and/or store, on an appraisal basis, air, petroleum or water into a part of a geological formation in the permit area. [126]

Other jurisdictions grant research rights that include limited, small-scale CO_2 injection in order to assess the suitability of site.[127] Whether test injections are permitted under the exploration license or separate authority must be obtained is an issue that should be considered in developing regulations.

As the license to explore is a valuable right, legislators may wish to impose an obligation on a license holder to carry out exploration activities and the scope of that obligation. Whether and the extent to which a license should be obligated to perform specified exploration activities should take into consideration the cost of activities. As permit areas will not be uniform, discretion with respect to this issue might be granted to regulators to allow flexibility for negotiation with prospective applicants in order to facilitate attracting applicants to pursue exploration activities.

The activities that are permitted and required under the exploration license should be defined in regulation and more specifically elaborated in an approved exploration work plan. The purpose of the work program is to ensure that the efforts of the licensee are designed to develop the resource in a safe manner using approved methods. It also ensures that an agreed amount of effort is undertaken to develop the storage site within a specified time. It is therefore important in the overall development of natural resources within the economy, and provides a benchmark for regulators to assess whether renewal of an exploration permit or granting of an injection permit are appropriate.

The ultimate purpose of a license is to produce data to be used by developers and regulators in evaluating the suitability of prospective storage sites. Accordingly, regulatory authorities will want to require certain data to be collected. Regulation should require that data produced as a result of exploration activities be reported to the regulatory authority and the rules governing the use and release of the data. These issues are discussed in detail in section 5.5.4 titled “Data Reporting and Confidentiality.”

An exploration license holder that has met all of its obligations and identified a suitable storage formation would be granted an exclusive right for a defined period to apply for an

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[126] Article 290, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[127] For example, Washington state allows for streamline permitting for CO_2 test injections of under 1,000 metric tons or greater volumes if approved. Wash. Admin. Code, 173-218-115(4)(b). The Commonwealth of Australia provides for a Research Consent permit for exploration of potential geologic formations and injection sites, the rights conferred to be specified in such the consent. Article 423, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006. European Union regulations do not apply to CO_2 injections under 100,000 tonnes undertaken for research purposes. Article 2(2), Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

injection or storage permit. Victoria's CCS legislation provides a five-year "retention lease", which can be renewed up to 15 years, that enables the holder of an exploration permit to retain the right to an underground geological storage formation that is not yet commercially viable to develop.[128] Australian Commonwealth offshore CCS legislation provides for a similar concept of a general "holding lease" for five-years that is renewable and a "special holding lease" that is indefinite.[129] During the period of holding lease, the license holder would possess certain rights to continue exploration and remain subject to a work program obligation.

5.4.2. Injection or Storage Permits and Site Integrity Requirements

The injection or storage permit is the regulatory document that authorizes the injection of CO_2 into a geologic formation for purposes of permanent storage. It is the central permitting document in a CCS regulatory regime that provides regulators with a tool to supplement or grant variances from regulation, including tailoring site-specific regulatory requirements.

The primary function of the injection or storage permit is to authorize injection of CO_2 for permanent storage into a specifically identified storage formation. The storage permit would also include authorization for activities incidental to injection (e.g. installation of necessary infrastructure), to the extent such authorization is within the jurisdiction of the regulator issuing the permit. Storage permits may also allow further exploration of potential storage sites within a defined area, and experimental injections in such formations.

In jurisdictions that integrate greenhouse gas and petroleum regulations, the injection permit may also cover incidental recovery of hydrocarbons or even EOR operations. For example, Australian Commonwealth legislation governing offshore CCS authorizes the operator to recover petroleum resources, however specifying that the owner does not own recovered petroleum. The Australian provisions are set out in their original form in the text box below.

[128] Articles 58 and 67, Victoria Greenhouse Gas Geological Sequestration Act 2008.

[129] Articles 322 and 331, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

Australian Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act 2006, Section 357: Rights Conferred by greenhouse gas injection license

(1) A greenhouse gas injection licence authorises the licensee, in accordance with the conditions (if any) to which the licence is subject:

(a) to inject a greenhouse gas substance into an identified greenhouse gas storage formation that is wholly situated in the licence area, so long as the relevant well is situated in the licence area; and

(b) to permanently store a greenhouse gas substance in an identified greenhouse gas storage formation that is wholly situated in the licence area, so long as the injection of the stored greenhouse gas substance takes place at a well situated in the licence area; and

(c) to explore in the licence area for a potential greenhouse gas storage formation; and

(d) to explore in the licence area for a potential greenhouse gas injection site; and

(e) to inject, on an appraisal basis, a greenhouse gas substance into a part of a geological formation, so long as the relevant well is situated in the licence area; and

(f) to store, on an appraisal basis, a greenhouse gas substance in a part of a geological formation, so long as the injection of the stored greenhouse gas substance takes place at a well situated in the licence area; and

(g) to inject, on an appraisal basis:

(i) air; or

(ii) petroleum; or

(iii) water;

into a part of a geological formation for purposes in connection with the exploration authorised by paragraph (c) or (d), so long as the relevant well is situated in the licence area; and

(h) to store, on an appraisal basis:

(i) air; or

(ii) petroleum; or

(iii) water;

in a part of a geological formation for purposes in connection with the exploration authorised by paragraph (c) or (d), so long as the injection of the stored air, petroleum or water takes place at a well situated in the licence area; and

(i) with the written consent of the responsible Commonwealth Minister, to recover petroleum in the licence area for the sole purpose of appraising a discovery of petroleum that was made as an incidental consequence of:

(i) the injection authorised by paragraph (a), (e) or (g); or

(ii) the exploration authorised by paragraph (c) or (d); and

(j) to carry on such operations, and execute such works, in the licence area as are necessary for those purposes.

(2) The rights conferred on the licensee by subsection (1) are subject to this Act and the regulations.

(3) If petroleum is recovered by the licensee in the licence area as authorised by paragraph (1)(i), the petroleum does not become the property of the licensee.

(4) A greenhouse gas injection licence does not authorise the licensee to make a well outside the licence area.

The storage permit should comprehensively specify the authorizations, restrictions and operating requirements for the particular storage site. These include:

- Areal extent and stratum for injection;
- Injection rate and total volume per annum;
- Injection period;
- Injection pressure;
- Monitoring, reporting and verification requirements;
- Emergency response; and
- Financial security requirements.

In addition to the discussion of injection permits, we discuss each of these requirements in individual sections of this chapter.

The regulator will typically possess broad authority to impose specific conditions on the project's operations in the injection permit. An excerpt from Australian Commonwealth legislation authorizing the regulator to impose conditions on a greenhouse gas injection license holder is set out in the text box below.

Storage permits would generally be exclusive to a particular geologic formation, however regulators in some jurisdictions may issue one or more permits to multiple operators to inject CO_2 into a common formation. Regulators may also retain the right to issue subsequent injection and storage permits for storage formations following completion of injection activities by another operator. Victoria's CCS legislation, for example, authorizes subsequent injection and monitoring licenses to be issued if the regulator is satisfied that granting a further license: (a) is in the public interest; (b) will not interfere with the post-injection monitoring and verification activities of the existing license holder; and (c) will not present a significant risk of contaminating or sterilizing other resources in the proposed license area.[130]

Regulation should specify the duration of greenhouse gas licenses if they are time-limited. Australian Commonwealth law, for example, provides a trigger for termination of injection

[130] Article 87, Victoria Greenhouse Gas Geological Sequestration Act 2008.

licenses if no injection operations occur for five years.[131] This is subject to regulators also issuing a site-closing certificate after assessment that relevant statutory requirements have been met; a decision on issuing a site-closing certificate must be made within five years after the application was made.[132]

The geologic assessment of the site is the basis for setting the specific requirements of the storage permit. Therefore completion of the site characterization is an essential step for permitting and the results should be provided to regulators as part of the injection permit application. Regulators may take an iterative approach to characterization by requiring additional information based on site-specific risks. The iterative process emphasizes learning and provides regulators with information to better tailor the permit. The specific requirements of geologic assessment are discussed in more detail in the section 5.4.3 on "Geologic Characterization Requirements".

[131] Articles 359 and 360, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[132] Articles 386(4)-(8) and 593, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

Australian Commonwealth Offshore Petroleum and Greenhouse Gas Storage Act 2006, Section 358: Conditions of greenhouse gas injection licenses

(1) The responsible Commonwealth Minister may grant a greenhouse gas injection licence subject to whatever conditions the responsible Commonwealth Minister thinks appropriate.

(2) The conditions (if any) must be specified in the licence.

Injection and storage of greenhouse gas substance

(3) A greenhouse gas injection licence is subject to the condition that the licensee will not:

> (a) inject a greenhouse gas substance into an identified greenhouse gas storage formation that is wholly situated in the licence area; or
>
> (b) permanently store a greenhouse gas substance in an identified greenhouse gas storage formation that is wholly situated in the licence area;
>
> unless:
>
> (c) the identified greenhouse gas storage formation is specified in the licence; and
>
> (d) the greenhouse gas substance is of a kind that is specified in the licence; and
>
> (e) the greenhouse gas substance complies with such requirements (if any) as are specified in the licence; and
>
> (f) the origin or origins of the greenhouse gas substance are as specified in the licence; and
>
> (g) the greenhouse gas substance is injected at a potential greenhouse gas injection site or sites specified in the licence; and
>
> (h) the greenhouse gas substance is injected during a period specified in the licence; and
>
> (i) the sum of:
>
> > (i) the total amount of greenhouse gas substance that has already been injected into the identified greenhouse gas storage formation; and
> >
> > (ii) the total amount of greenhouse gas substance that is proposed to be injected into the identified greenhouse gas storage formation;
> >
> > does not exceed the amount specified in the licence; and
>
> (j) the rate, or range of rates, of injection of the greenhouse gas substance is as specified in the licence; and
>
> (k) in a case where the fundamental suitability determinants of the identified greenhouse gas storage formation include particular engineering enhancements—those engineering enhancements have been made.

The storage permit application will typically require the provision of comprehensive data and proposed operating requirements for the storage project. Legislation, regulation and

guidance governing CCS projects in leading jurisdictions provide an example of information that would be typically required in the application:

- Draft site plan for each identified greenhouse gas storage formation;
- Proposal for work and expenditure for greenhouse gas storage formations;
- Technical qualifications of the applicant and of the applicant's employees;
- Applicant's financial resources;[133]
- Map showing the injection well and applicable containment zone or "Area of Review", showing the number or name, and location of all injection wells, producing wells, abandoned wells, plugged wells or dry holes, deep stratigraphic boreholes, approved subsurface cleanup sites, surface bodies of water, springs, mines (surface and subsurface), quarries, water wells, other pertinent surface features including structures intended for human occupancy, roads, and known faults;
- Information on the geologic structure and hydrologic properties of the proposed storage site and overlying formations, including:
    - Maps and cross sections of the Area of Review;
    - Location, orientation, and properties of known or suspected faults and fractures that may transect the confining zone(s) in the Area of Review and a determination that they would not interfere with containment;
    - Data on the depth, areal extent, thickness, mineralogy, porosity, permeability, and capillary pressure of the injection and confining zone(s); including geology/facies changes based on field data which may include geologic cores, outcrop data, seismic surveys, well logs, and names and lithologic descriptions;
    - Geomechanical information on fractures, stress, ductility, rock strength, and in situ fluid pressures within the confining zone(s);
    - Information on the seismic history including the presence and depth of seismic sources and a determination that the seismicity would not interfere with containment;
    - Geologic and topographic maps and cross sections illustrating regional geology, hydrogeology, and the geologic structure of the local area;

[133] Article 360, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

- Information on all wells within the Area of Review which penetrate the injection or confining zone(s), including well type, construction, date drilled, location, depth, record of plugging and/ or completion;

- Maps and stratigraphic cross sections indicating the general vertical and lateral limits of all underground sources of drinking water, water wells and springs within the Area of Review, their positions relative to the injection zone(s), and the direction of water movement, where known;

- Baseline geochemical data on subsurface formations;

- Proposed operating data for the proposed geologic sequestration site:

    - Average and maximum daily rate and volume and/or mass and total anticipated volume and/or mass of the carbon dioxide stream;
    - Average and maximum injection pressure;
    - The source(s) of the carbon dioxide stream;
    - An analysis of the chemical and physical characteristics of the carbon dioxide stream;

- Proposed pre-operational formation testing program to obtain an analysis of the chemical and physical characteristics of the injection zone(s) and confining zone(s);

- Proposed stimulation program, a description of stimulation fluids to be used and a determination that stimulation will not interfere with containment;

- Proposed procedure to outline steps necessary to conduct the injection operation;

- Schematics of surface and subsurface construction details of the well;

- Injection well construction procedures;

- Proposed Area of Review and corrective action plan;

- Demonstration that the applicant meets financial responsibility requirements;

- Proposed testing and monitoring plan;

- Proposed injection well plugging plan;

- Proposed post-injection site care and site closure plan;

- Proposed emergency and remedial response plan; and

- Logging and testing of the well and the formation[134]

Final issuance of a license and periodic maintenance of the license may also include requirements such as:

- Conducting mechanical integrity tests of the well;
- Updating plans and predictive models of plume migration against actual data; and
- Reporting status of corrective actions in wells within the permit area.

Regulation should specify clear criteria for granting the injection or storage permit. The criteria may include specific consultation or processes that the regulatory authority must adhere to in making its determination. All jurisdictions adopt criteria designed to ensure that geologic formations are suitable for CO_2 storage, although the formulations of these standards vary. For example, US regulation under the UIC program of the Safe Drinking Water Act requires applicants to demonstrate that the wells will be sited in areas with a suitable geologic system. Specifically, applicants must demonstrate that the geologic system comprises:

- An injection zone(s) of sufficient areal extent, thickness, porosity, and permeability to receive the total anticipated volume of the carbon dioxide stream; and
- Confining zone(s) free of transmissive faults or fractures and of sufficient areal extent and integrity to contain the injected carbon dioxide stream and displaced formation fluids and allow injection at proposed maximum pressures and volumes without initiating or propagating fractures in the confining zone(s).

Under US regulation, the regulator will also consider the compatibility of the CO_2 with fluids in the injection zone(s) and minerals in both the injection and the confining zone(s), based on the results of the formation testing program, and with the materials used to construct the well. The regulator may additionally require applicants to inject below the lowermost underground sources of drinking water and/or identify and characterize additional containment zones that will impede vertical CO_2 movement.[135]

Beyond the fundamental determination whether an underground geological formation is suitable for permanent storage of CO_2, some jurisdictions impose a commercial viability requirement in addition to safe operation requirements. For example, Australian Commonwealth legislation concerning offshore CCS requires that the regulator be satisfied that, if the greenhouse gas injection license were granted to the applicant, the

[134] 40 CFR §146.82.

[135] 40 CFR §146.83.

applicant will, within five years after the grant, commence injection operations.[136] Similarly, Victoria's onshore CCS legislation requires the regulator to consider:

- Applicant's access to a commercially viable volume of greenhouse gas substance;
- Merits of the work program proposed by the applicant; and
- Likelihood that the work program will be carried out.[137]

Although it is not a requirement under US regulation, the US Department of Energy's National Energy Technology Laboratory (NETL) (based in part on experience with CCS demonstration projects under the US Regional Carbon Sequestration Partnership program) recommends in its best practices guidance that project developers outline a site development plan, including an economic feasibility study, during the site screening, selection and characterization process.[138]

Regulation may also require the regulator to determine that the proposed project is in the broader public interest, and/or it does not significantly adversely affect other interests such as petroleum exploration and development. Australian Commonwealth legislation for offshore CCS requires these findings and moreover favors applicants obtaining the consent of holders of petroleum production licenses in the permit area.[139] As discussed in greater detail in section 5.5.2 entitled "Liability for Long-term Storage of CO_2," several US states subordinate CO_2 injection rights to mineral rights holders altogether.

5.4.3. Geologic Characterization Requirements

Geologic characterization is the critical step to provide regulators and project developers with the information necessary to ensure that a geologic formation is suitable to permanently and safely store CO_2.

Geologic characterization is the core part of a process to identify and screen potential sites suitable for storage, and then conduct more detailed assessment of promising sites in order to confirm their suitability. Therefore, elements of site characterization can be prioritized in order to focus resources on those sites that pass an initial screen and are deemed the strongest candidates for further assessment. An initial screening would involve collecting and analyzing basic data that would enable project developers and regulators to determine a site's potential suitability. Det Norske Veritas'

[136] Article 362, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[137] Articles 82 and 83, Victoria Greenhouse Gas Geological Sequestration Act 2008.

[138] Section 4.6, US National Energy Technology Laboratory, Best Practices for Site Screening, Site Selection and Initial Characterization for Storage of CO_2 in Deep Geologic Formations (2010).

[139] Article 362, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

CO2QUALSTORE Guidelines propose that the initial screening of sites be based on whether it posses the following characteristics:

- Adequate porosity and thickness (for storage capacity) and permeability (for injectivity) at sufficient depth of injection to achieve dense phase conditions;

- Capped by extensive confining, low permeable units (such as shale, mudstone, salt or anhydrite beds) to diminish the probability of CO_2 escaping into overlying, shallower rock units and to the surface;

- Seismically stable geologic environment to avoid compromising the storage integrity; provided however that seismically active areas or extensively faulted or fractured sedimentary basins should not a priori be disqualified, but may require more careful characterization to assess their suitability; and

- If other natural resources of value are present, compatibility of CO_2 storage operations with exploitation of these resources.[140]

The above criteria are not typically reflected in regulation, but rather are considered best practices. However, if site characterization costs are financed through public funds, criteria such as the above could appropriately be mandatory as a condition for proceeding with full geologic assessment. Based in part on experience with CCS demonstration projects, the US NETL recommends in its best practices guidance that project developers examine a broader range of issues during the site screening, selection and characterization process. These issues go beyond technical requirements and include economic feasibility, land use rights, broader environmental considerations and social aspects of the project including community support.[141]

Once a site has been qualified as an appropriate candidate under the screening criteria, the site would be fully assessed. Under US regulation, during the drilling and construction of a CO_2 injection well, the operator is required to further develop information about the site. It must log the well and conduct surveys and tests to determine or verify the depth, thickness, porosity, permeability, and lithology of relevant geologic formations.[142] Development of geologic information to supplement the initial characterization is an ongoing process throughout the life of the project.

Similar to other areas of CCS regulation, our survey of regulation in different jurisdictions shows that some adopt a prescriptive approach, whereby specific measures are required to be performed as part of the assessment, whereas others adopt goals for the

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[140] Det Norske Veritas, CO2QUALSTORE Guideline for Selection and Qualification of Sites and Projects for Geological Storage of CO_2, 2010.

[141] Section 3.0, US National Energy Technology Laboratory, Best Practices for Site Screening, Site Selection and Initial Characterization for Storage of CO_2 in Deep Geologic Formations (2010).

[142] US Environmental Protection Agency, Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Final Rule, 75 Fed. Reg. 77230, 77297 (December 10, 2010).

characterization assessment criteria without specifying specific requirements. A hybrid approach, specifying certain basic requirements for assessment, while leaving a degree of flexibility based on satisfaction of specified performance criteria, should also be considered. Regulators in APEC developing economies should consider which approach is more appropriate for their particular economy as part of the regulatory development process.

The OECD jurisdictions we surveyed reflect a risk-based approach to geologic characterization. Under a risk-based approach, information is required and developed based on the specific risks that a site presents.[143] This approach enables project developers and regulators to concentrate resources on the most significant risks and to tailor assessment efforts to the particular site. The risk-based approach is iterative in nature, involving interaction between regulators and developers throughout the characterization and even into the operation process.

At the same time, there is general consensus among the scientific community and regulators that have adopted CCS regulation that certain assessment requirements are desirable. The EU conceives of assessment in three steps: (1) data collection, (2) modeling of geologic subsurface, and (3) characterization of storage dynamic behavior, sensitivity characterization, and risk assessment. We set out assessment requirements as described in EU legislation:[144]

Step 1: Data collection

Data to construct a volumetric and three-dimensional static (3-D)-earth model for the storage site, including the caprock, surrounding area, and hydraulically connected areas, shall cover at least the following intrinsic characteristics of the storage complex:

- Geology and geophysics;
- Hydrogeology (in particular existence of ground water intended for consumption);
- Reservoir engineering (including volumetric calculations of pore volume for CO_2 injection and ultimate storage capacity);
- Geochemistry (dissolution rates, mineralization rates);
- Geomechanics (permeability, fracture pressure);

[143] Det Norske Veritas, CO2QUALSTORE Guideline for Selection and Qualification of Sites and Projects for Geological Storage of CO_2 (2010).

[144] See Annex I, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

- Seismicity; and

- Presence and condition of natural and man-made pathways, including wells and boreholes, which could provide leakage pathways.

The following characteristics of the storage complex vicinity shall be documented:

- Domains surrounding the storage complex that may be affected by the storage of CO_2 in the storage site;

- Population distribution in the region overlying the storage site;

- Proximity to valuable natural resources (including natural habitats of wild fauna and flora, potable groundwater and hydrocarbons);

- Activities around the storage complex and possible interactions with these activities (for example, exploration, production and storage of hydrocarbons, geothermal use of aquifers and use of underground water reserves); and

- Proximity to the potential CO_2 source(s) (including estimates of the total potential mass of CO_2 economically available for storage) and adequate transport networks.

Step 2: Three-dimensional static geological earth model

Using the data collected in Step 1, develop three-dimensional static geological earth model(s) of the candidate storage complex, including the caprock and the hydraulically connected areas and fluids using computer reservoir simulators, characterizing the complex in terms of:

- Geological structure of the physical trap;

- Geomechanical, geochemical and flow properties of the reservoir overburden (caprock, seals, porous and permeable horizons) and surrounding formations;

- Fracture system characterization and presence of any human-made pathways;

- Areal and vertical extent of the storage complex;

- Pore space volume (including porosity distribution);

- Baseline fluid distribution; and

- Any other relevant characteristics.

The uncertainty associated with each of the parameters used to build the model shall be assessed by developing a range of scenarios for each parameter and calculating the

appropriate confidence limits. Any uncertainty associated with the model itself shall also be assessed.

Step 3: Characterization of the storage dynamic behavior, sensitivity characterisation, risk assessment

The characterizations and assessment shall be based on dynamic modeling, comprising a variety of time-step simulations of CO_2 injection into the storage site using the three-dimensional static geological earth model(s) in the computerized storage complex simulator constructed under Step 2. In characterizing storage dynamic behavior, at least the following factors shall be considered:

- Possible injection rates and CO_2 stream properties;
- Efficacy of coupled process modeling (the way various single effects in the simulator(s) interact);
- Reactive processes (the way reactions of the injected CO_2 with in situ minerals feedback in the model);
- Reservoir simulator used (multiple simulations may be required in order to validate certain findings);
- Short and long-term simulations to establish CO_2 fate and behavior over decades and millennia, including the rate of dissolution of CO_2 in water.

The dynamic modeling shall provide insight into:

- Pressure and temperature of the storage formation as a function of injection rate and accumulative injection amount over time;
- Areal and vertical extent of CO_2 over time;
- Nature of CO_2 flow in the reservoir, including phase behavior;
- CO_2 trapping mechanisms and rates (including spill points and lateral and vertical seals);
- Secondary containment systems in the overall storage complex;
- Storage capacity and pressure gradients in the storage site;
- Risk of fracturing the storage formation(s) and caprock;
- Risk of CO_2 entry into the caprock;

- Risk of leakage from the storage site (for example, through abandoned or inadequately sealed wells);
- Rate of migration (in open-ended reservoirs);
- Fracture sealing rates;
- Changes in formation(s) fluid chemistry and subsequent reactions (for example, pH change, mineral formation) and inclusion of reactive modeling to assess affects;
- Displacement of formation fluids; and
- Increased seismicity and elevation at surface level.

The third step – characterizing dynamic behavior of the complex – involves simulation of potential CO_2 paths based on varying parameters and operating assumptions in the model. The third step culminates in a risk assessment that requires a hazard characterization of potential for leakage from the storage complex, including consideration of:

- Potential leakage pathways;
- Potential magnitude of leakage events for identified leakage pathways (flux rates);
- Critical parameters affecting potential leakage, such as maximum reservoir pressure, maximum injection rate, temperature, sensitivity to various assumptions;
- Secondary effects of storage of CO_2, including displaced formation fluids and new substances created by the storing of CO_2; and
- Any other factors which could pose a hazard to human health or the environment, such as physical structures associated with the project.

These factors are used to assess potential risk exposure of, and potential effects on human populations and the environment. The effects assessment takes into account the sensitivity of particular species, communities or habitats that can be impacted by potential leakage events. Ultimately, the modeling efforts produce an assessment of the safety and integrity of the proposed site over various time periods. Risk assessment should be integral part of the broader site assessment process, which is iterative in nature. In addition to providing information for regulators in assessing whether to permit a project, the risk characterization should be designed to help project developers and regulators identify possible ways to mitigate risks.

Best practice guidance developed by the US NETL describes the risk analysis process. The assessment involves the identification of specific risk features, events, and

processes (FEPs) that could contribute to leakage or unplanned CO_2 migration from the confining zone.[145] A generic database containing over 200 FEPs is publicly available, which provides a basis for developing a site-specific registry of FEPs.[146] Once FEPs are identified, the potential consequences of FEPs are assessed, and ultimately a probability distribution of their occurrence is developed. The FEPs, together with consequences and probability of occurrence, form the basis of the risk analysis.

Examples of Information and Data Sources for Characterization of Storage Sites

Formation Attribute	Key Information	Basic Data Sources	Basic Analysis	Advanced Analysis
Proof of functional confining zone(s)	• Presence, number, continuity, thickness, and character of confining zone • Fault azimuth and offset • Surface and formation well density • Well construction and plugging history	• Cores • Well-logs • Structure maps • In-situ stress • Well location maps • Well drilling and plugging records • 3-D seismic volumes	• Stratigraphic analysis • Structural analysis • Reservoir models • Simple calculation • Mohr-Coulomb failure calculation • Conventional simulation • Core analysis • Well location verification • Well logging-through casing (e.g., cement bonding logs)	• Aeromagnetic surveys • Capillary entry pressure tests • Fault segmentation analysis • Advanced simulation
Injectivity	• Thickness, porosity, and permeability • Production/flow rate • Delivery rate connectivity	• Conventional core analysis • Well-logs • Production history • Injection or leak-off tests Pressure	• Stratigraphic analysis • Population of static geological models • Core plug analysis • Conventional simulation • Well pump tests/injection tests	• Detailed stratigraphic characterization • Hydro-fracture analysis • Special core analysis
Capacity	• Accessible pore-volume • Lateral extent • Area of injection • Trapping mechanism	• Conventional core analysis • Well-logs • Structure maps • 3-D seismic data	• Stratigraphic analysis • Structural analysis • Static geomodels • Simple calculation • Conventional simulation • 3-D seismic mapping	• Advanced simulation • Fill-spill analysis • Special core analysis

Sources: World Resources Institute, CCS Guidelines: Guidelines for Carbon Dioxide Capture, Transport, and Storage (2008).

The data obtained during the geologic characterization process are essential to the project developer and regulators and inform all aspects of the CCS project's design and operation. The data are used to determine the design of the injection well and

[145] http://www.quintessa.org/consultancy/index.html?co2GeoStorage.html (accessed May 8, 2012).

[146] Section 2.2, US National Energy Technology Laboratory, Best Practices for Site Screening, Site Selection and Initial Characterization for Storage of CO_2 in Deep Geologic Formations (2010).

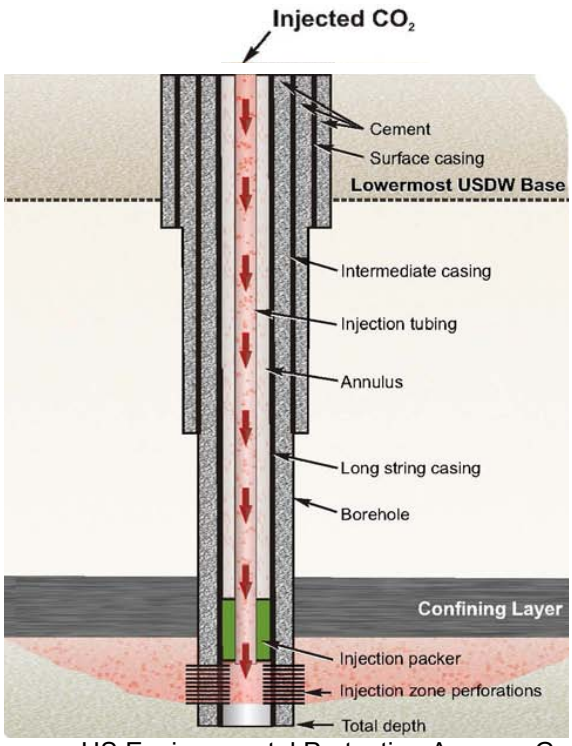
construction requirements, specify operating requirements, and the monitoring plan, mitigation and emergency response plans. The sections that follow which address these and other issues reflect the importance of geologic characterization as an on-going process through the operational phase.

5.4.4. Well Construction

Safe operation of a CCS project requires that the injection well be constructed in a manner designed to ensure the mechanical integrity of the well and the integrity of the geologic formation. Well construction and material requirements should be specified according to the specific storage formation and CO_2 stream.

The figure below shows a typical CO_2 injection well. Injection wells are constructed from concentric pipes, each successively smaller in diameter, fixed in place using cement. The surface casing is the outermost casing, the largest in diameter and shallowest. The long-string casing (the longest casing) extends into the injection zone. The long string casing contains the smallest-diameter tubing that runs the length of the casing and through which CO_2 is injected. This injection tubing is perforated at the injection zone to allow CO_2 to be injected into the formation.

Typical Injection Well Components Preventing Fluid Movement



Source: US Environmental Protection Agency, Geologic Sequestration of Carbon Dioxide: Draft Underground Injection Control (UIC) Program Class VI Well Construction Guidance for Owners and Operators (March 2011).

The space between the long string casing and the injection tubing is called the annulus. Packing material, typically hardened rubber material plated with nickel alloy to resist

corrosion is placed in the annulus between the long-string casing and the injection tubing, ideally at the level of the containment zone above the injection perforations. The injection tubing terminates below the packer. The annulus above the packer is typically filled with a noncorrosive fluid.

OECD jurisdictions surveyed in this study took several different approaches to requirements for well construction. The Commonwealth of Australia adopted dedicated regulation governing the construction and management of offshore greenhouse gas well operations. The regulations require that operators submit a well operations management plan that must, *inter alia*:

- Be appropriate for the nature and scale of the well activity;
- Show that the risks identified by the titleholder in relation to the well activity will be managed in accordance with sound engineering principles, standards, specifications and good oil-field practice;
- Provide information concerning the philosophy of, and criteria for, the design, construction, operational activity and management of the well; and
- Demonstrate that the well activity, and all associated operational work, will be carried out in accordance with good oil-field practice.[147]

Thus, Australian offshore regulation places the obligation on the operator to propose design and construction requirements and operating specifications in a manner consistent with "sound engineering principles, standards, specifications and good oil-field practice." The Australian Commonwealth requirements are tied closely to industry practices in the oil and gas industry and leave much discretion to the operator to propose designs for the particular injection well.

Industry and government regulators have expertise with the construction materials and requirements for injection wells based on experience gained in the oil and gas industry, deep injection wells for waste disposal, and the increasing body of research and demonstration from CO_2 storage projects. Oil and gas trade organizations (e.g. API and BSI) have developed standards and practices for well construction and operation that can be used or adapted to CCS applications. The table below sets out API standards and recommended practices that could be applied to CCS projects.

[147] Section 5.08, Commonwealth of Australia, Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011.

American Petroleum Institute Specification and Recommended Practices with Potential Application to CCS

Specification	Description
API Specification 5CT	Specification for Casing and Tubing
API RP 5C1	Recommended Practices for Care and Use of Casing and Tubing
API 5L	Line Pipe
API 6A	Wellhead and Christmas Tree Equipment
API 6D	Pipeline valves
API Specification 10A	Specification on Cements and Materials for Well Cementing
API RP 10B-2	Recommended Practice for Testing Well Cements
API RP 10D-2	Recommended Practice for Centralizer Placement and Stop Collar Testing
API Specification 11D1	Packers and Bridge Plugs
API RP 14B	Recommended Practice 14B, Design, Installation, Repair, and Operation of Subsurface Safety Valve Systems
API RP 14C	Recommended Practice 14C, Recommended Practice for Analysis, Design, Installation and Testing of Basic Surface Safety Systems for Offshore Production Platforms
API Guidance Document HF1	Hydraulic Fracturing Operations - Well Construction and Integrity Guidelines

Source: US Environmental Protection Agency, Geologic Sequestration of Carbon Dioxide: Draft Underground Injection Control (UIC) Program Class VI Well Construction Guidance for Owners and Operators (March 2011); US National Energy Technology Laboratory, Best Practices for Carbon Storage Systems and Well Management Activities (2012).

Among jurisdictions surveyed, US regulations are the most detailed with respect to well construction. US regulation imposes requirements intended to accommodate the unique physical characteristics of CO_2 as an injectant, specifically its buoyancy relative to other fluids in the subsurface, the potential presence of impurities in captured CO_2, and the corrosivity of CO_2 when mixed with water or other impurities. US regulation sets out detailed requirements for surface casing, long-string casing, tubing and packer, and construction.

Under US regulations, at least two casings must be used. The surface casing must extend through the base of the lowermost underground source of drinking water in order to prevent contact with the injection fluid and be cemented to the surface.[148] The long string casing must extend to the injection zone and be cemented to the surface.[149] All of the well components and materials must be compatible with the CO_2 stream and formation fluids, and of sufficient structural strength to maintain integrity over the design life of the project.[150] Specifically, the US EPA requires use of acid-resistant/corrosion-resistant cement,[151] a higher standard than is used by the oil and gas industry in injecting CO_2 for purposes of EOR. The regulator justified the use of special cements due to the potentially higher volumes and pressures associated with CO_2 storage. The packer must be set within an approved cemented interval,[152] ideally at the level of the confining layer, to provide an additional layer of protection between the injected CO_2 and the fluid moving out of the injection zone.

The US EPA requires well construction to facilitate continuous monitoring of pressure in the annulus between the tubing and casing,[153] and to accommodate tools necessary for maintenance and workover activities.[154] Thus, tubing must be of adequate width to allow for entry and use of appropriate tools.

Under US regulations, the annulus must be filled with approved non-corrosive fluid and the fluid pressure on the annulus must be greater than the operating injection pressure, unless the regulator determines that such pressure could harm the integrity of the well or endanger underground sources of drinking water.[155]

Surface shut-off systems are required for all US onshore wells and down-hole shut-off systems are required in all offshore wells within state territorial waters.[156] Down-hole shut-off systems may also be required at the discretion of regulator for onshore wells.[157]

Following well construction and before injection, the permitting regime should require that the well be tested for internal and external mechanical integrity. This would involve logging the well, including a cement bond log to verify that the cement bond has

[148] 40 CFR §146.86(b)(2).

[149] 40 CFR §146.86(b)(3).

[150] 40 CFR §146.86(b)(1).

[151] 40 CFR §146.86(b)(5).

[152] 40 CFR §146.86(c)(2).

[153] 40 CFR §146.86(a)(3).

[154] 40 CFR §146.86(a)(2).

[155] 40 CFR §146.88(c).

[156] 40 CFR §§146.88(e)(2) and 146.88(e)(3).

[157] 40 CFR §146.88(e)(2).

completely and properly formed between the casing and the formation. Mechanical integrity tests should be required throughout the operating period and are discussed in more detail below in the following section on operating requirements.

The full text of the US regulation governing well construction is set out in the text box below.

Section 146.86: Injection Well Construction Requirements

(a) General. The owner or operator must ensure that all Class VI wells are constructed and completed to:

(1) Prevent the movement of fluids into or between USDWs or into any unauthorized zones;

(2) Permit the use of appropriate testing devices and workover tools; and

(3) Permit continuous monitoring of the annulus space between the injection tubing and long string casing.

(b) Casing and Cementing of Class VI Wells.

(1) Casing and cement or other materials used in the construction of each Class VI well must have sufficient structural strength and be designed for the life of the geologic sequestration project. All well materials must be compatible with fluids with which the materials may be expected to come into contact and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the Director. The casing and cementing program must be designed to prevent the movement of fluids into or between USDWs. In order to allow the Director to determine and specify casing and cementing requirements, the owner or operator must provide the following information:

(i) Depth to the injection zone(s);

(ii) Injection pressure, external pressure, internal pressure, and axial loading;

(iii) Hole size;

(iv) Size and grade of all casing strings (wall thickness, external diameter, nominal weight, length, joint specification, and construction material);

(v) Corrosiveness of the carbon dioxide stream and formation fluids;

(vi) Down-hole temperatures;

(vii) Lithology of injection and confining zone(s);

(viii) Type or grade of cement and cement additives; and

(ix) Quantity, chemical composition, and temperature of the carbon dioxide stream.

(2) Surface casing must extend through the base of the lowermost USDW and be cemented to the surface through the use of a single or multiple strings of casing and cement.

(3) At least one long string casing, using a sufficient number of centralizers, must extend to the injection zone and must be cemented by circulating cement to the surface in one or more stages.

(4) Circulation of cement may be accomplished by staging. The Director may approve an alternative method of cementing in cases where the cement cannot be recirculated to the surface,

provided the owner or operator can demonstrate by using logs that the cement does not allow fluid movement behind the well bore.

(5) Cement and cement additives must be compatible with the carbon dioxide stream and formation fluids and of sufficient quality and quantity to maintain integrity over the design life of the geologic sequestration project. The integrity and location of the cement shall be verified using technology capable of evaluating cement quality radially and identifying the location of channels to ensure that USDWs are not endangered.

(c) Tubing and packer.

(1) Tubing and packer materials used in the construction of each Class VI well must be compatible with fluids with which the materials may be expected to come into contact and must meet or exceed standards developed for such materials by the American Petroleum Institute, ASTM International, or comparable standards acceptable to the Director.

(2) All owners or operators of Class VI wells must inject fluids through tubing with a packer set at a depth opposite a cemented interval at the location approved by the Director.

(3) In order for the Director to determine and specify requirements for tubing and packer, the owner or operator must submit the following information:

(i) Depth of setting;

(ii) Characteristics of the carbon dioxide stream (chemical content, corrosiveness, temperature, and density) and formation fluids;

(iii) Maximum proposed injection pressure;

(iv) Maximum proposed annular pressure;

(v) Proposed injection rate (intermittent or continuous) and volume and/or mass of the carbon dioxide stream;

(vi) Size of tubing and casing; and

(vii) Tubing tensile, burst, and collapse strengths.

5.4.5. Operating Requirements

Operating requirements must be adopted that are designed to ensure the mechanical integrity of the well and the integrity of the geologic formation. This section covers operating requirements for wells during the injection phase, from the start of injection to closure. Monitoring and remediation, both important aspects of operations, are discussed in sections 5.4.6 and 5.4.8, respectively.

In this section, we contrast performance-based and prescriptive operating requirements found in the Australian state of Victoria and US regulation. The approaches adopted in these jurisdictions differ significantly, and both approaches are described in some detail here to make it easier for regulators in APEC developing economies to evaluate which approach is appropriate for their jurisdiction. Notwithstanding the significant differences between these approaches, we emphasize that all jurisdictions reviewed require the site operator or owner to conduct a detailed geologic site assessment as part of the site selection process. The assessment will be used to inform operating requirements that are

reflected in the operating plan approved by the regulator as part of the storage or injection permit.

In addition to the general requirement to submit an operation plan for approval by the regulator, Victoria's Greenhouse Gas Geologic Sequestration Act requires operators to observe several principles concerning conduct of operations. Specifically, the holder of an injection authority is obligated to take "all reasonable steps" to:

- Control the flow and prevent the waste or escape in the authority area of the greenhouse gas substance or water;
- Prevent the escape in the authority area of any mixture of water or drilling liquid with the greenhouse gas substance or any other matter;
- Prevent greenhouse gas sequestration operations in the authority area from damaging underground geological storage formations in areas outside the authority area; and
- Keep separate each greenhouse gas substance injected in the authority area and any sources of water discovered in that area that the Minister directs the holder in writing to keep separate.[158]

The obligations set out above are intended ensure the integrity of the formation, the well, and water resources. However, the methods to be employed in doing so are not specifically identified and therefore would need to be addressed in the specific permit application and operating plan.

In contrast to the Victorian approach, US regulation with respect to operating requirements are highly prescriptive. Class VI operating requirements include specific requirements concerning injection pressure and rate, the use of automatic shut-down devices, hydraulic fracturing practices, and periodic mechanical integrity tests.

Injection pressure and rate are essential means to regulate the operation of a CCS project during the operating phase. While limiting the injection pressure is universally accepted as a necessary element of regulation, setting the precise limit is a matter of judgment. Injection pressures must be maintained at levels below the fracture pressure of the formation with a safety margin. In practice, this may be accomplished by requiring injection pressure of the well to be below the pressures experienced in the formation prior to the start of injection. This is necessarily a site-specific determination.

US regulations set prudential limits on pressure in the injection zone in order not to exceed 90% of the fracture pressure of the injection zone. The rule further provides that the actual injection pressure may not initiate new fractures or propagate existing fractures. Under the US rule, the calculated fracture pressure (and by extension the injection pressure limit) is based on site-specific geologic and geomechanical data collected during the site characterization process.

[158] Section 214, Victoria Greenhouse Gas Geologic Sequestration 2008.

The US regulations specifically require maintaining fluid pressure in the annulus between tubing and casing or between two strings of casing, greater than the injection pressure, unless the requirement might harm the integrity of the well or endanger underground sources of drinking water.[159] This requirement has been challenged by industry and the US EPA has itself acknowledged "that, in some circumstances, maintaining an annulus pressure greater than the injection pressure could result in a greater chance for damage to the well or the formation."[160] The American Petroleum Institute advises that common field practice is to maintain a positive annulus pressure of 200-250 psi, which is not detrimental to the integrity of the wellbore and provides the operator with the ability to monitor annulus pressure. A stable annulus pressure with slight fluctuations due to temperature variations indicates would indicate the integrity of the long- string casing, tubing and packer.[161]

US Class VI regulations require wells to be equipped with monitoring equipment and automatic shut-off devices to ensure that a loss of well integrity does not result in damage to the well, or injury to humans or the environment. Automatic down-hole shut-off devices are valves located in the well tubing that close if triggered by changes in flow rate or other monitored parameters. The valve will immediately shut-in the well to cease injection and isolate the CO_2 injectate. Automated shut-off devices prevent flow-back of CO_2 up an injection well, where it will expand as it moves toward the surface and can result in an uncontrolled stream of solid CO_2, which can damage the well. Automated shut-off devices may be installed at both the surface and/or down-hole and are commonly used in the oil and gas industry, primarily in offshore wells.

The US Class VI rule requires that onshore wells install automatic surface shut-off devices, with discretion on the part of the regulator to require automatic down-hole shut off devices.[162] The US EPA requires down-hole shut-off devices for offshore CCS operations. Industry views down-hole shut-off devices as unnecessary where surface devices are installed, providing little or no additional protection. Thus, in their view, these devices would only be appropriate for offshore wells. Moreover, use of such devices can complicate routine testing and well workovers, requiring removal of tubing to service them, and that failure of such devices could damage wells.[163]

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[159] 40 CFR §146.88(c).

[160] US Environmental Protection Agency, Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Final Rule, 75 Fed. Reg. 77230, 77257-9 (December 10, 2010).

[161] American Petroleum Institute, API Comments on EPA's Draft Underground Injection Control Program Class VI Well Guidance for Owners and Operators (May 31, 2011).

[162] 40 CFR §146.88(e)(2).

[163] US Environmental Protection Agency, Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Final Rule, 75 Fed. Reg. 77230, 77257 (December 10, 2010).

The US rule requires periodic maintenance on the injection well and the wells must be designed to accommodate tools for logging and maintenance.[164] A well workover involves sealing the well, removing the wellhead, and either removing equipment or inserting maintenance tools into the well. The workover may include replacing and repairing tubing, packer, valves and sensors, repairing corroded casing, and remedial cementing.[165]

An emerging operational consideration is whether hydraulic fracturing should be permitted to enhance injectivity in the geologic formation. Hydraulic fracturing is an increasingly common technique used in oil and gas operations to create new or propagate existing fractures in order to enhance the productivity of a well. Fracturing is accomplished by injecting water and/or chemicals in the well. Hydraulic fracturing can reduce the need to drill additional wells that penetrate the confining layer. However, for CO_2 storage operations, if induced fractures were to extend to the confining layer, the technique could compromise the integrity of the formation. The US regulations considered this issue and concluded that determinations concerning hydraulic fracturing should be made on a site-specific basis. This would include approval in the storage or injection permit stage as part of the site plan. It would also require notice to the regulator prior to commencement of hydraulic fracturing so that regulators can review and assess stimulation plans and materials and potentially witness the activity.[166] Regulation in other OECD jurisdictions surveyed in this study are silent on the use of hydraulic fracturing in the context of CCS operations. Until both CCS and the potential implications of hydrologic fracturing are better understood, APEC developing economies should adopt a highly cautious approach whether to allow hydraulic fracturing methods in connection with any CCS project.

Internal mechanical integrity of the well requires that there is no significant leak in the casing, tubing, or packer. The well's internal mechanical integrity can be compromised due to corrosion and high temperatures and pressures, resulting in mechanical failure of well's tubular and mechanical components. External mechanical integrity can be demonstrated by showing there is no unintended fluid movement through channels near the injection well.

Internal mechanical integrity of the well is generally demonstrated through monitoring pressure of the injection well and annulus. US regulation requires owners or operators to continuously monitor injection pressure, rate, injected volumes; pressure on the annulus between tubing and long-string casing; and annulus fluid volume.

Under US regulations, the mechanical integrity of the external well can be demonstrated through the absence of significant fluid movement outside the casing, between the cement and the well structure, and between the cement and the well-bore. Degradation of the cement that seals the annular space between the outside of the casing and the well-

[164] 40 CFR §146.86(a)(2).

[165] US Environmental Protection Agency, Geologic Sequestration of Carbon Dioxide: Draft Underground Injection Control (UIC) Program Class VI Well Construction Guidance for Owners and Operators (March 2011).

[166] 40 CFR §146.91(d)(2).

bore can lead to unintended movement of CO_2. US regulations require, at least once per year, the owner or operator to conduct either a tracer survey such as an oxygen-activation log or a temperature or noise log, and could also require the operator to run a casing inspection log to determine the presence or absence of corrosion in the long-string casing.[167]

The significant differences between the approaches taken in Victorian and US legislation provide useful contrast for regulators in APEC developing economies. The Victoria approach features flexibility, whereas the US approach provides clear guidance that can be varied by regulators based on site-specific data. Both approaches have merit. We believe that CCS-specific industry practice will emerge as the technology matures and this will inform the views and practices of operators and regulators and promote consensus, even if legislative approaches differ.

5.4.6. Monitoring, Reporting and Verification / Monitoring, Verification and Accounting

MRV or MVA requirements provide for site monitoring, reporting of results to regulators, and verification of compliance with regulations. The US NETL uses the term MVA in its Best Practices for Monitoring, Verification, and Accounting (MVA) of CO_2 Stored in Deep Geologic Formations (2009). Both terms are commonly interchanged.

MRV serves a number of purposes, including safety and environmental compliance, and project and national accounting of greenhouse gas emission reductions. MRV also plays an important role in furthering CCS research.

MRV takes place in the subsurface, near-surface and atmosphere and is essential to safe CCS operations.[168] MRV regimes should provide a basic set of requirements to which all sites must comply and also feature site-specific requirements. Monitoring technology is rapidly evolving as industry and research institutions gain experience; therefore, MRV regimes should be flexible in order to enable project operators and regulators to update techniques as both technology and experience improves.

An MRV regime necessarily begins with the geologic storage assessment of the particular formation into which CO_2 will be injected. The geologic assessment establishes baseline conditions of the formation, which will then be monitored throughout site operations and beyond in order to verify safe operation and compliance with regulations, and to alert operators and regulators to any conditions at the site that require remediation.

MRV requires periodic reporting of information to regulatory authorities. This information plays a vital role in the regulatory authority's project monitoring for compliance with regulations concerning the safe operation of the CCS site as well as any applicable regulatory requirements concerning greenhouse gas emissions reductions.

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[167] 40 CFR §146.89(c) and (d).

[168] US National Energy Technology Laboratory, Best Practices for Monitoring, Verification, and Accounting (MVA) of CO_2 Stored in Deep Geologic Formations (2009).

A CCS MRV scheme requires reporting a broad range of data at each stage of a project, from initial site characterization, through operation, to the post- injection site care period. A non-exhaustive list of items to be reported could include the following:

- Quantity of CO_2 emitted from regulated point sources (e.g., power plants);
- Quantity of CO_2 by-product produced from oil and gas operations;
- Quantity of CO_2 vented to atmosphere;
- Quantity of CO_2 transported;
- Pressure and quantity of CO_2 injected into subsurface;
- Source and composition of CO_2 stream;
- Quantity of CO_2 emitted from the subsurface;
- Assessments of the geologic formation;
- Well drilling logs, sampling and testing results and analysis;
- Plume migration models and testing;
- Operating and monitoring reports including periodic values for injection pressure, flow rate and volume, and annular pressure;
- Details of well maintenance;
- Any unsafe conditions;
- Results of air/soil monitoring;
- Water sampling;
- Mechanical integrity tests of wells; and
- Well plugging report.

The monitoring area must be specified in either regulation or site-specific documentation, specifically permits and monitoring plans. The area subject to monitoring can be specified in terms of the predicted three-dimensional extent of the plume and the pressure front based on assessment of the geologic formation and surrounding areas. The monitoring area should be adjusted as monitoring results suggest changes in the CO_2 plume or geologic characteristics of the formation and surrounding areas. US regulation requires the use of computational models that account for the physical and chemical properties of the CO_2 stream based on available site characterization, monitoring and operational data in order to define the "Area of Review" which is the area subject to monitoring.

Regulation should specify that the MRV plan be updated periodically. For example, US regulation requires that the testing and monitoring plan be reviewed and updated at least once every five years, or demonstrate that no amendment to the testing and monitoring plan is needed.[169] Similarly, the computational models must be updated at least every five years in order to update the Area of Review.[170]

Regulators must determine the frequency of collection and reporting for these items. This determination should depend upon the use of the information, as well as the cost associated with data collection and reporting. In practice, collection frequencies vary from continuously to annually or every several years. A separate determination must be made

[169] 40 CFR § 146.90(j).

[170] 40 CFR §146.84.

as to how frequently information is reported. Annual, semi-annual, quarterly, monthly and, on an emergency basis, within 24 hours are periods commonly specified in regulation.

The duration of the reporting obligations also must be determined based on actual use of the data and the duration of operator's control of the site. In the post-closure phase, the reporting obligation would ordinarily continue for a period specified by regulation. The reporting period should generally for the period for which the operator is liable for the site, typically with monitoring reports becoming less frequent as risk diminishes. In the US, where the operator remains liable for the site indefinitely from a legal point of view, the MRV obligation is a default 50-year period

Comprehensive regulation should specify records retention requirements. Records retention can vary based on the particular item of information. As a general rule, however, operators should be required to maintain records through site closure and then some years thereafter. For example, US regulation generally requires data to be maintained for 10 years after site closure.[171] As a prudential matter, operators may want to retain records for longer periods, especially if there is any potential ongoing liability associated with the site. Regulatory authorities should also maintain records independently of the operator that remain available to the regulator and the general public.

Regulators should specify whether information is required electronically or in paper format. As most of the data that would be collected on an ongoing basis is likely to be in electronic form, an electronic reporting system is likely to provide for greater standardization and in the long run prove more reliable and economic. However, this would require creation of data reporting systems for government as well as operators and, to the extent information is not available, regulators should consider whether to allow some information be provided in non-electronic form.

If there are other reporting obligations (e.g. greenhouse gas emissions), the CCS reporting regime should be coordinated and potentially integrated with other reporting regimes both in terms of substance and format. For example, the US greenhouse gas reporting program has dedicated rules addressing CCS for permanent storage as well as EOR, which are integrated into the larger scheme to ensure comprehensive coverage while minimizing unnecessary burden.

Several aspects generally common to MRV regimes are noteworthy. Data produced from MRV will be compared to predictions of plume movement and pressure front using the models developed during the geologic assessment and submitted as part of the permitting application. By comparing modeled results with actual data, operators and regulators can assess whether the injection and formation are behaving as expected. Where discrepancies between modeled and observed results exist, MRV data enables operators to update these models.

The use of MRV data is crucial to the important issue of liability transfer. In jurisdictions that allow the operator to transfer responsibility of the site to a governmental authority, the operator would be required to demonstrate to the satisfaction of regulatory authorities that the CO_2 plume has stabilized, pressure has reduced and the formation is expected to

[171] 40 CFR §146.91.

contain stored CO_2. MRV results are the foundation for this demonstration. Moreover, as a result of transfer of responsibility for a site, responsibility for any continuing MRV obligation may also transfer to another party.

Similar to other aspects of CCS regulations, APEC developing economies may adopt performance-based or a prescriptive approaches in specifying MRV requirements. The Australian state of Victoria provides an example of performance-based regulation. Victoria's legislation requires applicants for an injection and monitoring license to propose a monitoring plan that sets out a description of the monitoring techniques to be used and "how the behavior of any stored greenhouse gas substance will be monitored."[172] Regulations supplementing the law further require the applicant to specify the techniques, duration and frequency of monitoring. Pursuant to these regulations, the monitoring plan must differentiate among injected and natural substances; describe how the actual behavior of stored greenhouse gas substances will be verified against expected behavior; and describe how the effect of stored gases on naturally occurring liquids or gases (e.g., water, oil or gas) will be verified against expected effects.[173]

A leading example of a prescriptive approach is the US Class VI rule. The Class VI rule specifies minimum requirements for MRV, which typically may be varied by the regulator based on site-specific information. Moreover, under US regulations, additional requirements may be specified in the site permit.[174] While the objectives of US regulation are similar in many respects to those of performance-based systems, such as Victoria described above, the US regulation requires industry to use specific techniques in many cases. This approach enhances guidance, however reduces flexibility for operators.

The most essential aspects of monitoring focus on the CO_2 stream and plume. These involve analysis of the CO_2 stream on a periodic basis to provide data concerning its chemical and physical characteristics. In addition, all monitoring regimes reviewed require monitoring injection pressure, rate, and volume. US regulations require monitoring these continuously, as well as continuously monitoring pressure on the annulus between the tubing and the long string casing and the annulus fluid volume.[175]

Under US regulations, operators must track the extent of the CO_2 plume and the presence or absence of elevated pressure, using an approved method. These methods include monitoring wells, or indirect methods, such as seismic, electrical, gravity, or electromagnetic surveys and/or down-hole carbon dioxide detection tools.[176] Under the US rule, monitoring wells above the containment zone are specifically required. While monitoring wells provide valuable information concerning CO_2, additional wells

[172] Article 94(f) and (j), Victoria Greenhouse Gas Geological Sequestration Act 2008.

[173] Section 8(1)(d),(e),(f) and (g), Victoria Greenhouse Gas Geological Sequestration Regulations 2009, S.R. No. 149/2009.

[174] 40 CFR §146.90.

[175] 40 CFR §146.90(b).

[176] 40 CFR §146.90(g).

penetrating the confinement zone can act as conduits for CO_2 movement.[177] Regulators therefore have discretion to rely on less invasive and less costly surface air monitoring and/or soil gas monitoring to detect the movement of CO_2 in the subsurface.[178]

The US Class VI rule allows the regulator to require corrosion monitoring, as frequently as quarterly, where corrosive fluids are injected in the well. Although wells are required to be constructed with materials compatible with CO_2, the potential long-term effects of CO_2 on cement and other components warrant corrosion monitoring. The presence of water in CO_2, forming carbon acid, can cause corrosion of well components and weaken the mechanical integrity of the well. US regulations specify that the CO_2 stream must be passed in contact with samples of well material or through a loop made of well material that can be analyzed for loss of mass, thickness, cracking, pitting or other corrosion.[179]

US regulations require periodic ground water and geochemical monitoring to ensure protection of underground sources of drinking water and as a means to detect leakage of CO_2 or displacement of formation fluids out of the target formation and/or through the confining layer. Monitoring involves analyzing ground water quality (e.g., salinity, pH, and aqueous and pure-phase CO_2) above the confining layer to reveal geochemical changes that result from leaching or mobilization of heavy metals and organic compounds, or fluid displacement. US regulation does not specify the details of testing, instead providing that the amounts, frequency and type of monitoring are determined on a site-specific basis.[180]

US regulations require external mechanical integrity testing at least once annually until the well is plugged.[181] Mechanical integrity tests are described more fully in section 5.4.5 on operating requirements. US regulations also require a pressure fall-off test at least once every five years.[182]

Project operators and regulators can employ a variety of MRV tools, ranging in cost. The US NETL tests various methods, both in the laboratory and in the field. The US NETL categorizes technologies as primary (proven and mature), secondary (available and beneficial) and potential (potentially beneficial).[183] Primary technologies are widely used in demonstration projects and are generally regarded as adequate to meet US requirements. The table below sets out US NETL's evaluation of MRV technologies.

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[177] US Environmental Protection Agency, Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide (CO_2) Geologic Sequestration (GS) Wells; Final Rule, 75 Fed. Reg. 77230, 77261-2 (December 10, 2010).

[178] 40 CFR §146.90(h).

[179] 40 CFR §146.90(c).

[180] 40 CFR §146.90(d).

[181] 40 CFR §146.90(e).

[182] 40 CFR §146.90(f).

[183] US National Energy Technology Laboratory, Best Practices for Monitoring, Verification, and Accounting (MVA) of CO2 Stored in Deep Geologic Formations (2009).

US NETL Ranking of Monitoring, Reporting & Verification Technologies

Objectives	Primary Technologies	Secondary Technologies	Potential Technologies
Atmospheric Monitoring Objectives: • CO_2 concentration • CO_2 surface flux		CO_2 Detectors (Ambient CO_2 Concentration) Laser systems and LIDAR* (Ambient CO_2 Concentration)	Eddy Covariance (Surface Flux) Advanced Leak Detection System (Surface Flux) Isotopes
Near-Surface Monitoring **Objectives:** • Groundwater Monitoring • Fluid Chemistry • Soil gas monitoring • Crustal Deformation • Leak Detection • Vegetative Stress Monitoring • Vadose Zone Characterization	Geochemical Analysis (Groundwater Monitoring) (Fluid Chemistry)	Advanced Water Quality Analysis • Inorganics & Organics • Isotopes • Total Organic & Inorganic Carbon Aerial Photography (Vegetative Stress) (Crustal Deformation) Seismic Surveying (Vadose characterization) (Leak Detection) • Shallow 2-D Seismic Soil and Vadose Zone Gas Monitoring (Gas sampling) Flux Accumulation Chamber (Surface Flux)	Tracers (Leak Detection) • Noble Gases • Mercaptans • Stable Isotopes • Perfluorocarbons Geophysics (Leak Detection) (Vadose zone characterization) • Conductivity • Induced Polarization • Self-Potential Tiltmeters (Crustal Deformation) Remote Sensing (Crustal Deformation) • Color Infrared Transparency Film • Hyper-spectral-multispectral • Synthetic Aperture Radar & InSar
Subsurface Monitoring **Objectives:** • Groundwater Monitoring • Soil Gas Monitoring • Leak Detection • Subsurface & Reservoir Characterization • Plume Tracking • Well Integrity Testing	Water Quality Analysis • Injection Fluid Monitoring • Formation Fluid Monitoring • Water Level Caprock Integrity (Reservoir Characterization) • Geomechanical Analysis • Core Collection Wireline Logging (Well Integrity) • Temperature • Noise • Cement Bond • Density • Gamma Ray • Sonic (Acoustic) Physical Testing (Well Integrity) • Annulus Pressure • Injection Volume/Rate • Wellhead Pressure • Downhole Pressure • Downhole Temperature	Seismic Surveying (Reservoir Integrity) • Acoustic (2-D and 3-D) • VSP • 2-D and 3-D Geochemistry (Reservoir Integrity) • Brine/Fluid Composition • Tracer Injection/Monitoring Injection Well Logging (Wireline Logging) (Plume Tracking) (Reservoir Integrity) • Temperature Logging • Reservoir Saturation Tool • Optical	Geophysical Techniques (Leak Detection) (Subsurface and Reservoir Characterization) (Plume Tracking) • Crosswell Seismic • Microseismic (Passive) • EMIT • Magnetotelluric Sounding • Resistivity and EM • Electrical Resistivity Tomography • Time-lapse Gravity Survey • Electromagnetic Resistivity • Wireline Logging (Well integrity and Subsurface Characterization) - Resistivity

Source: US National Energy Technology Laboratory, Best Practices for Monitoring, Verification, and Accounting (MVA) of CO2 Stored in Deep Geologic Formations (2009).

5.4.7. Post-Injection Site Care, Well Plugging and Site Closure

After the cessation of injection, the following four activities take place: post-injection MRV, remediation, well plugging and abandonment, and site closure. MRV and remediation are specifically addressed in other sections of this chapter; here we focus on well plugging and abandonment and site closure.

The proper plugging and abandonment of an injection well is critical to preventing leakage of CO_2 and ensuring the long-term integrity of the geologic formation. For those jurisdictions that relieve operators of responsibility for the long-term stewardship or liability associated with an injection well, compliance with plugging and abandonment requirements is a condition of transfer of responsibility. As with other aspects of the design, construction and operation of injection wells, the oil and gas industry has developed extensive experience in the area of well closure, which would inform a CCS operation.

OECD jurisdictions reviewed in connection with this study generally require operators to develop a plugging and abandonment plan or closure plan as part of the injection and storage permitting process.[184] For example, the Commonwealth of Australia's required "Well Operations Management Plan" must include provisions for the abandonment of wells approved by the regulator. [185] US regulation requires owners or operators of Class VI injection wells to prepare an "Injection Well Plugging Plan" that describes how the owner or operator will meet the Class VI injection well plugging requirements as part of the permit application, a requirement that is common to Class I and II injection wells under the UIC program.[186]

Australian offshore CCS legislation, for example, requires the registered holder of the greenhouse gas storage permit to plug or close off all wells as a condition of surrender of the area and release from responsibility for its care.[187] The legislation specifically requires that the registered holder has:

- Paid all fees under applicable regulation;
- Complied with all conditions in the permit and applicable regulation;
- Removed all property brought into the surrender area under the permit;
- Plugged or closed off all wells made in the surrender area;
- Provided for conservation and protection of natural resources in area;
- Made good any damage to the seabed or subsoil in the surrender area; and

[184] See, e.g., Section 116(3)(3), Mines and Minerals Act, as amended by the Alberta Carbon Capture and Storage Statutes Amendment Act.

[185] Part 5, Commonwealth of Australia, Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011.

[186] 40 CFR §146.82(a)(16).

[187] Article 442(3)(d), Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

- A site-closing certificate is in force. [188]

In Australia, site closure requirements are directly related to government acceptance of liability. The site-closing certificate will be issued at the earliest 5 years after injection ceases, upon which the injection licence can then be surrendered if specified conditions (including well plugging) are met. The operating entity's statutory obligations cease at that time, however they remain subject to common law liabilities for at least another 15 years until the closure assurance period is completed and relevant conditions met.[189] In assessing the request to surrender the area, the regulator must consider whether the plugging or closing of wells has been be carried out in a way that minimizes damage to the petroleum bearing qualities of geological formations.[190]

The province of Alberta, Canada has adopted similar site closure requirements, which are also tied to transfer of liability to the state. Under Alberta legislation, the regulator may issue a closure certificate if it is satisfied that:

- Lessee has complied with well monitoring requirements;
- Lessee has abandoned all wells and facilities in accordance with regulations;
- Lessee has complied with reclamation requirements under environmental laws;
- Closure period specified in the regulations has passed;
- All other conditions specified in the regulations have been met; and
- Captured CO_2 behaves in a stable and predictable manner, with no significant risk of future leakage.[191]

US regulation requires owners or operators of Class VI injection wells to prepare an Injection Well Plugging Plan that describes how the owner or operator will meet the Class VI injection well plugging requirements as part of the permit application, (a requirement also common to Class I and II injection wells under the UIC program).[192] Preliminary guidance issued by the regulator note that well plugging activities include flushing the well with a buffer fluid, testing the external mechanical integrity of the well, and emplacing cement into the well to prevent fluid movement.[193] US regulation does not specify the

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[188] Article 442(3), Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[189] Articles 386-401, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[190] Article 442(6), Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[191] Section 120(3), Mines and Minerals Act, as amended by the Alberta Carbon Capture and Storage Statutes Amendment Act.

[192] 40 CFR §146.82(a)(16).

[193] US Environmental Protection Agency, Geologic Sequestration of Carbon Dioxide: Draft Underground Injection Control (UIC) Program Class VI Well Project Plan Development Guidance for Owners and Operators (March 2011).

materials or tests that must be used during well plugging, recognizing that various methods, materials and tests could be appropriate or become available in the future. However, the rule does require operators to:

- Use plugging materials compatible with the injectate (e.g., corrosion-resistant materials);[194]
- Submit a notice of intent to plug at least 60 days prior to plugging the well;[195]
- Submit revision to the post-injection site care plan and the well plugging plan based on operational and monitoring data or data collected during Area of Review reevaluations;[196]
- Submit a site plugging report within 60 days after plugging;[197]
- Give notice of intent to close the site 120 days in advance; [198]
- After site closure is approved, plug all monitoring wells in a manner which will not allow movement of injection or formation fluids that endangers underground sources of drinking water; [199]
- Submit and overall site closure report within 90 days after closure;[200]
- Record a notation on the facility deed giving notice of use of property for CCS, where the survey plat is filed, and volume, period and location of CO_2 stored.[201]

The site closure report provides information to future site users and regulators. It includes documentation of injection and monitoring well plugging, copies of notifications to governmental authorities, and records reflecting the nature, composition, and volume of the injected CO_2 stream.[202]

The criteria and timing of site surrender or closure varies by jurisdiction. Jurisdictions that relieve the site owner or operator of further responsibility for the site after site surrender typically require a period of years to pass during which the CO_2 plume and pressure front have stabilized. In the US, which does not provide for transfer of responsibility for the injection well at the federal level, the determination whether a site should be closed requires a finding by the regulator that the site no longer poses a risk of endangerment to

[194] 40 CFR §146.92(b)(5).

[195] 40 CFR §146.92(c).

[196] 40 CFR §§146.93(a)(4), 146.92(c).

[197] 40 CFR §146.92(e).

[198] 40 CFR §146.93(d).

[199] 40 CFR §146.93(e).

[200] 40 CFR §146.93(f).

[201] 40 CFR §146.93(g).

[202] 40 CFR §§146.93(f) and (g).

underground sources of drinking water.[203] The Class VI rule nevertheless requires a default period of 50-years to continue monitoring after injection of CO_2 has ceased, and before plugging and abandonment can occur.[204] The 50-year period can be shortened or extended by the regulator, and allows for owners or operators to seek to amend the site closure plan to an appropriate time frame based on monitoring data and modeling results.[205] In determining whether to shorten the period, considerations include site-specific computational modeling of the Area of Review; predicted timeframe for cessation of CO_2 plume migration and pressure decline; and site-specific chemical processes and rate of CO_2 trapping (e.g., by capillary trapping, dissolution, and mineralization). Other considerations include characterization of the confining zone(s), such as thickness, integrity, and the presence or absence of transmissive faults or potential conduits for fluid movement near the injection well; the quality of wells and well plugs in wells; and the distance between the injection zone and the nearest underground source of drinking water above and/or below the injection zone.[206]

The developing APEC economies in this study that produce oil and gas have experience with well operations and several have regulations concerning well plugging and abandonment. For example, Malaysia's Petronas maintains guidelines governing well abandonment and decommissioning that provides guidance to operators[207] and internal technical standards with greater detail.[208] Similarly, Indonesian production sharing contracts provide general provisions for safety, monitoring, reporting, and well plugging and abandonment obligations. Thailand's Petroleum Act sets out detailed provisions governing exploration and production permitting regimes,[209] and regulations issued under the Petroleum Act define requirements for monitoring and remediation, well plugging and abandonment,[210] and site safety.[211] Clearly, APEC economies with an oil and gas industry have a foundation upon which to develop well closure requirements appropriate for CCS.

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[203] 40 CFR §146.93(b)(2).

[204] 40 CFR §146.93.

[205] 40 CFR §§146.93(b) and (c).

[206] 40 CFR §146.93(c).

[207] Section 16, Petronas Procedures and Guidelines for Upstream Activities, August 2008.

[208] Stakeholder consultations, October 7, 2011.

[209] Sections 22-53, Petroleum Act B.E. 2514.

[210] Ministerial Regulation No. 5 (B.E. 2514) issued under the provisions of the Petroleum Act B.E. 2514.

[211] Ministerial Regulation No. 7 (B.E. 2514) issued under the provisions of the Petroleum Act.

Injection Well Plugging and Post-Injection Site Care Requirements under US Class VI Rule

§146.92 Injection well plugging.

(a) Prior to the well plugging, the owner or operator must flush each Class VI injection well with a buffer fluid, determine bottomhole reservoir pressure, and perform a final external mechanical integrity test.

(b) Well plugging plan. The owner or operator of a Class VI well must prepare, maintain, and comply with a plan that is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit. The well plugging plan must be submitted as part of the permit application and must include the following information:

(1) Appropriate tests or measures for determining bottomhole reservoir pressure;

(2) Appropriate testing methods to ensure external mechanical integrity as specified in § 146.89;

(3) The type and number of plugs to be used;

(4) The placement of each plug, including the elevation of the top and bottom of each plug;

(5) The type, grade, and quantity of material to be used in plugging. The material must be compatible with the carbon dioxide stream; and

(6) The method of placement of the plugs. ***

§ 146.93 Post-injection site care and site closure.

(a) The owner or operator of a Class VI well must prepare, maintain, and comply with a plan for post-injection site care and site closure that meets the requirements of paragraph (a)(2) of this section and is acceptable to the Director. The requirement to maintain and implement an approved plan is directly enforceable regardless of whether the requirement is a condition of the permit.

(1) The owner or operator must submit the post-injection site care and site closure plan as a part of the permit application to be approved by the Director.

(2) The post-injection site care and site closure plan must include the following information:

(i) The pressure differential between pre-injection and predicted post- injection pressures in the injection zone(s);

(ii) The predicted position of the carbon dioxide plume and associated pressure front at site closure as demonstrated in the Area of Review evaluation required under § 146.84(c)(1);

(iii) A description of post-injection monitoring location, methods, and proposed frequency;

(iv) A proposed schedule for submitting post-injection site care monitoring results to the Director pursuant to § 146.91(e); and,

(v) The duration of the post-injection site care timeframe and, if approved by the Director, the demonstration of the alternative post-injection site care timeframe that ensures non-endangerment of USDWs.

5.4.8. Remediation and Emergency Response

A remediation and emergency response plan is essential to the safe operation of a CCS project and the OECD jurisdictions reviewed in connection with this study all require such a plan. The permit application for injection or permanent storage should require the applicant to develop and submit a remediation and emergency response plan as part of the application. The plan should be specifically designed for the project, including such factors as the composition of the CO_2 stream and the specific risks or hazards particular to the project based on the geologic characterization and risk assessment.

Developing a remediation and emergency response plan helps project owners, operators and regulators anticipate contingencies and identify stakeholders that must be prepared to respond in the event corrective or emergency action is required. The exercise in developing an emergency response should help parties identify methods and adopt protocols that can reduce risk and minimize potential harm in the event of an actual emergency. The plan should cover all phases of the project, including the construction, operation, and post-injection site care periods, and be maintained during the entire life of the project.

Regulations should require the project operator to promptly provide notice of any irregularity or unsafe condition at the project and enable the regulator to take corrective action if necessary. The Commonwealth of Australia's Offshore CCS legislation grants broad powers to the regulator upon the occurrence of a "serious situation." A serious situation occurs if the formation is determined not suitable for the permanent storage of the substance in the amounts injected at the relevant location(s) over the relevant period or there is risk of or actual occurrence of the greenhouse gas substance:

- Leaking during injection or from a storage formation;
- Behaving otherwise than as predicted; or
- Significantly adversely impacting the geotechnical integrity of the whole or part of the geologic formation or geologic structure.[212]

The occurrence of a "serious situation" gives the regulator broad power to take corrective action, including suspending injection and directly managing or remediating the serious situation.[213]

US regulations, which are designed to protect underground sources of drinking water, require project operators, upon discovering that injected CO_2 and the associated pressure front could cause an endangerment to an underground source of drinking water, to immediately cease injection, investigate any possible release of CO_2, notify the regulatory authority within 24 hours, and implement the emergency and remedial response plan.[214]

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[212] Article 379, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[213] Article 380, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[214] 40 CFR §146.94(b).

The emergency and response plan should be periodically reviewed by the project owner and operator and updated to reflect changing site or demographic conditions, and improvements in the performance and cost of technology. US regulations, for example, require owners or operators to review the emergency and remedial response at least once every five years, and to submit an amended plan or demonstrate that no amendment is needed.[215] The requirement to update the plan is tied to the overall reevaluation of the Area of Review, which coordinates the provision of updated information.

The Intergovernmental Panel on Climate Change (IPCC) has identified remediation options for various scenarios that could arise in a CCS project. These options are set out in the table below.

Remediation Options for Geological CO_2 Storage Projects

Scenario	Remediation Options
Leakage up faults, fractures and spill points	• Lower injection pressure by injecting at a lower rate or through more wells • Lower reservoir pressure by removing water or other fluids from storage structure • Intersect the leakage with extraction wells in the vicinity of the leak • Create hydraulic barrier by increasing reservoir pressure upstream of the leak • Lower reservoir pressure by creating a pathway to access new compartments in the storage reservoir • Stop injection to stabilize the project • Stop injection, produce the CO_2 from the storage reservoir and reinject it back into a more suitable storage structure.
Leakage through active or abandoned wells	• Repair leaking injection wells with standard well recompletion techniques such as replacing the injection tubing and packers • Repair leaking injection wells by squeezing cement behind well casing to plug leaks behind the casing • Plug and abandon injection wells that cannot be repaired by the methods listed above • Stop blow-outs from injection or abandoned wells with standard techniques to “kill” a well such as injecting a heavy mud in the well casing. After control of the well is re-established, the recompletion of abandonment practices described above can be used. It the wellhead is not accessible, a nearby well can be drilled to intercept the casing below the ground surface and “kill” the well by pumping mud down the interception well
Accumulation of CO_2 in the vadose zone and soil gas	• Accumulations of gaseous CO_2 in groundwater can be removed or at least made immobile, by drilling wells that intersect the accumulations and extracting the CO_2. The extracted CO_2 could be vented to the atmosphere or reinjected back into a suitable storage site • Residual CO_2 that is trapped as an immobile gas phase can be removed by dissolving it in water and extracting it as a dissolved phase through groundwater extraction well; • CO_2 that has dissolved in the shallow groundwater could be removed, if needed, by pumping to the surface and aerating it to remove the CO_2. The groundwater could then either be used directly or reinjected back into the groundwater • If metals or other trace contaminants have been mobilized by acidification of the

[215] 40 CFR §146.94(d).

	groundwater, “pump and treat” methods can be used to remove them. Alternatively, hydraulic barriers can be created to immobilize and contain the contaminants by appropriately placed injection and extraction wells. In addition to these active methods of remediation, passive methods that rely on natural biogeochemical processes may also be used.
Leakage into the vadose zone and accumulation in soil gas	• CO_2 can be extracted from the vadose zone and soil gas by standard vapor extraction techniques from horizontal or vertical wells • Fluxes from the vadose zone to the ground surface could be decreased or stopped by caps or gas vapour barriers. Pumping below the cap or vapour barrier could be used to deplete the accumulation of CO_2 in the vadose zone. • Since CO_2 is a dense gas, it could be collected in subsurface trenches. Accumulated gas could be pumped from the trenches and released to the atmosphere or reinjected back underground. • Passive remediation techniques that rely only on diffusion and “barometric pumping” could be used to slowly deplete one-time releases of CO_2 into the vadose zone. This method will not be effective for managing ongoing releases because it is relatively slow. • Acidification of the soils from contact with CO_2 could be remediated by irrigation and drainage. Alternatively, agricultural supplements such as lime could be used to neutralize the soil.
Large releases of CO_2 to the atmosphere	• For releases inside a building or confined space, large fans could be used to rapidly dilute CO_2 to safe levels • For large releases spread out over a large area, dilution from natural atmospheric mixing (wind) will be the only practical method for diluting the CO_2 • For ongoing leakage in established areas, risks of exposure to high concentrations of CO_2 in confined spaces (e.g. cellar around a wellhead) or during periods of very low wind, fans could be used to keep the rate of air circulation high enough to ensure adequate dilution.
Accumulation of CO_2 in indoor environments with chronic low- level leakage	• Slow releases into structures can be eliminated by using techniques that have been developed for controlling release of radon and volatile organic compounds into buildings. The two primary methods for managing indoor releases are basement/substructure venting or pressurization. Both would have the effect of diluting the CO_2 before it enters the indoor environment.
Accumulation in surface water	• Shallow surface water bodies that have significant turnover (shallow lakes) or turbulence (streams) will quickly release dissolved CO_2 into the atmosphere. • For deep, stably stratified lakes, active systems for venting gas accumulations have been developed and applied at Lake Nyos and Monoun in Cameroon.

Source: Intergovernmental Panel on Climate Change, IPCC Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press (2005).

5.5. Legal and Financial Issues

5.5.1. Subsurface Rights

Parties that plan to inject CO_2 in geologic formations must possess rights of access to the injection site and the right to inject CO_2 in the geologic formation as stored CO_2 will occupy the miscroscopic spaces in subsurface rock. Property laws control the ownership of subsurface pore space, the rights to access and use that space, and liability concerning its use. In turn, these rights determine whose consents are necessary or desirable before proceeding with a CCS project. In addition to property laws, rights to pore space can be defined by a dedicated statute governing CCS and rights may be subject to contractual arrangements. As discussed further below with respect to liability issues, ownership or use of pore space is also related to responsibility for stewardship of the stored CO_2 and potentially liability.

In common law jurisdictions, in the absence of specific legislation governing property rights in relation to CCS, property laws generally determine ownership of underground pore space and injected CO_2. Because different types of geologic formations (e.g. saline formations, depleted oil and gas reservoir) may be subject to different bodies of property law, rules governing CCS projects differ depending upon the type of formation. Oil and gas reservoirs are typically governed by laws regarding oil, gas and mineral rights, whereas saline formations are generally governed by water rights laws. [216]

For mineral-bearing formations, the "American Rule" vests legal title to the formation in the surface rights holder unless these rights are severed. Where a separate mineral rights holder exists, the mineral rights holder's interest is dominant over the surface estate as long as minerals remain on the property. Minerals are typically never completely exhausted, so the mineral rights holder will generally continue to retain an interest following the completion of active mining activities under the American Rule.[217] The "English Rule", in contrast, vests the mineral rights holder with the ownership of the mineral formation even following completion of mining activities.

For saline formations, water laws could control ownership of the pore space and the potential rights of other parties who use subsurface water. In the US, for example, there are five major rules that govern water law: the absolute dominion rule, reasonable use rule, correlative rights rule, restatement rule, and prior appropriation rule.[218] Under the

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[216] Mark A. de Figueiredo, Howard J. Herzog, Paul L. Joskow, Kenneth A. Oye, and David M. Reiner, Regulating Carbon Dioxide Capture and Storage, MIT Center for Energy and Environmental Policy Research Working Paper 07-003 (2006) *available at* http://tisiphone.mit.edu/repec/mee/wpaper/2007-003.pdf.

[217] Orpha A. Merrill, Note and Comments, *Oil and Gas: Substratum Storage Problems*, 7 OKLA. L. REV. 225, 227 (1954).

[218] Mark A. de Figueiredo, *Property Interests and Liability of Geologic CO_2 Storage: A Special Report to the MIT Carbon Sequestration Initiative* (Sept. 2005), *available at* http://sequestration.mit.edu/pdf/defigueiredo_property_interests.pdf.

absolute dominion rule, the surface interest owner owns and can use all water beneath the property without liability to others.[219] The reasonable use rule allows a landowner to use groundwater in reasonable amounts for beneficial uses on the land above the aquifer. Under the correlative rights rule, landowners may extract water from a common aquifer in proportion to their land area.[220] In California, application of the correlative rights rule also takes into account reasonableness of use based on custom, social utility, safe yield, and need.[221] Under the restatement rule, a surface rights owner may use groundwater for any purpose or location (including off the property) in a reasonable manner. The prior appropriation rule grants water use rights to prior users (the "first in time" rule).

Given the potential for different property regimes to apply to geologic storage formations, governments considering CCS may wish to adopt dedicated CCS legislation addressing rights over pore space. Dedicated CCS legislation also offers an opportunity to clarify other aspects of pore space ownership, such as status of prior grants, competing mineral rights, and ability to sever pore space rights from other property rights.

Dedicated CCS property rights rules have been adopted in a number of jurisdictions. The Canadian province of Alberta enacted legislation that declares all pore space below the surface of any land (other than federal Crown land) to be vested in, and the property of, the Alberta Crown, irrespective of whether minerals or water have been or are being recovered from such pore space. The declaration further clarifies that grants of mines and minerals rights in land will not be deemed to convey rights to use subsurface pore space occupied.[222] The Australian Commonwealth and several Australian states have similarly enacted statutes vesting ownership of geologic formations in the state. For example, Victoria's CCS legislation confirms that the state owns all underground geological storage formations and the CO_2 that is injected in them.[223] In the US, Wyoming, Louisiana, Montana, and North Dakota have all vested ownership of subsurface pore space in the surface owner, granting dominance to any mineral rights holders in both the surface and subsurface estate. Wyoming allows severance of pore space from the surface interest, whereas North Dakota expressly forbids severance, and Montana law is silent on the issue. Wyoming provides for unitization of pore space rights if 80% of the owners consent. Several other states have defined ownership of CO_2 or provided eminent domain powers over sequestration sites.

In oil-and gas-producing jurisdictions, property laws commonly feature unitization. Field unitization is the common management, including profit and loss sharing, of oil producing

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[219] *Bristor v. Cheatham*, 255 P.2d 173, 178 (Ariz. 1953).

[220] Earl Finbar Murphy, The Recurring State Judicial Task of Choosing Rule for Groundwater Law: How Occult Still?, 66 NEB. L. REV. 120, 134 (1987).

[221] *City of Pasadena v. City of Alhambra*, 207 P.2d 17, 33 (Cal. 1949) *cert. denied*, 339 U.S. 937 (1950).

[222] Section 6, Province of Alberta, Bill 24, Carbon Capture and Storage Statutes Amendment Act, amending Section 15 of the Mines and Minerals Act.

[223] Articles 14-16, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

properties within a formation in order to maximize the field's production and resolve competing claims for production.[224] Unitization has proven to be an effective method to address property rights issues in oil production areas. Unitization could be employed in the CCS context to overcome property rights and legal liability issues associated with operating a large carbon sequestration project involving many property holders.

Most oil producing states have some form of unitization law, either on a purely voluntary or a compulsory basis when a statutorily specified percentage of ownership in a field petitions for the arrangement. The degree of consent required for mandatory unitization in different US states, for example, ranges from a single owner representing any percentage to as high as 85% of the land in a field.[225] Although Texas has a voluntary unitization arrangement, the Texas Railroad Commission which regulates oil production in that state will approve unitization arrangements among field owners seeking unitization, omitting those that do not consent.[226]

Jurisdictions may also wish to require demonstration of rights to pore space as a condition of granting a permit. Requiring rights to be procured before granting a permit helps ensures that regulatory authorities will allocate time and resources to projects that are viable. It also enables regulatory authorities to more fully understand the potential land use issues that could arise in a proposed project.

Another variant is to require that permit applicants demonstrate that they have resolved any potential claims brought by potential land rights owners and users that could be affected by a project. Victoria's CCS law, for example, requires those carrying out any GHG storage activity to enter into a compensation agreement with the holder any resource extraction permit, owner of land or occupier of land. Applicants who fail to secure a compensation agreement are subject to a determination by the Victoria Civil and Administrative Tribunal as to the amount of compensation that is payable in relation to a project.[227]

For jurisdictions in which the state owns or controls pore space, the grant of pore space rights can be integrated into the permitting process. This would streamline the overall permitting process. If an agency other than the lead permitting agency controls land rights, coordination among agencies will be essential.

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[224] A. Allen King, Pooling and Unitization of Oil and Gas Leases, 46 MICH. L. REV. 311, 313 (1948); Jacqueline Lang Weaver & David F. Asmus, Unitizing Oil and Gas Fields Around the World: A Comparative Analysis of National Laws and Private Contracts, 28 HOUS. J. INT'L. L. 3, 12 (2006).

[225] US Office of Technology Assessment, Enhanced Oil Recovery Potential in the United States 24 (NTIS PB-276594, 1978), *available at* http://www.princeton.edu/nota/disk3/1978/7807/7807.pdf.

[226] Paula C. Murray & Frank B. Cross, *The Case for a Texas Compulsory Unitization Statute*, 23 ST. MARY'S L.J. 1099, 1153 (1992).

[227] Sections 48-49, 104-105, 118, 200-201, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

For all except one of the APEC developing economies in this study, rights to the subsurface are controlled directly by the state, and in all nine economies offshore storage is state controlled. For oil and gas producing economies in the study, if storage involves EOR or is conducted in an oil or gas field, the government agency responsible for the regulating the petroleum industry could potentially posses the rights to grant rights to use the pore space.

5.5.2. Liability for Long-Term Storage of CO_2

Liability for stewardship of CO_2 is a universal concern for industry and government stakeholders. Based on the experience in jurisdictions where this issue has been addressed, the prevailing approach appears to be for a government authority to take title to, and release operators from liability for, CCS reservoirs after these operations have ceased injection and the wells are properly closed and meet all regulatory requirements. The acceptance of liability generally would occur after a period of time designed to ensure that the underground CO_2 plume has stabilized and the risks associated with the operation have diminished. However, operators would remain liable for leakage caused by negligence or intentional misconduct.[228] This has been the approach followed in Australia for offshore storage, Canada's province of Alberta, the EU, and several US states that have elected to accept liability for CCS injections.

As discussed further in Section 6.1 of this report, resolution of long-term stewardship for CO_2 is one of the threshold issues that should be resolved before a project of significant scale proceeds. Unless a private party is willing to accept responsibility, as has frequently occurred in CCS demonstration projects with an EOR component,[229] resolution of this issue would likely require government action.

The "long-term liability" issue in reality encompasses various aspects of responsibility for stored CO_2 and their implications for the environment, neighboring and subsequent landowners, the public, and general environmental and greenhouse gas management regulatory regime. Examples include:

- Liability for leakage of CO_2;
- Liability for damage to property (induced seismicity, commingled resources);
- Liability for trespass (multiple users of reservoirs, boundary disputes, including transnational and international waters);
- Liability for CCS activities after transfer of ownership of property;

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[228] See, e.g., Interstate Oil and Gas Compact Commission Task Force on Carbon Capture and Geologic Storage, Storage of Carbon Dioxide in Geologic Structures: A Legal and Regulatory Guide for States and Provinces (September 25, 2007) *available at* http://www.southwestcarbonpartnership.org/_resources/pdf/2008-co2-storage-legal-and-regulatory-guide-for-states-full-report.pdf.

[229] See C. Hart, "Putting It All Together: The Real World of Fully Integrated CCS Projects." Discussion Paper 2011-06, Cambridge, Mass.: Belfer Center for Science and International Affairs, (2011).

- Liability under environmental statutes;
- Health, safety and environmental liability (worker safety, groundwater contamination, flora, fauna) under federal and state regulations;
- CCS site selection, permitting, operation and closure requirements; and
- Long-term monitoring, remediation, and financial responsibility for CCS sites

A broad range of issues must therefore be considered by regulators developing a CCS regulatory and permitting regime. Liability issues are necessarily closely associated with various other laws, notably those concerning environment, property, tort, occupational health and safety and the civil code. Developing dedicated CCS regulations therefore require review of, and possibly amendment of, other laws and regulations that could also potentially govern a CCS operation.

Our focus on liability in this section is primarily on environmental, property and tort laws as they are conceptualized in common law jurisdictions. These areas of law most closely touch on the fundamental concerns of project developers in relation to the long-term storage of CO_2, specifically rights to inject CO_2, and possible damage to property and human life. For APEC developing economies, the civil code will be another important area of law that could regulate liability for injury to the environment, property and people.

Property ownership concepts are central to the issues of who may inject CO_2 and would be responsible for the long-term care of the injection site. From a property law perspective, the party who owns the rights to the pore space would presumptively have the right to inject and be responsible for the CO_2, subject to laws and regulations governing CO_2 activities. Simply adopting a rule guided by the traditional property concepts, however, could prove inadequate to promote the adoption of the technology. Liability is a universal concern in each OECD and APEC jurisdiction with which we are familiar. The issue of liability needs to be addressed between developers, governments and the public as to how liability will be allocated or shared between industry and government if this technology is to advance.

Among OECD jurisdictions examined, there were marked differences in their handling of such issues as pore space ownership and acceptance of liability. The EU CCS directive requires Member States to accept long-term liability provided all available evidence showing stored CO_2 will be "completely and permanently contained" documented by operator's report, default period of at least 20 years has elapsed, financial security requirements satisfied, and site has been sealed and injection facilities removed. Member States must adopt legislation implementing the directive and the specific terms of transfer of liability.[230]

Australia's Commonwealth government has jurisdiction over offshore storage. Australia has adopted a liability transfer scheme for offshore CCS, which transfers liability to the

[230] Article 18, Directive 2009/31/EC of the European Parliament and of the Council on the geologic storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006.

Commonwealth at the end of the Closure Assurance Period that is no earlier than 15 years after issue of Closing Certificate provided Commonwealth is satisfied that CO_2 (a) behaves as predicted in approved site plan, (b) poses no significant risk of significant adverse impact on geotechnical integrity of geological formation or geological structure, and (c) poses no significant risk of significant adverse impact on environment, human health or safety; and (d) since cessation day, there have not been any operations for the injection of a greenhouse gas substance into the formation. The liability arrangement is structured as an obligation by the Commonwealth to indemnify the license holder against third party claims for damages attributable to an act done or omitted in operations authorized by the license provided liability is incurred after end of Closure Assurance Period, or indemnify third party claimants if the license holder no longer exists.[231]

Australian states have jurisdiction over onshore property. Several of the Australian states also have also passed CCS legislation governing onshore CO_2 storage, which in some cases addresses liability. The Commonwealth and Western Australia governments have agreed to indemnify the Gorgon Project for all common law liability arising from independent third party claims for loss or damage, suffered post-closure, as a result of the long-term storage of greenhouse gas substances.[232] In this case, the liability transfer is project-specific, and not generally available to any CCS project developer. Victoria's onshore regulation separates ownership of land and CO_2 from liability. While Victoria's CCS legislation confirms that the state owns all underground geological storage formations and the CO_2 that is injected in them,[233] it does not explicitly accept liability for stored CO_2. The law further provides that "the Crown is not liable to pay any compensation in respect of a loss caused by the operation of this section".[234] Moreover, Victorian law requires those carrying out any GHG storage activity to enter into a compensation agreement with the holder of any resource extraction permit, owner of land or occupier of land, or the Victoria Civil and Administrative Tribunal can determine the amount of compensation that is payable in relation to proposed work. These arrangements define liability for damages to property, loss of value or amenity.[235] Queensland's onshore CCS law similarly vests ownership of storage land and CO_2 in the state, but does not provide for transfer of liability to the state government.

Alberta, Canada accepts liability without a specific time period. In Alberta, liability transfers upon issuance of a closure certificate, at which time the Crown becomes owner of CO_2 pursuant to agreement with the operators and assumes its obligations. Issuance of a closing certificate occurs if the operator complied with well monitoring and closure

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[231] Articles 399-401, Commonwealth of Australia Offshore Petroleum and Greenhouse Gas Storage Act 2006.

[232] Nicola Durrant, Carbon Capture and Storage Laws in Australia: project facilitation or a precautionary approach? Environmental Liability Journal Volume 18 Issue 4, pp 148-157.

[233] Articles 14-16, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

[234] Article 14(4), Victoria Greenhouse Gas Geologic Sequestration Act 2008.

[235] Articles 48-49, 104-105, 118, 200-201, Victoria Greenhouse Gas Geologic Sequestration Act 2008.

activities regulations, abandoned wells in accordance with Oil and Conservation Act, complied with reclamation requirements under Environmental Protection and Enhancement Act, the closure period to be specified in regulation has passed, and CO_2 is behaving in a stable and predictable manner (no risk of future leakage). Alberta similarly collects fees from the operator to fund its Post-Closure Stewardship Fund.[236]

In the US, property rights are the purview of the individual states, not the federal government. Thus, US federal CCS regulation does not address pore ownership and as of yet Congress has not acted to address liability. In the absence of a dedicated liability rule for CCS in the US, parties that conducted injection activities or are deemed to "own" the CO_2 are likely to be held liable under general common law principles. However, in an effort to promote CCS, several states have adopted their own CCS regulations, some of which include provisions concerning long-term liability. The text box below summarizes selected US state laws governing CCS, in particular property rights and liability issues.

Long-term stewardship and liability for stored CO_2 is a concern of stakeholders in all nine developing APEC economies in this study. Resolution of the stewardship issue requires political consensus around property rights, liability and accountability between the state and developers.

In all of our subject economies except the Republic of Korea, rights to subsurface pore space are owned by the State. The Republic of Korea allows private ownership of land, however storage is likely to occur offshore, which would belong to the Korean state. Ownership and long-term stewardship of injected CO_2 on government land therefore must be addressed for the economies in this study. State-owned property may be leased under oil and gas laws or other property rights regimes for limited periods of time. For petroleum producing economies, oil and gas or mineral concession practices could be extended to govern CO_2 injection as one possible path to granting rights to pore space and regulating CCS through contractual arrangements. All of the petroleum producing economies have mechanisms for project developers to provide a liability fund for oil and gas or environmentally critical projects, which could provide a model for funding mitigation and remediation costs. Environmental laws would provide for liability for negligence or intentional misconduct in carrying out a CCS project. In all economies, liability for stewardship of CO_2 in the absence of negligence or misconduct would need to be addressed, possibly through legislation, contractual arrangements, creation of a liability fund or other financial assurance mechanism, or a combination thereof.

[236] Section 20, Province of Alberta, Carbon Sequestration Tenure Regulation, Regulation 68/2011.

US State CCS Laws and Regulations

In the absence of comprehensive federal legislation, several states have enacted CCS legislation aimed at addressing legal and financial barriers. These laws include defining ownership rights to pore space, allocating liability, specifying requirements for monitoring, mitigation and verification of CO_2 sequestration sites, and providing financial incentives to local CCS activity. The table below summarizes state actions governing CCS for selected issues. In addition to these, over a dozen other states are considering CCS legislation.

Selected US State CCS Laws

	Site Permit	Property Rights	State Liability Transfer Rule	Liability Fund
Illinois		•	•	
Kansas	•			•
Kentucky				
Louisiana	•	•	•	•
Mississippi				
Montana	•	•	•	•
North Dakota	•	•	•	•
Oklahoma	•	•		
Texas	•	•	•	•
Utah	•			
Washington	•			
West Virginia	•	•		
Wyoming	•	•	¤	•

Notes: Property rights include specifying ownership of pore space or CO_2, clarifying potentially competing claims of mineral rights holders to pore space, and providing for the state to exercise eminent domain over sequestration sites.
"¤" indicates rule that prohibits state acceptance of liability.

Wyoming, Louisiana, Montana, and North Dakota have all defined ownership of pore space. All these states have vested ownership of subsurface pore space in the surface owner, granting dominance to any mineral rights holders in both the surface and subsurface estate. Wyoming allows severance of pore space from the surface interest, whereas North Dakota expressly forbids severance, and Montana law is silent on the issue. Wyoming provides for unitization of pore space rights if 80% of the owners consent. Several other states have defined ownership of CO_2 or provided eminent domain powers over sequestration sites.

Louisiana, Montana, and North Dakota have enacted legislation governing liability, in which liability first resides with the operator, and then is transferred to the state at some point after well closure, provided the operator complies with state requirements. Liability

rests with the operator for 15 or more years after injection ends in Montana, and for 10 years in Louisiana and North Dakota, provided CO_2 is expected to be stable and meets closure requirements. Texas and Illinois have also developed legislation to address liability that is specific to the FutureGen project. The Texas legislation transfers liability to the state upon completion of injection. Unlike other states, Wyoming has passed legislation expressly allocating liability to the operator indefinitely. Wyoming law prohibits the state from accepting liability for CO_2 injections.

Six states have created liability funds to cover the costs of monitoring, enforcement, and post-closure remediation. These funds do not relieve operators of liability for negligence during the operational phase. The funds are capitalized through fees paid by operators, generally on a volume of CO_2 injected basis.

5.5.3. Financial Assurance for Closure and Post-Closure

The financial integrity of the CCS operator and financial resources available to the project are critical in order to ensure the proper operation and closure of the injection facility and long-term stewardship of stored CO_2. Financial assurance requirements are therefore critical to all stages of the project. Because a CCS project is likely to have a variable revenue stream and cost profile, the type and extent of financial assurance requirement could appropriately be varied.

CCS project revenues are likely to be highest during the injection phase, when an operator is collecting storage fees or producing oil or gas if the project involves hydrocarbon recovery. Revenues will fall-off at closure, at which time costs will be incurred for properly plugging injection wells. The project operator will continue to incur costs for monitoring, remediation and any liability associated with the facility until such time as the operator is relieved of such obligations under regulation. As discussed in the next section, in some jurisdictions' liability for third party losses associated with a CCS project would continue indefinitely without legislation relieving parties of liability. During these periods in which costs are not offset by revenues, financial assurance requirements are especially important.

Financial assurance during the operation of the project is typically addressed through a combination of a demonstration of financial integrity of the CCS operator as part of the permitting process. In addition, regulation may require the posting of a bond or other measures to ensure that financial resources are available in the event an operator's assets are unavailable. These measures are typically designed to cover the cost of closure and costs of monitoring and remediation and sometimes liabilities in the post-closure period. Here we focus on financial assurance measures that should be considered in order to address the closure and post-closure periods.

Financial assurance measures can be classified in three basic types: (1) self-insurance instruments, including the corporate financial test and the corporate guarantee; (2) third party instruments, including insurance, surety bond, financial guarantee bond or performance bond, letters of credit, and an irrevocable trust fund; and (3) government-

organized industry funded arrangements such as are typically used for orphan funds in the oil and gas industry.

Robust financial assurance requirements will be important for ensuring public acceptance of CCS projects. The rigor of financial assurance requirements should be adequate to meet anticipated costs associated with closure and post-injection site care, as well any contingencies that might reasonably be expected. Reliance entirely on a financial test of the operator may not be adequate in the event its financial condition changes. This is especially important given the high costs and long time periods associated with a CCS project. Thus, third party financial assurance measures and/or government-organized measures are essential to ensuring that a project has the resources to meet regulatory obligations and the public supports the project.

The cost of third party or government-organized financial assurance mechanisms should be considered by government regulators with industry and other stakeholders. Also, the availability of third party financial mechanism should be evaluated as part of the regulatory process. Currently, there is not an active insurance market offering products for the long-term risks associated with CCS operations although insurance products are offered during the operational and post-closure phases. In the absence of a deep private sector market for long-term risk products, a government-organized industry-funded solution may be necessary.

For third party risk assurance measures, third-party providers, such as insurers, should also meet continuing financial solvency requirements and/or credit rating tests. These tests should be applied periodically and failure to meet them should result in a requirement to replace the financial assurance product with a comparable product. Events such as bankruptcy of a third-party provider should trigger an obligation to notify the regulator and an immediate obligation to substitute an acceptable form of financial assurance instrument.

The amount of financial assurance should be adequate to cover the cost of corrective action, injection well plugging, site closure, post-injection site care, and emergency and remedial response:

- Corrective action in the permit area, based on monitoring and inspections;
- Well closure, including plugging and abandonment, mechanical integrity tests or other verification;
- Post-injection site care and closure, including monitoring; and
- Emergency and remedial response to address damage to injection site, environment and property.

In addition to these contingencies, jurisdictions such as the US have required the financial assurance provisions to cover protection of underground drinking water sources.

As the cost of these are necessarily projections, the operator should be required to provide an estimate of costs, which should be updated periodically to adjust for inflation and site-specific conditions. Corrective action plans, injection well plugging plan, site closure plan and emergency and remedial response plans necessarily evolve as monitoring of the site produces information that causes operators to update information

and plans. Initial and subsequent projections should be approved by the regulator. US regulations require these estimates to be based on the costs of hiring a third party who is not affiliated with the owner or operator.[237] Changes to estimates could trigger an obligation to increase the amount of financial assurance provided by the operator.

Financial Tests

The financial position of CCS project owners and operators should meet stringent financial tests. Similarly, third party financial assurance providers should meet equivalent tests. The financial position of entities subject to tests should be reviewed periodically for changes in the quality of their position or of the financial assurance instrument. Below are US financial tests for CCS owners, operators and guarantors.

US Financial Test for CCS Owners, Operators or Guarantors

<table>
<tr><td colspan="3">Owner or operator or its guarantor must have:
• net working capital and a tangible net worth of at least six times the sum of the current well plugging, post-injection site care and site closure cost; and
• assets located in the US of at least 90% of total assets or at least six times the sum of the current well plugging, post-injection site care and site closure cost</td></tr>
<tr><td colspan="3">And</td></tr>
<tr><td>Pass a bond rating test Standard & Poor's or Moody's for which the bond's rating must be one of the four highest categories (i.e., AAA, AA, A, or BBB for Standard & Poor's or Aaa, Aa, A, or Baa for Moody's)</td><td>Or</td><td>Meet all of the following five financial ratio thresholds:
• ratio of total liabilities to net worth less than 2.0;
• ratio of current assets to current liabilities greater than 1.5;
• ratio of the sum of net income plus depreciation, depletion, and amortization to total liabilities greater than 0.1;
• ratio of current assets minus current liabilities to total assets greater than 0.1; and
• net profit greater than 0.</td></tr>
</table>

Source: 40 CFR §146.85.

[237] 40 CFR §146.85(c)(1).

Third Party Financial Assurance

In general, operators should be provided with flexibility to use any combination of measures that meet regulatory requirements. By taking a flexible approach, regulators encourage a market to develop to provide risk management tools for CCS. At the same time, certain minimum requirements must be specified for third party financial assurance instruments, such as:

- Type of instruments that are acceptable;
- Credit requirements governing institutions that provide third party instruments;
- Amount of coverage required; and
- Conditions under which the instrument can be released, such as provision of an engineering evaluation showing risk levels are below levels specified in regulation.

Types of Third Party Financial Assurance

Corporate Guarantee	Provided by corporate affiliate (usually parent corporation) that meets financial test guaranteeing the obligations of the CCS operator.
Payment Surety Bond	In the event of operator or guarantor default to make payment, surety provides funds in the amount equal to the face value of the bond, which should be sufficient to cover estimated costs
Performance surety bond	In the event of an operator failure to perform, guarantees performance of the specific activity or payment of an amount equivalent to the estimated costs of performance.
Third party insurance	Cover the estimated costs of specified liabilities associated with CCS operations.
Letter of Credit	Issued by a financial institution guaranteeing that a specific amount of money will be available to a designated party under specified conditions.
Trust	Operators fund a trust account to cover financial responsibility requirements based on a schedule and in amounts specified by the regulator.

Third party financial assurance instruments should be standardized wherever possible. Standard language helps reduce the risk of gaps in coverage and facilitates a common understanding among stakeholders as to the instruments conditions of coverage, and terms for cancellation, renewal, and continuation. If financial assurance requirements involve a funded-trust or a government-organized fund, the amount required to be paid-in and the time period over which the amount must be paid are issues to consider in designing the requirements.

Government-Funded, Industry Organized Schemes

Industry-funded, government-backed organized risk management schemes have long been used to address risks in the oil and gas industry, for underground injection of waste and other substances, and the nuclear power industry. Examples of industry-funded, government-organized risk management mechanisms include the US Oil Pollution Act of 1990's Oil Spill Liability Trust Fund, the Texas Oil Field Cleanup Fund, and Alberta's Acid Gas Injection Orphan Well Fund. The oil and gas industry schemes generally impose a volume-based fee on the private operator that is deposited in a public fund to cover costs of remediation. The funds are available to cover the costs of remediation of wells and or catastrophic events such as oil spills. Following these models, several US states have adopted liability funds for CCS. Kansas, Louisiana, Montana, North Dakota, Texas and Wyoming have enacted legislation that features a government-organized fund to cover costs associated with remediation of sites.

In the US nuclear industry, the Price-Anderson Act established a three-tier liability scheme for the nuclear industry that is a potentially interesting model for CCS. Price-Anderson combines site-specific private insurance, industry-wide pooling, and a federal government indemnity for extreme loss events. Price-Anderson is significant because its first two layers are private, with a federal backstop for risks that cannot be privately insured at commercially reasonable rates. It has been effective at promoting the development of both the nuclear power industry and a private insurance market to support it.

A public-private risk transfer structure could incorporate self-insurance, private insurance, and government transfer of liability for CO_2. To address moral hazard issues, the structure should ensure that operators retain risk for a period of time and in cases of their own negligence, as in the Interstate Oil and Gas Compact Commission (IOGCC) model. Optimizing the use of private insurance increases the funds available to cover risks, provides third party pricing for risk, and strengthens risk management. The use of private insurance should promote pricing of risk based on project-specific factors,[238] while facilitating the development of a competitive CCS insurance market.

Self-insurance and a private insurance requirement should help ensure that when the government does accept liability for stored CO_2, the risks of leakage and potential financial loss are mitigated. Transfer of liability for CO_2 stewardship to a government insurance scheme should only be available to CCS projects that are properly designed, sited, constructed and operated in accordance with law and regulation, and follow best practices. Qualifying projects could also be subject to a number of technical conditions designed to protect health and safety, and to reduce government exposure to potential liability under an insurance scheme. These requirements could include geologic structures, limits on volume of injection based on formation characteristics, depth of injection, purity of injectate, and proximity to underground sources of drinking water, human settlements, or ecologically sensitive areas. The US DOE possesses various

[238] J. Dooley, C. Trabucchi and L. Patton, "Tipping Fees Can't Save us from the Tipping Point: The Need to Create Rational Approaches to Risk Management that Motivate Geologic CO_2 Storage Best Practices" Energy Procedia, Volume 1, Issue 1 (February 2009), pp. 4583-4590.

resources, particularly in the national laboratories, to provide guidance for establishing appropriate technical conditions.[239] As with the private insurance component, the government liability transfer should be priced based on project-specific factors to properly align project operator incentives to design, site, construct, and operate CCS projects in a safe and prudent manner.

One of the first studies to assign a value to potential liability for the operational period suggests the costs of insurance could be modest, and by implication a CCS insurance market feasible. The study assesses the financial valuation of potential liability associated with the three possible FutureGen project sites located in Illinois and Texas, assuming an operating period of fifty years and 50 million tons of CO_2 stored, concluding that damages during the operating period would likely be less than $0.20 per ton.[240] While no studies yet provide estimates for long-term post-closure liability, research suggests that the operating period is the period of greatest risk and that risk reduces significantly over time as the CO_2 plume stabilizes.[241] If correct, this means that risks associated with properly designed and implemented projects can be priced at a commercially acceptable level and transferred to a third party insurer.

5.5.4. Confidentiality of Data and Intellectual Property Issues

The reporting regime should specify rules for certifying reported data. Some data may require certification by the operator, with liability associated with false or incomplete data. In some cases, verification may be required by third parties or professional organizations engaged by the operator. The regulator can specify monitoring equipment and secure data transmission requirements to help ensure accurate reporting.

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[239] See Curtis M. Oldenburg and Steven L. Bryant, Certification Framework for Geologic CO_2 Storage, Sixth Annual Conference on Carbon Capture and Sequestration, National Energy Technology Laboratory, Pittsburgh, PA, May 7-10, 2007, available at www.netl.doe.gov/publications/proceedings/07/carbon-seq/data/papers/tue_062.pdf; Curtis M. Oldenburg, Steven L. Bryant, Jean-Philippe Nicot, and Ying Zhang, Certification Framework for Geologic Carbon Sequestration Based on Effective Trapping, Seventh Annual Conference on Carbon Capture and Sequestration, National Energy Technology Laboratory, Pittsburgh, PA, May 5-8, 2008; Curtis M. Oldenburg, Steven L. Bryant, and Jean-Philippe Nicot, Certification Framework Based on Effective Trapping for Geologic Carbon Sequestration, Int. J. of Greenhouse Gas Control 3, 444–457, LBNL-1549E (2009).

[240] See Michael Donlan and Chiara Trabucci, Valuation of Consequences Arising from CO_2 Migration at Candidate CCS Sites in the US, Energy Procedia, Elsevier (2010); Chiara Trabucci, Design Considerations for Financial Risk management Related to the Deployment of Carbon Capture and Storage Technologies. Presentation to the US Senate CCS Liability Workshop, Senate Energy & Natural Resources Committee, June 18, 2010.

[241] Sally M. Benson, "Multi-Phase Flow and Trapping of CO_2 in Saline Aquifers," Paper No. OTC 19244 (2008); International Energy Agency Greenhouse Gas R&D Program, A Review of Natural CO_2 Occurrences and Releases and Their Relevance to CO_2 Storage, Report No. 2005/8 (September 2005).

Regulation should specify policies concerning the use of information provided to regulatory authorizes. These policies should clarify how information can be used beyond the regulation of the particular project. For example, data submitted by CCS operators could provide valuable information for identifying resources in the subsurface, which could inform future oil and gas exploration.

Regulations should also spell out policies concerning the release of information to the public. In general, best practice suggests that broad dissemination of information is strongly preferable. The provision of information enables civil society to monitor projects and build trust with the local community. Public information is also essential for research institutions, equipment manufacturers and service companies to evaluate CCS operations and improve the state of existing technologies. Furthermore, wider access to information can assist prospective CCS site operators to evaluate and minimize risk and promote technology development.

While broader access to information is strongly preferable, release of certain information would adversely affect the business competiveness of an operator, service or equipment provider. This information should legitimately be restricted in order to encourage operators and commercial companies engaged in CCS operations to supply comprehensive information. There are several strategies that can be adopted in regulation to address these concerns such as redacting data that is commercially sensitive and delaying the release of sensitive information. Reporting policies could also distinguish between factual data concerning a site and analysis of that data, the latter being more likely to contain proprietary or commercial sensitive information. Where information could provide competitors with a commercial advantage in pursuing geologic sequestration, mineral or other subsurface rights, another approach is to provide the original exploration license holder with an exclusive right to pursue subsurface injection or other rights.

Petroleum-producing economies generally have regulations concerning the release of information received by regulators in connection from oil and gas operators. Where such regulations exist they may provide guidance for a CCS regime. In cases in which CCS operations are taking place in depleted oil and gas reservoirs, these provisions may be directly applicable to information relating to the storage aspects of the operation.

5.6. Public Engagement and Participation

Public support for CCS is essential for its successful adoption. Gaining public support requires information sharing about the project as well as public engagement and consultation. Experience with other technologies and CCS demonstration projects to date strongly suggests that the consultation process should be initiated early in a project's planning and involve an open dialogue with stakeholders broadly drawn from government, industry, expert organizations, civil society groups such as NGOs, and most importantly, the local community in the project area.

While experience suggests that public engagement is generally more successful the earlier, more open, and more interactive the process, law and regulation typically only require minimal public dissemination of information, often as part of a zoning, environmental impact assessment or public hearing process. For example, all of the

APEC developing economies in this study require environmental impact assessments (EIAs) to be conducted for projects that could potentially cause significant environmental impacts. Regulations governing the preparation of EIAs typically require public participation during the approval process. While the EIA process will be critical to assuring the social acceptance of CCS projects in these jurisdictions and assuring their environmental integrity, the EIA process alone is unlikely to be sufficient to ensure meaningful and effective public engagement.

A meaningful public consultation process will involve extensive public outreach, more than would be typical of a project using familiar technology. As reflected in the recommendation at the conclusion of this study, the EIA process should be supplemented with public education and discussion. Public engagement models range from public opinion surveys, to information dissemination, and active participation from key stakeholders and experts in project design and implementation. The prevailing view of best practices is that public engagement should be a two-way process that develops trust by actively inviting public involvement to shape and improve the project.[242]

Public concern regarding CCS generally center around the key issues of public acceptance of CCS technology cost, and participation in the approval and regulation of a CCS project. Public engagement and participation have been addressed in greater detail in Section 4.2.3 of this study. Cost issues relating to social acceptance of CCS projects are addressed further below in Section 6.1 of this study discussing threshold issues.

5.7. International Agreements and Transboundary Issues

For many of the economies, particularly in Asia, geologic storage will primarily be offshore, which could raise issues relating to competing territorial claims. This is especially an issue in the South China Sea, where oil and gas exploration has generated tensions over resources located in contested areas. Offshore CO_2 storage could exacerbate these tensions if linked to expanding oil production in disputed areas or the act of CO_2 storage itself is viewed as an effort to assert sovereignty over disputed territory.

A number of the developing APEC economies in this study are party to international agreements concerning the exploitation of subsea resources. In the context of a CCS project featuring offshore storage, these agreements could govern their projects or provide guidance for how potential transboundary issues might be addressed.

Eight of the APEC developing economies in this study are party to multilateral and/or bilateral agreements with other economies that would limit or potentially guide

[242] See, e.g., World Resources Institute, CCS and Community Engagement: Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects (2010). National Energy Technology Laboratory (2009), Public Outreach and Education for Carbon Storage Projects. Washington, D.C.: US Department of Energy; Commonwealth Scientific and Industrial Research Organisation (CSIRO), Communication and Engagement Toolkit for CCS Projects (2011).

transboundary transfer or storage of CO_2. Only Chinese Taipei is not a party to some international treaty or convention.

All study economies except Chinese Taipei have signed and ratified the 1982 United Nations Convention on the Law of the Sea (UNCLOS), pursuant to which they claim jurisdiction over subsea resources in their respective Exclusive Economic Zones (EEZ), which they may claim extend up to 200 nautical miles from the baselines from which the breadth of their territorial seas are measured. UNCLOS governs rights to resources within EEZs only, and does not address claims of sovereignty over disputed territory. Where the EEZs of two or more economies overlap, UNCLOS provides for the economies to reach agreement demarcating their rights, failing which they may adjudicate the dispute before the International Court of Justice. Significantly, other than agreement, UNCLOS specifies no method to determine competing claims to resources.

Several of the study economies have entered into bilateral agreements concerning the demarcation of boundaries for purposes of establishing rights to oil and gas fields that straddle borders or joint exploitation of oil and gas resources in defined areas of the continental shelf along neighboring exclusive economic zones. These bilateral agreements could govern or provide guidance for use of geologic formations that straddle the boundaries of two or more economies. Bilateral agreements establishing joint exploitation regimes include:

- The Australia-Indonesia Timor Gap Zone of Co-operation Treaty, signed on 11 December 1989 and entered into force on 9 February 1991, for joint exploitation of petroleum resources in a part of the Timor Sea seabed which were claimed by both Australia and Indonesia;

- Agreement between the Republic of Korea and Japan concerning Joint Development of the Southern Part of the Continental Shelf Adjacent to the Two Countries, 30 January 1974;

- 1979 Memorandum between Malaysia and the Kingdom of Thailand on the Establishment of a Joint Authority for the Exploitation of the Resources in the Sea-Bed in a Defined Area of the Continental Shelf of the Two Countries in the Gulf of Thailand;

- Agreement between the Government of Malaysia and the Kingdom of Thailand on the Constitution and Other Matters Relating to the Establishment of the Malaysia-Thailand Joint Authority, 30 May 1990; and

- Memorandum of Understanding Between Malaysia and Viet Nam for the exploration and Exploitation of Petroleum in the Gulf of Thailand, 5 June 1992, entered into force 4 June 1993.

A number of territorial boundary agreements also exist involving the APEC study economies, including:

- Agreement between Australia and Indonesia establishing certain seabed boundaries signed at Canberra on 18 May 1971;

- Agreement between Australia and Indonesia establishing certain seabed boundaries in the area of the Timor and Arafura Seas supplementary to the preceding agreement and signed at Jakarta on 9 October 1972; and

- Agreement between Australia and Indonesia concerning certain boundaries between Papua New Guinea and Indonesia signed at Jakarta on 12 February 1973.

Indonesia, Malaysia, the Philippines, Thailand and Viet Nam are members of ASEAN and may also take guidance from the ASEAN Agreement on the Conservation of Nature and Natural Resources 1985,[243] which establishes the principle among ASEAN Members to share and conserve natural resources. Although intended to govern conservation and development of natural ecosystems, Article 19 of the ASEAN Agreement can be interpreted broadly to govern the exploitation of all natural resources: "Contracting Parties that share natural resources shall cooperate concerning their conservation and harmonious utilization, taking into account the sovereignty, rights and interests of the Contracting Parties concerned in accordance with generally accepted principles of international law." It further provides for parties to seek bilateral or multilateral agreements to "secure specific regulations of their conduct in respect of the resources concerned."

Of the study economies, the People's Republic of China, the Republic of Korea, Mexico, and the Philippines are party to the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the "London Convention"), and only the People's Republic of China and the Republic of Korea and Mexico are party to the 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (the "London Protocol"), which is intended to supersede the London Convention. Pursuant to restrictions in the London Convention, parties would be prohibited from engaging in the storage of CO_2 in the seabed. The London Protocol allows storage of CO_2 in a sub-seabed geological formation and the export of CO_2 for purposes of injection provided an agreement or arrangement is reached between exporting and receiving countries, consistent with the provisions of the London Protocol and applicable international law.[244] Although not all of the APEC developing economies in this study are party to either the London Convention or London Protocol, other countries that are subject to either of these treaties would be required to observe their obligations in transactions involving CO_2 with any other economy.

5.8. International Standards

The development of an internationally recognized standard for CCS operations would provide regulators and industry in developing APEC economies with guidelines that could

[243] The agreement is not yet in force. It was signed on 9 July 1985 by Brunei Darussalam, Indonesia, Malaysia, the Philippines, Singapore and Thailand, the six ASEAN members at that time. The agreement has not yet been ratified by the required number of countries.

[244] Article 6(2),1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

be adopted in national legislation. An internationally recognized standard would help regulators establish requirements for the siting, design, operation, closure, monitoring and long-term stewardship of sites intended for the geological storage of CO_2. While not a substitute for regulation, standards generally reflect consensus among industry experts, including project developers, regulators, academic and expert organizations. They promote harmonization and can promote best practices.

Standards can also play an important role in defining the duty of care for industry, which can reduce the uncertainty associated with legal liability assuming such standards are followed. For economies with incomplete legislative framework, standards can provide guidance in the absence of specific national legislation or regulation. This can be especially important for economies that have limited experience with CCS or lack the resources to develop comprehensive legislation.

Presently, developing APEC economies rely upon internationally recognized standards for oil and gas operations, such as API, American National Standards Institute, and BSI. These standards could inform operating decisions as part of a CCS project, especially one involving EOR; however a dedicated CCS standard is necessary.

A number of guidelines have been developed on specific topics or for specific economies. As mentioned previously, the WRI has developed Guidelines for Carbon Dioxide Capture, Transport and Storage (WRI 2008) and Guidelines for Community Engagement in Carbon Dioxide Capture, Transport, and Storage Projects (WRI 2010). WRI, in collaboration with Tsinghua University's BP Clean Energy Research and Education Centre, has also developed CCS guidelines for the People's Republic of China based on WRI's 2008 CCS guidelines. Det Norske Veritas has developed recommended practices designed for identifying and managing risks associated with CO_2 capture technology, pipeline operation and geologic storage.

The Canadian Standards Association (CSA) and the International Performance Assessment Centre for Geologic Storage of CO_2 (IPAC-CO2) have developed draft standards for geologic storage of CO_2 for the Standards Council of Canada and the American National Standards Institute for adoption as a voluntary standard in Canada and the US, respectively. In 2011, the International Organization for Standardization (ISO) established a technical committee to progress development of an internationally recognized standard for materials, equipment, environmental planning and management, risk management, quantification and verification, and related activities in the field of CCS.

6. A Path for CCS in Coal-Fired Power Plants in Developing APEC Economies

The application of CCS in coal-fired power plants in developing APEC economies will require a strategy tailored specifically to the conditions of each economy. Such a strategy must address certain threshold issues for the adoption of CCS (discussed in previous chapters) and present a feasible commercial path for the technology. Threshold issues – cost, public acceptance and long-term liability – must be addressed in order for any CCS permitting regime to effectively facilitate CCS adoption. In this chapter, we outline the possible contours of such a strategy and some practical steps APEC economies can take to advance CCS regulation, which are based on consultations with stakeholders in the APEC developing economies and our assessment of their circumstances. As part of the practical steps discussion, we also consider issues beyond CCS, such as power sector regulatory reform and international and domestic financial mechanisms that can provide an enabling environment for CCS adoption. Finally, we review opportunities for international collaboration to support capacity building among APEC developing economies in order to achieve these objectives.

6.1. Threshold Challenges: Cost, Public Acceptance and Long-term Liability

Application of CCS for coal-fired power plants in developing APEC economies present several fundamental challenges for governments and developers which must be overcome for successful implementation. For governments, pubic acceptance of the technology due to safety concerns and projected increases in the cost of electricity for consumers are critical threshold issues. Public acceptance issues increase the need for standards reflecting best practices in safety and environmental integrity, public engagement and education.

The cost of CCS to consumers in the form of increased electricity prices is also likely to be a critical issue. For developing APEC economies, electricity prices are often linked to various development and socio-economic factors, such as household income and access to affordable electricity. In developing economies, increased costs associated with CCS could require low-income households to reduce electricity consumption or force households to go without electricity altogether, presenting developmental, political and economic challenges. Faced with these challenges, stakeholders in several study economies expressed the view that their economies' per capita CO_2 emissions do not warrant reducing greenhouse gas emissions using expensive means such as CCS.

Cost factors could therefore have a significant influence on public acceptance of CCS in developing APEC economies and the willingness of policymakers to pursue the technology. These issues must ultimately inform the strategies APEC economies adopt to implement CCS regulation. Although a large-scale demonstration project would be expensive in itself (and likely require concessionary financing in a developing economy), a single demonstration plant would probably not appreciably increase the overall cost of

electricity in any of the study economies. However, the widespread adoption of CCS would entail electricity cost increases at the current cost of CCS technology.

Socio-Economic Factors Among Selected Developing APEC Economies

APEC Economy	GDP per capita (US$)	Access to Electricity	Cost of Electricity (US cents/kwh)	CO_2 emissions tons per capita
Brunei Darussalam	31,239	99.7	N/A	19.8
Chile	11,873	98.5	14.5	4.3
People's Republic of China	4,382	99.4	10	4.9
Hong Kong, China	31,799	100	12.3	4.57
Indonesia	3,015	64.5	6.1	1.8
Republic of Korea	20,591	100	6.9	10.5
Malaysia	8,423	99.4	7.42	7.3
Mexico	9,558	98	8	4.4
Papua New Guinea	1,488	45	N/A	0.5
Peru	5,172	85.7	10.44	1.5
Philippines	2,007	89.7	28.8	0.8
Singapore	43,117	100	17.34	12.1
Chinese Taipei	18,458	99	9	12.1
Thailand	4,992	99.3	9.4	4.1
Viet Nam	1,174	97.6	9.89	1.3

Source: International Monetary Fund, IEA, UNESCO, Carbon Dioxide Information Analysis Center.

The relatively high cost of CCS for power applications and socio-economic considerations in APEC developing economies point to the need for international financial support that reduces the burden of CCS for the most vulnerable parts of society if CCS is to be widely adopted. CDM revenues could, for example, help reduce the burden. Other measures developing APEC economies can pursue include broader power sector reform to enhance overall efficiency and reduce the cost of power generation and delivery, and "pro-poor" policies that shield low-income households from increases in the cost of electricity through modification of the power tariff structure or subsidies.

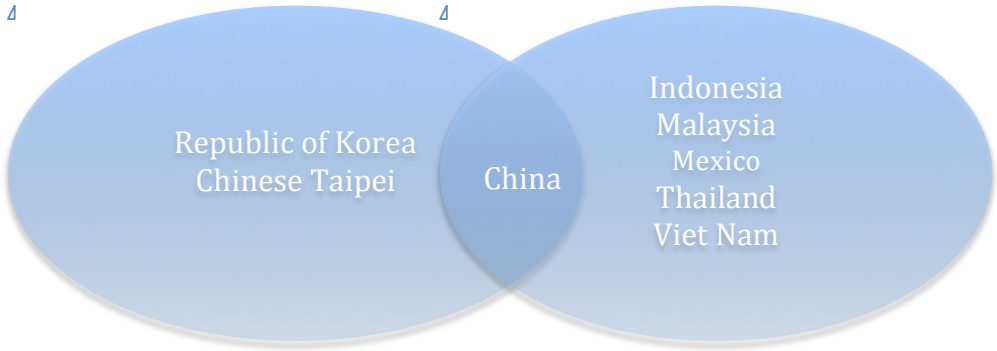
For project developers, the return on investment for undertaking a CCS project and issues associated with long term liability for CO_2 storage are critical threshold issues. As many of state-owned power generators in the APEC developing economies in this study operate at a loss, ensuring an adequate return on investment will be a priority. However, further increasing the cost of generation without a commensurate increase in tariffs will be politically and economically infeasible. For some generators, CCS may present an opportunity to justify increasing rates, however as discussed previously, measures should be taken to prevent increasing rates for lower-income households.

6.2. *A Commercially Viable Path for CCS*

With respect to the cost of CCS, a commercially viable path must be identified by each economy without raising the cost of electricity for the poorest members of society. The financing strategy for each economy need not be identical, and differences among them point to different approaches. Based on our assessment of current and planned activities in the field of CCS among the study economies, the nine APEC economies can be characterized following one of two paths that could support adoption of CCS as part of coal-fired power generation — technology innovators or CO_2 users.

Technology innovators are focused on developing technologies for capture, transportation or storage. The People's Republic of China, the Republic of Korea and Chinese Taipei are technology innovators. Carbon dioxide users have economic uses for commercial volumes of CO_2, primarily for enhanced oil and gas recovery. These economies are the People's Republic of China, Indonesia, Malaysia, Mexico, Thailand and Viet Nam. In our assessment, only China falls into both categories. Although the Philippines possesses unique geologic formations that may enable it to produce research in storage applications, it not clearly fit within either category.

Technology Innovators and CO_2 Users



6.2.1. Technology Innovators

For economies pursuing the technology innovator strategy, industry and government cooperation in promoting research, development and demonstration (RD&D) is essential. A strong domestic market for CCS technology can play a critical role in supporting the development of the technology and these economies may position themselves as equipment suppliers and ultimately technology leaders.

The People's Republic of China, the Republic of Korea and Chinese Taipei are all pursuing a strategy of technology innovation, with the People's Republic of China at the most advanced stage. Importantly, all three economies support research and development efforts in CCS and related technologies and have all adopted technology roadmaps to guide CCS development and funding. These plans sharply differentiate these economies from the other APEC economies in this study and provide the strongest

indicator of their intention to become technology innovators, and potentially leaders, in the CCS field.

All three economies are also planning carbon legislation that will involve a cap and trade regime among other policies. By capping greenhouse gas emissions and adopting a pricing mechanism, these economies are developing a policy environment that could incentivize CCS adoption. The Republic of Korea and Chinese Taipei have specifically identified CCS as a technology that they plan to deploy to reduce domestic greenhouse gas emissions. Although the People's Republic of China has not elaborated a policy to promote the domestic CCS deployment, it has also identified CCS as a potential future technology to achieve domestic emissions reductions.

Significantly, energy market conditions in the Republic of Korea and Chinese Taipei could also favor the development of CCS for coal-fired power plants. In both economies, the supply of natural gas is limited and costly and coal remains the favored fuel for baseload power generation.

People's Republic of China

Although the People's Republic of China had not yet elaborated a policy to promote the domestic deployment of CCS, it first integrated CCS into its National Medium- and Long-term Science and Technology Development Plan in 2005, which guides science and technology development during the 2006 to 2020 period. In 2007, China's National Climate Change Program set a goal to strengthen the development and dissemination of advanced technologies, including CCS.[245] That same year, *China's Scientific and Technological Actions on Climate Change* prioritized RD&D of CO_2 capture, utilization and storage (CCUS) technologies.

Currently, the People's Republic of China has a number of CCUS pilot projects that are in the planning or implementation stages. China's early CCUS efforts began within its gasification R&D, a part of the Chinese government's 863 Program, which advances a wide range of strategic technologies with the goal of making China technologically independent. The Ministry of Science Technology (MOST), which administers the 863 Program, has mandated and partially funded the development and construction of two IGCC coal-to-liquids plants, three IGCC demonstration power plants, and one gas turbine demonstration project for use with IGCC. None of the plants will store CO_2 upon completion; however, these projects are important steps in developing CO_2 capture technology and systems integration know-how in China. Furthermore, a number of pilot storage projects have emerged from them.

One of the IGCC projects sponsored by MOST, the GreenGen project (featured in the text box below), will be China's first fully-integrated power generation application with CCUS. Furthermore, Shenhua Group, the world's largest coal company, developed and operates a US$1.46 billion direct coal liquefaction plant with a hydrogen facility in Ordos,

[245] National Development and Reform Commission of China, China's National Climate Change Program (2007). Available at http://www. ccchina.gov.cn/WebSite/CCChina/UpFile/File188.pdf (accessed October 9, 2011).

Inner Mongolia that employs a CO_2 capture facility designed by China National Petroleum Corporation. In its current phase, the project is injecting an initial 100,000 tons of CO_2 per year into the Ordos Basin, and by 2012, expects to inject 2.9 Mt per year from the hydrogen facility, making it the first dedicated CO_2 storage facility in China.

GreenGen

China Huaneng Group, the largest power generation company in China, initiated the GreenGen project in 2004 to conduct RD&D for a near-zero emission coal- based power plant. The project's first phase is to develop a 250 MW, 2,000 tons of coal per day IGCC plant using domestic gasification technology and GE 9E-class gas turbines. Xi'an Thermal Power Research Institute (TPRI), which is part of the China Huaneng Group, developed the dry-feed gasifier used in the plant and provides systems integration and technical expertise. During the first phase, GreenGen will also research and test key technologies for the next stages, including hydrogen production through coal gasification, fuel cells, and CO_2 capture and storage. GreenGen's first phase may also include a 30,000-ton CO_2 test injection into a nearby oil field. The second phase (2012–2014) will optimize the gasification technology. Further R&D will be conducted on CCS technologies, including EOR with PetroChina. The third phase (2014–2016) will be the construction of a 2×400 MW IGCC for power generation with CCS. The plant will release nearly zero emissions, capturing one million tons of CO_2 per year and injecting it for EOR.

GreenGen is 52% controlled by the state-owned Huaneng Group. GreenGen's other owners, each holding a 6 % share, are China's other large power producers (Datang Group, Huadian Corp, Guodian Corp and China Power Investment Corporation), top coal mining companies (Shenhua Group, China Coal Group), China's State Development and Investment Corporation (SDIC), and US- based Peabody Energy Corporation. GreenGen is projected to cost about 7 billion Yuan. The 863 program provided startup funding and the ADB provided construction loans and grants.

Source: C. Hart and H. Liu, Advancing Carbon Capture and Sequestration in China: A Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).

Although China has not yet mandated domestic CCS deployment, there is evidence the government may pursue a greenhouse gas mitigation strategy that includes CCS. As CCS pilot projects advance to the early commercial deployment stage, the National Development and Reform Commission (NDRC), which sets economic and energy policy, will be presented with the decision whether to grant operating licenses for these plants. The NDRC has already approved an increased electricity tariff for the GreenGen power plant, which could indicate that China's CCS policies are at a critical juncture. Given the importance of creating a domestic market for indigenous technology and gaining practical experience operating these facilities, it will be essential that these projects be granted approval to operate if China is to continue to play a leadership role in CCS technology.

China's goals for reducing greenhouse gases could eventually provide additional impetus for China to adopt CCS technology. China has pledged to reduce the amount of CO2 emitted per unit of gross domestic product (GDP) by 40% to 45% by the end of 2020, compared to 2005 levels. Towards this goal, China's 12th Five-Year Plan for Economic and Social Development (2011 – 2015) set a target of 17% CO2 emission reduction per unit of GDP. The Plan also calls for the gradual development of a greenhouse gas emissions trading market, adoption of low carbon product standards, identification and certification systems, and promotion of low carbon pilot projects.

Seven cities in China will conduct trial emissions trading starting in 2013 as preparation for nationwide cap-and-trade for 2015. These trading pilots will cover the power sector, and possibly cement, iron and steel and buildings. CCS for industrial applications are

particularly attractive in China, and are less than half the cost of CCS power plant applications. An approach that begins with CCS for the industrial sector could help drive down costs for later-stage implementation in the coal-fired power sector.

Republic of Korea

The Republic of Korea adopted its CCS Master Plan in July 2010, which identified CCS R&D goals, created a timetable for the development of at least two demonstration projects, called for the assessment of potential geologic storage sites, and stipulated development of CCS regulation by 2014.

The Republic of Korea's CCS efforts are led by KEPCO, the state power company. KEPCO has launched two of four planned national CCS RD&D projects and is expected to lead the other two. The Korea National Oil Company (KNOC), Korea Institute of Geoscience and Mineral Resources, and the Ministry of Land, Transportation and Maritime Affairs are collaboratively undertaking geologic assessments of potential CO2 storage sites. The Korea CCS Association was formed pursuant to the Master CCS Plan in order to support CCS technology RD&D, assist in the development of regulations and enhance knowledge sharing. KCCSA's President is also the President of KEPCO and its members include KEPCO subsidiaries, several major Korean engineering companies, KNOC, and over two-dozen research institutes and universities.

One of the challenges Korea faces is limited CO2 storage space. The Korean legislature has amended the Marine Environment Management Act to specifically allow offshore (subsea) CO2 storage and provide regulation for CO2 purity and the recovery of costs associated with storage. Korean stakeholders are also considering the possibility of shipping CO2 to other economies for storage. If Korea is successful in developing cost-effective CO2 transport by ship, it could become a technology leader in this area.

The Republic of Korea's CCS efforts have been adopted as part of its climate policies to reduce domestic GHG remissions. In August 2008, the government announced its "Low Carbon, Green Growth" plan, a broad-based mandate for green growth initiatives. "Low Carbon, Green Growth" identifies 17 new national growth engines divided into three categories: green technology industries, state-of-the-art fusion industries, and high value-added industries. The government plans to invest KRW 6.3 trillion (US$5.88 billion) in the 17 growth engines over the next four years.

The Framework Act on "Low Carbon, Green Growth," enacted in February 2010, sets a national target to reduce greenhouse gas emissions by 30% of business-as-usual projections by 2020. According to the Act, a basic plan will be established and implemented every five years within a 20-year planning framework for climate change and energy. The first five-year strategy includes CCS as one of 27 core technologies that must be promoted to achieve green growth. A bill is pending in the National Assembly proposing an Emissions Trading Scheme (ETS) to be launched by 2015. It is one means by which Korea aims to reduce greenhouse gas emissions by 30% from projected levels by 2020.

Chinese Taipei

CCS technology has been recognized by Chinese Taipei's government as one of the possible means to reduce national emissions to reach its greenhouse gas reduction targets. Chinese Taipei's Framework for Sustainable Energy Policy identifies "CCS technology through international cooperation to reduce the CO2 emission of power generating system" as a means to achieve its 2020 and 2025 greenhouse gas emissions reduction goals. The Ministry of Economic Affairs (MOEA), which is responsible for energy, has proposed a CCS roadmap that includes timelines for CCS R&D projects as part of the national energy plan. The roadmap contemplates development of post-combustion, IGCC, oxyfuel and other supporting technologies. The roadmap also calls for small-scale demonstration projects of under 3 MW in the near term, up to 30 MW by 2016, and readiness for commercialization by 2025.

Chinese Taipei's Environmental Protection Agency (EPA) and the MOEA have each appointed committees to examine CCS potential. The EPA committee known as the CCS Strategic Alliance concentrates on developing regulations for CCS. Members of the CCS Strategic Alliance include key stakeholders such as Taiwan Power Company, China Petroleum Company, China Steel Company and several government agencies under the EPA. The MOEA's CCS R&D Alliance includes Taiwan Power Company, China Petroleum Company, Industrial Technology Research Institute and China Steel Company. In addition to these efforts, the National Science Council leads the Clean Coal Master Project under the National Energy Project that funds CCS R&D projects, including a pilot project conducted by Taiwan Power Company to inject 10,000 tons of CO2.

Chinese Taipei is adopting carbon policies that could facilitate the eventual adoption of CCS. Although Chinese Taipei has no international obligation to control its greenhouse gas emissions, it has officially adopted a policy of "voluntary compliance" with international environmental agreements. The government announced its target of stabilizing Chinese Taipei's emissions at 2008 levels by 2020. The EPA later expanded this to a three-step target to reduce emissions to 2008 levels by 2020; to 2000 levels by 2025; and to half of 2000 levels by 2050. Although it is not a signatory to the UNFCCC, Chinese Taipei made a further commitment to reduce greenhouse gas emissions by 30% of business as usual by 2020 in response to the COP held in Copenhagen in December 2009.

The government implemented its "Frameworks for Sustainable Energy Policy – An Energy-Saving and Carbon-Reduction Action Plan" in June 2008. The laws and policies to carry out this plan have either been implemented or are scheduled for legislative review. The Greenhouse Gas Reduction Act (draft), which was approved by the Executive Yuan in September 2006 and is pending final approval from the Legislative Yuan, would implement a cap and trade system among its measures. The EPA is developing a voluntary prototype carbon emissions trading program until the law is enacted. In 2009, the central government announced plans to impose a carbon tax, however no timeline has been set for its adoption.

6.2.2. CO_2 Users: Oil and Gas Producing Economies

The People's Republic of China, Indonesia, Malaysia, Mexico, Thailand and Viet Nam are candidates to use CO_2 in oil and gas operations. If CO_2 proves effective for enhanced oil or gas production, these economies will gain valuable expertise across the CCUS chain.

During the past decade, all of these petroleum-producing economies have experienced rapid growth. China, Indonesia and Thailand are already net oil importers and Malaysia is expected to become a net importer of oil in the near future.[246] Only Mexico remains a major net exporter of oil. Concerned about depletion of their oil and gas fields and future energy security, stakeholders in each of these economies expressed interest in EOR and several economies are actively studying their CO_2 EOR potential. For these economies, CO_2 EOR could represent an attractive proposition to increase domestic oil production while reducing domestic greenhouse gas emissions.

For these economies, any application of CCS linked to EOR will likely be driven by the state-owned oil and gas company, or by oil and gas companies that either enter into production sharing or service contracts or are granted a concession. One possible approach, for example, is that that EOR could be required as a condition of future production sharing or service contracts. In these cases, the possible selection of CO_2 as an injectant will depend on a number of factors including reservoir type and the CO_2 source will likely be selected based on cost considerations. Oil and gas operators may have access to lower cost sources of CO_2, such as CO_2 derived from gas separation facilities, which they also may control near potential EOR sites.

Thus, for economies with oil and gas production, the future path of CCS will directly depend upon its contribution towards the profitability of oil and gas operations, and the ability to develop CCS technology and infrastructure at acceptable cost. As much of the potential storage capacity is offshore, projects that involve construction of underwater pipelines over long distances can be prohibitively expensive. An ADB study examined possible combinations of sources and storage sites for Indonesia, the Philippines, Thailand and Viet Nam, and more work of this kind is needed to fully assess potential.[247]

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[246] The Malaysia Insider, "Malaysia likely to be net oil importer by next year", May 27, 2010, http://www.themalaysianinsider.com/malaysia/article/malaysia-likely-to-be-net-oil-importer-by-next-year/ (accessed March 4, 2012).

[247] Asian Development Bank's Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

Economics of Enhanced Oil Recovery

In EOR, CO_2 is injected into an oil reservoir in order to increase well pressure and reduce the viscosity of oil, thereby increasing production. Using conventional methods, approximately 20% to 40% of original oil in place will be recovered in a typical oil or gas field.[248] Carbon dioxide floods can increase a field's production by 7% to 15% of original oil in place and extend the life of a field by 15-30 years.[249] One ton of CO_2 can produce anywhere from 1.5 to 6.5 barrels of oil, with an average of about 2.5 barrels.[250] Results vary by field characteristics: porosity, permeability, miscibility, gravity of the oil, operating depth, original and current reservoir pressure, location of oil in reservoir, operating temperature of reservoir, and geologic structure (e.g., dolomite, sandstone, carbonaceous).

Results also depend on operating decisions whether CO_2 injection is conducted solely to enhance oil production or also to achieve CO_2 storage. A portion of the CO_2 is separated and recovered from the produced oil and re-injected into the reservoir; however, most of CO_2 is trapped in the reservoir. Through repeated cycles, essentially all of the CO_2 can be permanently stored, depending on operating decisions. By some estimates, one quarter to one third of a tonne of CO_2 per barrel of oil produced is stored through EOR.[251] A similar process is followed for CO_2 enhanced natural gas recovery.

Source: C. Hart, "Putting It All Together: The Real World of Fully Integrated CCS Projects - A Study of Legal, Regulatory and Financial Barriers in Phase III of the US Department of Energy Regional Carbon Sequestration Partnerships Program," Cambridge, Massachusetts: John F. Kennedy School of Government, Harvard University (2011).

6.3. Advancing CCS Regulation in Developing APEC Economies

CCS regulatory development in APEC developing economies should precede any large-scale CCS demonstration projects. The investment required for developing CCS regulation is relatively modest compared to other costs associated with RD&D. Resolving threshold issues such as liability, long-term stewardship and financial incentives will greatly facilitate project developers in assessing costs, risks and any potential investment return. Regulation should therefore aim to protect human health, safety and the environment while providing greater certainty to project developers and other stakeholders that can reduce cost and risk and increase public acceptance.

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[248] Electric Power Research Institute, Enhanced Oil Recovery Scoping Study. Palo Alto, California: EPRI (1999).

[249] Moritis, G., "Future of EOR & IOR," Oil & Gas J., 99.20 (2001), 68-73.

[250] Martin, F.D. and J.J. Taber, "Carbon Dioxide Flooding," J. Petroleum Technology (1992), 396-400.

[251] WorleyParsons, Strategic Analysis of the Global Status of Carbon Capture and Storage, Report 2: Economic Assessment of Carbon Capture and Storage Technologies. Canberra, Australia: Global CCS Institute (2009).

In order to advance CCS regulation in developing APEC economies, we suggest several practical measures, which range in degree of effort: appointment of a regulatory working group, initiation of a legal reform process to consider relevant laws and resolve jurisdiction, taking a step-by-step approach to regulation and undertaking broader power sector reform.

6.3.1. Regulatory Working Group and Law Reform Process

Several APEC developing economies have already established CCS working groups that can serve as a model for economies that have not yet formed such groups. Generally, CCS working groups include key ministries, state-owned and private enterprises and research institutions, and serve as a coordinating bodies for stakeholder engagement and regulatory development efforts. CCS working groups should report to a government official or body with clear authority to progress efforts towards adoption of CCS regulation and ability to coordinate among different governmental organizations. Such a group could address and make recommendations on key issues, such as:

- Whether comprehensive legislation or amendment to existing laws or regulation should be made to accommodate CCS demonstration projects;
- Selection of a lead regulator for different types of CCS projects;
- How liability for CO_2 stewardship should be addressed; and
- Approaches to help finance the cost of CCS for the power sector.

Working groups should initiate a transparent and inclusive law reform process that promotes best practices in the development of CCS regulation. The law reform process should clarify jurisdiction and roles among government ministries for regulating CCS (e.g. determination whether CCS regulation will be implemented through adaptation of existing laws and regulations or adoption of a new dedicated law, and whether the appropriate body of law for CCS regulation is environment, water protection, oil and gas and / or pipeline and well construction).

6.3.2. Pore Space Rights and Long Term Stewardship

Long-term stewardship is a universal concern for stakeholders in all nine developing APEC economies in this study. Unlike the other permitting issues, which tend to be more technical in nature, the stewardship issue presents issues that require political consensus around property rights, liability and accountability between the state and developers.

In all of subject economies in this study except the Republic of Korea, rights to subsurface pore space are owned by the State, which may in turn lease subsurface rights under oil and gas laws or other property rights regimes for limited periods of time. Ownership and long-term stewardship of injected CO_2 on government land therefore should be addressed. For petroleum producing economies, oil and gas or mineral concession practices could be extended to govern CO_2 injection as one possible path to granting rights to pore space and regulating CCS through contractual arrangements. Several of the petroleum-producing economies possess mechanisms for project developers to provide a liability fund for oil and gas or environmentally critical projects,

which could provide a model for funding mitigation and remediation costs. Environmental laws would provide for liability for negligence or intentional misconduct in carrying out a CCS project. In all economies, liability for stewardship of CO_2 in the absence of negligence or misconduct would need to be addressed, possibly through contractual arrangements, a liability fund, resolution of ownership of CO_2 or regulation, or a combination thereof.

6.3.3. Step-By-Step Approach to Regulation

Taking a step-by-step approach to regulation that incorporates experience from pilot projects and small-scale demonstrations has been a valuable and credible approach for regulators in leading OECD jurisdictions. In the US, for example, the US DOE launched a comprehensive multi-stage program involving 25 pilot test storage projects ranging from 43 to several hundred thousand tons of CO_2 injected. This pilot stage was followed by nine fully-integrated small scale demonstration projects, initially in the absence of dedicated legislation at the federal or state levels.[252] Regulation has evolved with experience gained from these and other pilot projects and dedicated CCS regulations under various existing laws were adopted by the time the fully integrated projects entered the planning stage. Alberta, Canada took a similar approach, adopting dedicated legislation after 10 years of experience gained through the Weyburn-Midale CO_2 Storage and Monitoring Project in Saskatchewan.[253] A similar "learning-by-doing" approach could be a practical way forward for the developing APEC economies in this study as well. While a gradual approach will facilitate demonstration-scale and possibly first-of-a-kind commercial projects, widespread commercial adoption of CCS would ultimately require the development of dedicated regulations addressing the full range of CCS issues.

6.3.4. Power Sector Regulatory Reform

Among developing APEC economies included in this study, most have state-owned power companies that control most if not all power generation in their jurisdiction. These state-owned power companies generally operate at a financial loss and depend upon the government budget for subsidies. The weak financial condition of state power generators in most APEC developing economies makes CCS extremely difficult to finance and implement.

Attracting investment in CCS and other low carbon energy technologies will be difficult without a transparent, equitable, and independent regulatory regime governing the power sector. Allowing competitive private sector power generation that brings new technology, private capital, and enhanced management capacity can increase efficiency and potentially facilitate CCS adoption.

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[252] US Department of Energy. http://www.fossil.energy.gov/programs/sequestration/partnerships/index.html (accessed on August 18, 2011).

[253] See Weyburn-Midale CO_2 Project, http://www.ptrc.ca/weburn_overview.php (accessed on August 18, 2011).

The introduction of transparent dispatch and pricing rules, creation of a system operator independent of market participants, a regulator that is independent of political pressure, and liberalizing entry to increase competition in generation are generally considered key elements of successful reform. A study of 150 developing economies shows that almost half the economies surveyed embrace some degree of power sector reform but only a handful of economies have adopted full horizontal and vertical de-bundling. Among economies that undertook reform, allowing independent power producers (IPPs) to operate in the market is the single most common measure.[254]

All of the APEC developing economies in this study allow IPPs, which could be important for introducing advanced technologies such as CCS. At the same time in all of these economies, state-owned power companies dominate the electricity sector, generating most of its power. In most of the APEC economies in this study, the state-owned electricity generator is also the single buyer of power, owns the transmission and distribution network, and either acts as system operator or houses the system operator within it.

For IPPs or any other power producer that must sell their electricity on a competitive basis, implementing a CCS-equipped power plant will require regulations governing dispatch and compensation that ensure they can sell their electricity as if they are the low-cost electricity producer. At the same time, regulatory reform that is intended to spur adoption of CCS must ensure transparency and efficiency in the operation of electricity markets.

Regulatory reform has experienced mixed results in developing APEC economies. Indonesia, the Republic of Korea and Chinese Taipei have all announced plans to undertake more complete reforms, involving a greater degree of unbundling, which have been delayed. In Indonesia, a national law requiring de-bundling has been ruled unconstitutional by Indonesia's Supreme Court.

For adoption of CCS in the electricity sector, regulatory reform could become a central issue in financing these facilities and the cost of electricity for consumers. Stakeholder consultations revealed that these issues are critical to private power generators that could support these economies in adopting CCS. Further work on these issues is essential to developing financing plans for CCS. Regulatory working groups in consultation with private generator and consumer stakeholders in each economy should evaluate that economy's reform efforts to date and the specific elements of reform that would be needed to facilitate the adoption and financing of CCS.

6.4. International Financing Mechanisms for CCS

Lack of financial incentives and support for CCS remains a significant barrier to its adoption. Concerns over the financial viability of the technology and the cost to consumers influence stakeholder perceptions of the appropriateness and feasibility of the

[254] John E. Besant-Jones, Reforming Power Markets in Developing Countries: What Have We Learned? Energy and Mining Sector Board Discussion Paper, Paper No. 19 (September 2006).

technology for developing economies, and in turn the urgency of developing regulations for CCS.

Developing APEC economies that host a CCS project before widespread commercial adoption of the technology would be early movers and bear higher costs relative to later adopters.[255] The incremental cost of equipping a coal-fired power plant with CCS in OECD economies operating at 90% capture efficiency is estimated to increase capital costs on average by approximately 70% to 75%.[256] To place this in perspective, for a 630 MW power plant built in North America, CCS would increase capital costs by approximately US$1.5 billion over that of a conventional plant.[257] These plants would also consume additional coal in order to provide power to operate the capture and compression system, contributing to an overall decrease in efficiency of up to 30%. The additional capital and operating costs result in an increase in the cost of electricity, which by some estimates can be as much as almost 80%.[258]

The Kyoto Protocol to the UNFCCC adopted the principle that developed countries are to provide developing countries with technology transfer and financial support reflecting the incremental costs associated with reducing their greenhouse gas emissions.[259] With the extension of the Second Commitment period of the Kyoto Protocol to 2017 or 2020 and the inclusion of CCS in the CDM, there is general consensus that developed countries must provide financial support if CCS technology is to be adopted by developing countries.

With prices for CDM allowances currently trading below Euro 10 and expected to remain low in the foreseeable future, CDM revenues alone will be inadequate to meet the incremental cost of CCS for power plant applications. Therefore, additional international funding support is necessary, which could come from the Green Climate Fund under the UNFCCC or innovative financing structures such as the EU's NER 300 program. As discussed previously, the NER 300 program set aside 300 million EUAs under the EU ETS to be auctioned, the proceeds of which will subsidize installations of innovative renewable energy technology and CCS projects in the EU.

To make CCS economically viable, international public resources must leverage private investment and domestic government support. Possible mechanisms for support include

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[255] Riahi, K., Rubin, E., Taylor, M., Schrattenholzer, L. Hounshell, D. Technolgical learning for carbon capture and sequestration technologies. Energy Economics 26 (2004) 539-564. Elsevier B.V.

[256] See Al-Juaied, M. and A. Whitmore. (2009). Realistic Costs of Carbon Capture. Cambridge, Massachusetts: Belfer Center for Science and International Affairs; Finkenrath, M., Cost and Performance of Carbon Dioxide Capture from Power Generation. Paris: IEA/OECD (2011).

[257] Hart and Liu, Advancing Carbon Capture and Sequestration in China: A Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).

[258] Finkenrath, M., Cost and Performance of Carbon Dioxide Capture from Power Generation. Paris: IEA/OECD (2011).

[259] Article 11(2)(b), Kyoto Protocol.

tax incentives and feed-in-tariffs or consumer surcharges for those capable of paying more for electricity. For electricity generation applications, these types of measures will be essential in order to attract private investment.

As described above, oil- and gas-producing APEC economies that can use CO_2 for EOR can potentially generate a positive return on CCS investment; however, additional work must be done to further assess CO_2 EOR potential in APEC developing economies. APEC has initiated a new clean fossil energy project devoted to CCUS-EOR, which will examine permitting regimes in the context of CCUS-EOR.

6.5. Opportunities for International Collaboration

Collaboration between industrial stakeholders such as oil and gas companies and the power sector will be essential to the development of coal-fired power projects with CCS. There is a clear need for further training and capacity building among government officials responsible for policy development, technical personnel, key state-owned enterprises that could deploy CCS technology, and research institutions that advise and support government and industry. Capacity building should be undertaken with both legislative branch and executive branch personnel in these economies.

Capacity building efforts also should also be undertake to facilitate workforce training and public acceptance of CCS technology. Stakeholders in several study economies suggested surveys of public opinion should be conducted at several stages of outreach activities. Other options for public outreach could include television, especially news and educational programming, and cooperation between academia and non-governmental organizations.

International organizations are facilitating the adoption of CCS in the regulatory area through capacity building with key stakeholders, sponsoring economy-specific techno-economic and regulatory studies, and promoting best practices in public education and outreach.

The **Global CCS Institute** (GCCSI) launched in 2009 and supported financially by the Australian government, funds a wide range of CCS activities in globally and in APEC developing economies. The GCCSI's capacity building efforts span technical, regulatory, financial, public engagement, and knowledge sharing aspects of CCS. The GCCSI's efforts in the regulatory area include a 2009 study of regulatory issues in 16 economies worldwide, funding the ADB's CCS program that is developing a CCS roadmap for China and evaluation of the potential for CCS in Indonesia, the Philippines, Thailand and Viet Nam; and the World Bank's CCS Trust Fund. In addition, the GCCSI is directly engaged in these economies as well as Malaysia and Mexico. The organization has also developed the *Carbon Capture and Storage Regulatory Test Toolkit* (the *Toolkit*), which is designed to assist economies in developing CCS regulation through a comprehensive stakeholder exercise that considers a hypothetical CCS projects at every stage of the approval process. The *Toolkit* is designed to identify gaps in existing regulation and the exact points at which supplementary or streamlining regulation should be adopted.

The **World Bank** launched its CCS Trust Fund in December 2009 to help spur CCS in developing economies, with initial funding of US$8 million contributed from Norway and the GCCSI. It has published *Carbon Capture and Storage in Developing Countries: a Perspective on Barriers to Deployment*, which features techno-economic and regulatory assessments for the Southern African and Balkan regions. The World Bank is conducting further studies in North Africa and is working with China and Mexico among APEC developing economies in this study.

The **Asian Development Bank** (ADB), a regional multilateral development bank that promotes economic and social development in Asian and Pacific economies, is conducting *Exploring the Potential for CCS in Southeast Asia* a study of the potential for CCS in Indonesia, the Philippines, Thailand and Viet Nam, which includes regulatory assessments for these economies and have been used in this APEC study.[260] ADB has also funded regulatory analysis in China as part of program of loans and technical assistance to the GreenGen project.

NGOs have also played an important role in promoting the development of CCS regulation in APEC developing economies. The **Clinton Foundation** sponsored a CCS scoping study for Malaysia with the GCCSI, which included a focus on regulation. The **World Resources Institute** (WRI), together with Tsinghua University and Chinese experts, have developed guidelines for deployment of CCS technology in China based on WRI's CCS guidelines for the United States. The latter guidelines include: *Guidelines for Carbon Dioxide Capture, Transport, and Storage* (2008), which provides comprehensive, preliminary guidelines for deployment of CCS technologies in the US based on extensive stakeholder participation, and *Breaking Ground: Engaging Communities in Extractive and Infrastructure Projects* (2009), which provides principles for community engagement for CCS projects in order to foster a constructive and supportive working relationship with the public for these projects.

Government and intra-governmental organizations have also developed resources for CCS that can be applied to developing APEC economies. **APEC** has developed community outreach strategies for CCS projects, specifically focusing on the Asia-Pacific Region. APEC's *Community Outreach Strategy for CO_2 Capture and Storage Projects* (2009) provides a seven-step approach to engage local communities in CCS projects. The APEC strategy focuses on communication and approaches to address community concerns. APEC also conducted capacity building in APEC developing economies in 2005 and again in 2011, and produced a manual for training policymakers on *CCS issues: Building Capacity for CO_2 Capture and Storage in the APEC Region: A Training Manual for Policy Makers and Practitioners* (APEC Energy Working Group Project EWG 03/2004T (March 2005).) Finally, the present study is the most recent example of APEC's efforts to facilitate the adoption of CCS among its members.

The **International Energy Agency** (IEA) publishes the IEA CCS Legal and Regulatory Review on a periodic basis, which summarizes regulatory actions in economies, and hosts the IEA International CCS Regulatory Network, a forum for discussion among

[260] Asian Development Bank's Regional Technical Assistance Project 7575 "Determining the Potential for Carbon Capture and Storage in Southeast Asia" (forthcoming 2012).

regulators and other interested stakeholders. The IEA also prepared a *Model CCS Regulatory Framework* to help economies develop their own regulation, drawing examples from the EU, Australia, Canada, US and other economies.

The **Carbon Sequestration Leadership Forum (CSLF)** has provided an important forum for government leaders at the ministerial level to develop consensus on CCS issues for developed and developing economies. CSLF funds capacity building efforts for its member economies, including in the regulatory area.

The **US Department of Energy (DOE)**, through its **National Energy Technology Laboratory** (NETL), produces best practice guidelines for various aspects of CCS operations. In 2006, it also published *International Carbon Capture and Storage Projects: Overcoming Legal Barriers*, which assessed legal and regulatory issues for CCS projects and analyzed how five projects in five different economies have addressed or plan to address these issues.

6.6. Recommendations for Future Capacity Building

Future capacity building should seek to strengthen efforts among developing APEC economies to become CCS technology providers or CO_2 users.

Technology development for developing APEC economies represents an opportunity to advance CCS technology and drive down the cost of adoption. International collaboration can significantly strengthen RD&D efforts in these economies and broaden possible market opportunities. The People's Republic of China commonly engages in international collaborations among governments, industry and other stakeholders in CCS technologies.[261] Similar efforts are at early stages in the Republic of Korea and Chinese Taipei. Significantly, the Republic of Korea and Chinese Taipei intend to deploy CCS to reduce their greenhouse gas emissions. Economies that develop their own technologies have additional incentives for adopting them. As a result, capacity building efforts by APEC and other international organizations should prioritize these economies.

In particular, capacity building efforts that focus on demonstration projects and offer real world experience in implementing the practical technical and non-technical issues would be particularly appropriate for economies with advanced CCS research programs. These initiatives would help develop CCS technology as well as the associated regulation. Examples of these kinds of international capacity building collaborative efforts include the People's Republic of China's GreenGen project and, in the United States, the Department of Energy's Regional Carbon Sequestration Partnerships program.

The most promising opportunities for promoting CO_2 use among APEC developing economies involves integrating EOR and EGR practices into oil and gas field operations. Efforts should concentrate on improving assessments of key CO_2 utilization opportunities with a focus on EOR and EGR. As these practices are common particularly in the United States, oil and gas industry knowledge transfer to developing economies should be a

[261] C. Hart and H. Liu, Advancing Carbon Capture and Sequestration in China: A Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).

priority. With respect to the development of regulation, APEC has initiated a project to study regulation specifically for CCS involving EOR and EGR. This approach to regulation, which finds an immediate application for CO_2 use in the developing economy, would be both practical and appropriate to the needs of developing APEC economies.

Appendix A: Stakeholder Consultations

People's Republic of China

Stakeholder Meetings China Regulatory Issues	September 21-23, 2011
Stakeholder Meetings China Regulatory Issues	October 13-15, 2011

Indonesia

CCS Regulatory Issues and Best Practices Workshop	March 24, 2011
CCS Working Group Meetings	March 23-25, 2011
CCS Working Group Meetings	June 30, 2011
Stakeholder Meetings Indonesia Regulatory Issues	July 4-5, 2011
Stakeholder Meetings Indonesia Storage Permitting Issues	July 1, 4-7, 2011
Stakeholder Meetings Indonesia Regulatory Issues	October 10-12, 2011

Republic of Korea

CCS Regulatory Issues and Best Practices Workshop	March 9, 2011
Stakeholder Meetings Korea Regulatory Issues	September 26-28, 2011

Malaysia

CCS Regulatory Issues and Best Practices Workshop	July 7, 2011
Stakeholder Meetings Malaysia Regulatory Issues	July 8 and 11, 2011
Stakeholder Meetings Malaysia Regulatory Issues	October 5-7, 2011

Mexico

CCS Regulatory Issues and Best Practices Workshop	August 29, 2011
Stakeholder Meetings Mexico Regulatory Issues	August 30 - September 2, 2011

Philippines

CCS Regulatory Issues and Best Practices Workshop	November 17, 2010
CCS Working Group Meetings	November 18-19, 2010
Stakeholder Meetings Philippine Regulatory Issues	February 14, 2011
Stakeholder Meetings Philippine Regulatory Issues	March 21, 2011
Stakeholder Meetings Philippine Storage Permitting Issues	June 21-22, 2011

Chinese Taipei

CCS Regulatory Issues and Best Practices Workshop	July 12, 2011
Stakeholder Meetings Taiwan Regulatory Issues	July 13, 2011
Stakeholder Meetings Taiwan Regulatory Issues	September 28 - October 4, 2011

Thailand,

CCS Regulatory Issues and Best Practices Workshop	November 22, 2010
Stakeholder Meetings Thailand Regulatory Issues	November 23-26, 2010
Stakeholder Meetings Thailand Regulatory Issues	January 14, 2011
Stakeholder Meetings Thailand Regulatory Issues	June 28-30, 2011

Viet Nam

CCS Regulatory Issues and Best Practices Workshop	January 17, 2011
Stakeholder Meetings Viet Nam Regulatory Issues	January 18-21, 2011
Stakeholder Meetings Viet Nam Storage Permitting Scheme	June 23-24, 27, 2011

PEOPLE'S REPUBLIC OF CHINA REGULATORY ASSESSMENT

1. POLITICAL AND LEGAL SYSTEM

The government of the Peoples Republic of China (China) is composed of the National People's Congress, the executive State Council, President and Vice-President, all of which are approved by the National People's Congress. Legislative and executive office holders are appointed for five-year terms. China comprises 22 provinces, four municipalities directly under central government control and five autonomous regions. Each of these political subdivisions elect local people's congresses, and are administered by people's governments

China's form of government is a unitary system that does not rely on a system of checks and balances among branches. Instead, the legislative, executive, and judicial functions are intended to work in unison, sometimes with shared responsibilities over certain functions.

The National People's Congress is a legislative body and the highest organ of State power. The National People's Congress comprises 2,989 delegates that are selected from provinces, municipalities, autonomous regions and the armed forces. The National People's Congress approves the President and members of the State Council, as well as the members of the Standing Committee of the National People's Congress, which meets when the National People's Congress is not in session.

Under the National People's Congress, there are local People's Congresses at the provincial, city and county levels. The bodies have four main functions and powers: legislation, supervision of the implementation of laws, appointment and removal of officials, and making decisions on major issues. All administrative, judicial and prosecutorial organs of the State are created and supervised by a People's Congress.

Each People's Congress is a single house legislative body. Representatives of the national and local People's Congress serve on a part-time basis and are elected for 5-year terms. The deputies to congresses at the county and township levels are elected directly by the electors. Deputies to the national, provincial and city people's congresses are elected by the people's congress at the immediately lower level. There are approximately 2.8 million deputies to the people's congresses at all levels nationwide.

The National People's Congress meets in session once a year, and local people's congresses meet at least once a year. The National People's Congress may not exceed 3,000 deputies pursuant to the Election Law of People's Congresses. Due to the size of the National People's Congress, and the part-time status of its deputies, the National People's Congress Standing Committee was established pursuant to the Constitution to exercise national legislative functions when the National People's Congress is not in session. The Standing Committee has the right to propose bills to the National People's Congress and to revise existing laws without the approval of the National Peoples Congress. People's Congress deputies have the right to propose bills.

The People's Congresses and their standing committees elect, appoint or remove, government officials in the administrative and judicial organs. With respect to the administrative organs, the National People's Congress elects the President and the Vice-President of China, approves the Premier of the State Council upon nomination by the President; and approves various subordinate government officials upon nomination. With respect to the judiciary, the National People's Congress elects the President of the Supreme People's Court and the Chief Prosecutor of the Supreme People's Prosecutor's Office. The local people's congresses elect, appoint or remove members of local organs of State power at the corresponding level.

The Chinese Communist Party (CCP) is China's dominant political party and the only party to have been in power since China's founding in 1949. The politburo (political bureau) of the CCP sets policy and controls all administrative, legal and executive government appointments. The CCP's nine-member politburo standing committee leads the CCP. Hu Jintao is the currently General Secretary of the CCP and President of China.

Certain government ministries would play a major role in the development of CCS regulation and the approval of a CCS project in China. Key government ministries and agencies include:

State Council is the chief administrative authority of the People's Republic of China. The State Council is chaired by the Premier and comprises the approximately 50 heads of governmental departments and agencies. The State Council supervises the various subordinate provincial governments. The State Council is formally responsible for the nationwide supervision and control of electric power operations, whereas county governments responsible for electric power operations. In practice, the State Council acts through the National Development & Reform Commission with respect power sector regulation.

National Development & Reform Commission (NDRC) is responsible for developing policy and regulations that affect the national economy and guiding economic reform. NDRC is responsible for drafting the national energy development strategy; implementing planning, policies and standards in the energy and other industrial sectors; developing new energy and promoting energy efficiency; and developing climate change policies. The NDRC acts for the State Council in reviewing and approving infrastructure projects throughout China. The NDRC also issues power plant licenses for facilities over 25 MW, with smaller plants being approved by the local DRCs. Under the NDRC, two groups play potentially important roles for CCS development:

> ***National Energy Administration*** studies and drafts national energy development strategies and considers major issues of energy security and development. As described further below, the National Energy Administration has certain regulatory authority over the oil and gas sector.
>
> ***State Energy Bureau*** drafts and implements industrial planning, policies and standards in the energy sector; and develops new energy and promotes energy efficiency.

Ministry of Science & Technology (MOST) is the lead agency in preparing China's science and technology development plans and policies, drafting related laws and regulations, and implementing the country's basic and applied research programs. MOST administers several national R&D initiatives that fund applied research in gasification, enhanced oil recovery and other technologies that are important to CCS. For example, MOST's 863 program funded three IGCC projects, one of which is GreenGen.

Ministry of Environmental Protection is China's national environmental policy and enforcement body. It is responsible for drafting and implementing environmental protection planning, policies and standards. The Ministry of Environmental Protection has counterpart offices at the provincial and local level.

Ministry of Industry and Information Technology (MIIT) drafts and implements planning, policies and standards, and monitors daily operations in industrial sectors. It is tasked with accelerating the development of indigenous innovation of important technologies.

Ministry of Finance (MOF) in responsible for budget and tax management. It approves all borrowing from international organizations, such as the World Bank and Asian Development Bank.

Ministry of Land Resources is responsible for the planning, administration, protection and rational utilization of natural resources in China, including land, mineral and marine resources. Its major functions and responsibilities include developing policies, regulations and standards for land, mineral and marine resources.[1]

Ministry of Water Resources is responsible for managing water resources in China.

State-owned Assets Supervision and Administration Commissions of the State Council (SASAC) supervises and manages State-owned enterprises. SASAC appoints and removes top executives of supervised enterprises, and evaluates their performances.[2]

In June 2007, the State Council created the **Climate Change Leading Group** headed by Premier Wen Jia-bao in charge of climate change and energy saving and emission reduction.[3] The Foreign Ministry set up a leading group headed by Foreign Minister Yang Jie-chi in charge of the international aspects of climate change; Vice Foreign Minister Wu Dawei and Assistant Foreign Minister Cui Tiankai serve as deputy heads of the group.[4].

China's Agenda 21 is a government body tasked with supporting China's sustainable development goals. Its members include all ministries, key government agencies, trade groups

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[1] Ministry of Land and Resources Web Site available at http://www.mlr.gov.cn accessed on Oct. 5, 2011.
[2] SASAC Web Site available at http://www.sasac.gov.cn, accessed on Oct. 6, 2011.
[3] Notice of the State Council on Establishing the Leading Group in Charge of Climate Change and Energy Saving and Emission Reduction, *State Council, Guo Fa [2007] No. .June 12, 2007.*
[4] "FM Sets Up Climate Change International Working Group," *Xinhua News Agency,* Sept. 5, 2007, available at http://www.china.org.cn/english/environment/223237.htm.

and other State organizations with an obligation to progress sustainable development. The organization actively promotes the industrial use of CO_2, such as enhanced oil recovery, as part of a CCS program.

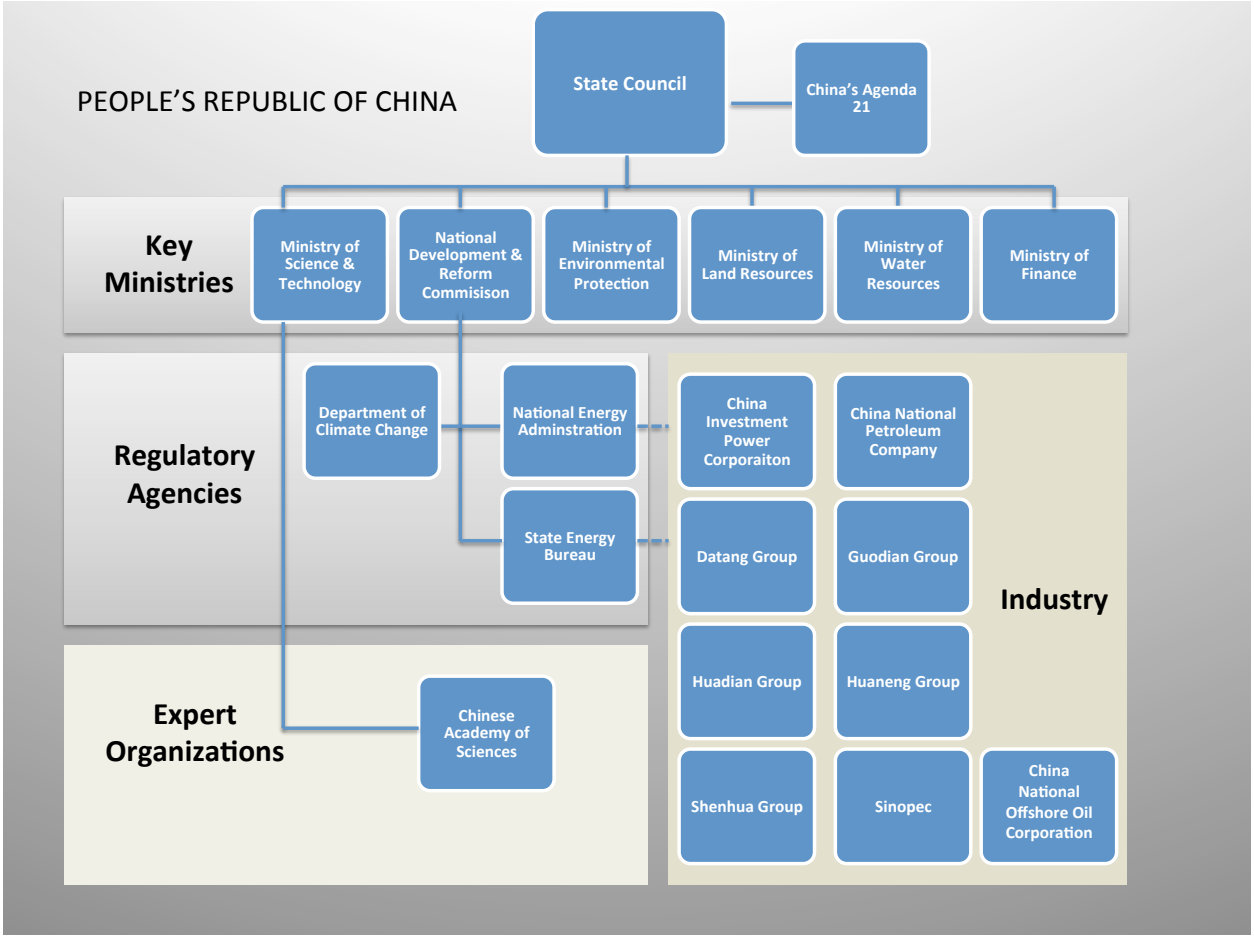
State Power Corporation of China is a wholly State-owned company that acts as the government's arm for investment in the power industry and owns and operates power plants directly as well as holds shares in other generation, transmission and distribution companies.

GreenGen is a joint venture with the near-term objective to design, build and operate the country's first IGCC power plant in Tianjin that integrates coal gasification hydrogen production, power generation and supplies CO_2 for use in enhanced oil recovery on a test basis. **GreenGen** is 52 percent controlled by the State-owned power company **Huaneng Group**, China's largest power producer and the second largest power producer in the world. GreenGen's other shareholders, each holding a 6 percent share, are China's other large State-owned power producers (**Datang Group, Huadian Corp, Guodian Corp and China Power Investment Corporation**), China's top coal mining companies (**Shenhua Group, China Coal Group**), **China's State Development and Investment Corporation** (SDIC), and the U.S.-based Peabody Energy Corporation.

Shenhua Group, the world's largest coal company, has developed the world's first commercial direct coal liquefaction plant in Inner Mongolia. The Shenhua plant will supply CO_2 for use in enhanced oil recovery.

China National Petroleum Company (CNPC), its subsidiary **PetroChina**, and **Sinopec** are China's largest mainland petroleum exploration and production companies. **China National Offshore Oil Corporation** operates offshore and foreign oil and gas operations. CNPC and Sinopec conduct research in enhanced oil recovery on the mainland, would likely be responsible for the sequestration phase of any CCS project on mainland China, and could become major consumers of CO_2.

The diagram below shows selected central government entities and stakeholders that would be involved in regulating or undertaking a CCS project. Regional or local government entities are not shown on the diagram.



2. CLIMATE CHANGE LAW AND POLICY

China is a non-Annex I country under the UNFCCC, and is a signatory to the Kyoto Protocol.

China's 11th Five-Year Plan (covering 2006-10) emphasized sustainable GDP growth and the quality of economic output. The plan sets specific environmental targets that include a 20% cut in the amount of energy consumed per unit of GDP, a 10% reduction in the total discharge of major pollutants, an increase in forest cover, improvements in the efficiency of industrial and agricultural water use, and more waste-water treatment. The **Outline of the 12th Five-Year Plan for Economic and Social Development of the PRC (**2011 – 2015) sets a new goal of 17% CO_2 emission reduction per unit GDP and 8% SO_2 emission reduction.[5] The Plan encourages advancing low carbon technology development; and controlling GHG emission in the areas of industry, construction, transportation and agriculture. It also urges the country to establish low carbon product standards, identification and certification systems, and gradually the carbon emission exchange market; and to promote low carbon pilot projects and demonstration.[6]

[5] Chapter III, The Outline of the 12th Five-Year Plan for Economic and Social Development of the PRC.
[6] Chapter XXI, The Outline of the 12th Five-Year Plan for Economic and Social Development of the PRC.

China has adopted a series of policies in respond to the climate change. The **Medium- and Long-term National Plan for Science and Technology Development 2006-2020** sets the energy and environment as the pilot areas in the development of science and technology, and lists monitoring and response to global environment as the major subjects in the environment area. The **National Climate Change Program** clearly states that scientific and technological work should act as important measures in response to the climate change through scientific and technological improvement and innovation. After the **National Assessment Report of Climate Change** and **National Climate Change Program,** the government issued the **Scientific and Technological Actions on Climate Change 2007-2020,** which outlines the country's action plan to respond the increasing impact of the climate change.

Until recently, China had not elaborated a domestic policy to promote the development and deployment of CCS. In 2005, CCS technology was first integrated into *China's National Medium- and Long-term Science and Technology Development Plan*, which guides science and technology development during the 2006 to 2020 period. In 2007, China's National Climate Change Program set a goal to strengthen the development and dissemination of advanced technologies, including CCS.[7] That same year, *China's Scientific and Technological Actions on Climate Change* prioritized research, development and demonstration (RD&D) of CO_2 capture, utilization and sequestration technologies.

Notwithstanding these policies, China's leadership has not yet mandated implementation of CCS as a part of its policy for reducing CO_2 emissions.[8] China's MOST has advanced CCS-related RD&D through its administration of China's technology development programs. As CCS technology enters the deployment stage, the NDRC exercises jurisdiction over CCS projects through its implementation of China's low carbon and energy efficiency targets, setting electricity tariffs and approving new power plants and industrial facilities.

3. LAWS AND REGULATION APPLICABLE TO CCS

China currently has no laws that specifically govern CCS. However a number of existing laws and regulations could apply to CCS.

3.1 Classification of CO_2

The **Environmental Protection Law** of the People's Republic of China uses the terms "waste" and "pollution" but does not define their meaning. As described further below, the Environmental Protection Law contains reporting and liability provisions for discharges of waste or pollutant.

The **Law on the Prevention and Control of Water Pollution** defines "water pollutant" as "substances which are directly or indirectly discharged to waters and may cause pollution to waters," and "pathogenic pollutant" as "pollutants which are capable of, after being directly or

[7] National Development and Reform Commission of China (2007), China's National Climate Change Program. Available at http://www. ccchina.gov.cn/WebSite/CCChina/UpFile/File188.pdf (accessed October 9, 2011).
[8] Ministry of Science and Technology of China et al. (2007). China's Special Scientific & Technological Actions in Response to Climate Change. Available at http:// www.ccchina.gov.cn/WebSite/CCChina/UpFile/ File199.pdf (Accessed October 9, 2011).

indirectly absorbed by an organism, causing the organism or its descendants to become sick, act abnormally, vary genetically, physiologically function abnormally, become deformed or die."[9]

The **Law on the Prevention and Control of Environmental Pollution by Solid Wastes,** defines "hazardous waste" as solid waste that is included in the national list of hazardous waste or identified to be dangerous according to the identification criteria and methods of hazardous waste as prescribed by the State."[10] The **Measures for the Administration of Permit for Operation of Dangerous Wastes**, formulated pursuant to the Law on the Prevention and Control of Environmental Pollution by Solid Waste, more broadly governs business activities of collection, storage and disposal of dangerous wastes and preventing the dangerous wastes from polluting the environment, and requires an operation permit for entities to engage in activities of dangerous wastes' collection, storage and disposal within the territory of the PRC.[11]

3.2 Surface Rights and Subsurface Rights

Land Administration Law of the People's Republic of China establishes that the country's land is owned by the whole people and their rights are exercised by the State Council on behalf of the State through the Land Administration Department.[12] The law provides for nationwide centralized land planning, the right of the State to requisition land owned by collectives and return it to State ownership, eminent domain over leaseholds of State-owned land, compensation provisions for land and leaseholds reacquisition by the State, and guidelines for the development of land, and liability for violations of the law.

There are four types of land use rights in China: grant, lease, allocation and collective rights. Land grant is similar to ownership except that the grant is for a limited term, generally with the possibility of renewal. The grantee can use, transfer or encumber the property during that term. The Land Use Regulations specify limits for different types of land. Grants of land used for industrial scientific, educational and technological purposes may not exceed 50 years.[13]

Land may also be leased directly from the government. According to the **Land Lease Regulations**, the period of the lease may not exceed those periods available under land grants.[14] The **Contract Law**, however, limits the terms of lease contracts to 20 years.[15]

Land allocation is an administrative allocation by government to other State entities, and does not imply ownership. Allocation is subject to the government's right to recover the land at any time.

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[9] Article 91, Law on the Prevention and Control of Water Pollution.
[10] Article 88, Law on the Prevention and Control of Environmental Pollution by Solid Wastes.
[11] Article 2, The Measures for the Administration of Permit for Operation of Dangerous Wastes.
[12] Article 2, Land Administration Law of the People's Republic of China.
[13] Article 12, Urban Land Regulations.
[14] Several Opinions Regulating the Lease of State-owned Land, issued by the Ministry of Land and Natural Resources on [August 1, 1999].
[15] Article 214, People's Republic of China Contract Law.

Collective land use rights are provided to farming collectives. These land use rights are not ownership rights as they cannot transfer or otherwise encumber the land.

Significantly, rights to use industrial land may be separately granted for the surface and subsurface.[16] The law grants priority to existing uses, stating that newly created rights may not infringe the rights of existing users.[17] The law provides several means to obtain rights to industrial land, with the preferred method being public bidding, however allocation is permitted but the rights granted using this method are to be "strictly limited."[18]

Natural and mineral resources, waterways and maritime waters belong to the State.[19] Natural resources may also be owned collectively, if provided for by law.[20] It appears the provisions concerning mineral rights would govern, or be analogous to the rights governing, pore space.

The **Civil Law** states that "Mineral resources owned by the State may, in accordance with the law, be exploited by a unit under the ownership of the whole people or by a collectively-owned unit. They may also, in accordance with the law, be extracted by a citizen."[21] If further clarifies that rights of citizens and collectives to manage natural resources would be pursuant to contract. Rights to exploit the subsurface, such as exploration, mining, and water extraction rights are governed by concepts of usufruct.[22]

The **Property Rights Law** governs the ownership and utilization of property. According to the law, the Real Property Register is the basis of evidence pertaining to the ownership and content of the property rights and is supervised by the registration department.[23] "No expropriation of the collectively-owned land in violation of the authority and procedure prescribed by laws is allowed."[24] Furthermore, the properties belong to the country and are owned by the country, and the State of Council exercises the ownership with respect to the State properties including the properties, the mineral resources, water, sea areas and the urban lands.[25] Public facilities like railways, roads, electric power, communications and gas pipes also belong the State and are owned by the State.[26] The properties owned by the State and by collectively-owned are protected by law and will not be occupied, privately divided, withheld, damaged by any institution and individual.[27] The legitimate properties of individuals will also be protected and not be occupied and damaged by any institution and individual, and legally owned properties owned by social communicates are also protected.[28] Under the law, institutions and individuals "may occupy, utilize and obtain profits from such natural resources as owned by the State, or owned

[16] Article 136, Property Rights Law.
[17] Article 136, Property Rights Law.
[18] Article 137, Property Rights Law.
[19] Articles 46 and 48, Property Rights Law.
[20] Article 48, Property Rights Law.
[21] Article 81, Civil Law.
[22] Articles 120 and 123, Property Rights Law.
[23] Article 16, Property Rights Law.
[24] Article 43, Property Rights Law.
[25] Article 45-47, Property Rights Law.
[26] Article 52, Property Rights Law.
[27] Article 56 and 63, Property Rights Law.
[28] Article 66 and 69, Property Rights Law.

by the State while used by the collective or collectively-owned organizations according to law."[29] The law further clarifies that the right to use industrial land includes the "right to the use of the land's surface, ground or underground."[30]

According to the **Construction Law**, a construction unit should apply and obtain construction permit from the local government at or above county level where the project is located.[31]

3.3 Long-Term Stewardship and Liability for Stored CO_2

The Civil Law imposes liability for violation of a contract or for infringement upon the rights of the State, collective property, rights of others, or harm to another person.[32] The remedy is restoration of property to its original state or compensation for equivalent value. Additional award of compensatory damages are available for "serious damage."[33]

Activities involving a high degree of danger to the surrounding environment or violation of environmental protection or pollution prevention laws create a presumption of that the operator shall be liable under the Civil Law.[34] The Civil Law specifies several methods of assuming civil liability, including stopping the infringement; restoring property to its original condition, compensation for damage; and making an apology.[35] Civil law claims are subject to a two-year statute of limitations, except for certain claims including those involving compensation for bodily harm, which have a one-year period.[36]

Rights holders in immoveable property is prohibited form disposing of solid waste, water pollutants or hazardous substances in violation of law.[37] Further, rights holders in immovable property are acquired to avoid any damage to adjacent property holders and are liable for any damage caused by their use of property.[38]

In the **Law on the Prevention and Control of Water Pollution,** enterprises, public institutions and individual industrial and commercial households directly discharging pollutants to waters "shall pay pollutant discharge fee according to the category and quantity of the discharged water pollutants as well as the charging rates of such fee," and income from pollutant discharge fee shall be used to prevent and control pollution only.[39]

Under the **Law on the Prevention and Control of Atmospheric Pollution,** a system of collecting fees exists for the discharge of pollutants on the basis of the categories and quantities of the atmospheric pollutants discharged, and specific measures and implementing procedures are formulated by the State Council. All the fees collected will be turned over to the State

[29] Article 118, Property Rights Law.
[30] Article 136 and 139, Property Rights Law.
[31] Article 7, Construction Law.
[32] Article 106, Civil Law.
[33] Article 177, Civil Law.
[34] Articles 123 and 124, Civil Law.
[35] Article 134, Civil Law
[36] Articles 135 and 136.
[37] Article 90, Property Rights Law.
[38] Article 92, Property Rights Law.
[39] Article 24, Law on the Prevention and Control of Water Pollution.

treasury and be used exclusively for the prevention and control of atmospheric pollution and will be subject to the lawful auditing and supervision of the auditing authorities according to law.[40]

3.4 Environmental Protection

China has adopted over 60 laws at the national level addressing environmental issues. Regional and local governments also have developed their own environmental regulations.

China's most important environmental law is **Environmental Protection Law of the People's Republic of China**[41], which establishes environmental protection as a goal to be implemented through the national economic plan, education, technology development, standard setting, requiring environmental impact statements for major construction projects, reporting and remediation. The law requires all levels of government to protect the environment. Specifically, the law provides for legal liability, administrative penalties, suspension and cessation of operations for failure to comply with pollution control, reporting or inspection requirements.

In addition to the basic law, there are specific laws governing the regulation of water pollution, air pollution, solid wastes, marine environment, environmental noise, and environmental impact statements. China also implemented a law on renewable energy in 2005.

Law on the Prevention and Control of Water Pollution regulates "the prevention and control of pollution of rivers, lakes, canals, irrigation channels, reservoirs and other surface waters and ground waters within the territory of the PRC."[42] Local governments at or above the county level are responsible for the quality of the water environment under their administration, and the departments in charge of water administration, State land and resources, health, construction, agriculture and fishery under the governments at or above the county level as well as the institutions in charge of protecting water resources in important rivers and lakes are required to exercise supervision and administration over the prevention and control of water pollution.[43] In the Law, "the building, renovation and enlargement of construction projects directly or indirectly discharging pollutants to waters and other water establishments are subject to environmental impact assessment."[44] Violations of the Law are subject to sanctions including financial penalties.[45]

Law on the Prevention and Control of Atmospheric Pollution regulates air pollution from stationary and mobile sources. Local governments at various levels responsible for "the quality of the atmospheric environment under their own jurisdictions, making plans and taking measures to make the quality of the atmospheric environment under their own jurisdictions meet prescribed standards."[46] Environmental protection bureaus at or above the county level are responsible for administering the law with respect to stationary sources. The administrative

[40] Article 14, Law on the Prevention and Control of Atmospheric Pollution.
[41] Adopted at the 11th Meeting of the Standing Committee of the Seventh National People's Congress on December 26, 1989, promulgated by Order No. 22 of the President of the People's Republic of China on December 26, 1989, and effective on the date of promulgation.
[42] Article 2, Law on the Prevention and Control of Water Pollution.
[43] Article 4 and 8, Law on the Prevention and Control of Water Pollution.
[44] Article 17, Law on the Prevention and Control of Water Pollution.
[45] Article 69-83, Law on the Prevention and Control of Water Pollution.
[46] Article 3, Law on the Prevention and Control of Atmospheric Pollution.

departments of public security, transportation, railways and fishery at various levels regulate air pollution caused by motor-driven vehicles and vessels."[47]

Provincial and municipal government and autonomous regions are allowed to "establish their local standards for items not specified in the national standards for atmospheric environment quality" and report to the administrative department of environmental protection under the State Council.[48] According to the Law, units discharging atmospheric pollutants must "report to the local administrative department of environmental protection" its existing discharge and treatment facilities for pollutants and the categories, quantities and concentrations of pollutants, and relevant technical data concerning the prevention and control of atmospheric pollution.[49] The local government authority approves the total emissions of major air pollutants by enterprises and institutions and issues licenses for emission of major air pollutants.[50]

The **Measures for the Administration of Permit for Operation of Dangerous Wastes** was formulated pursuant to the Law on the Prevention and Control of Environmental Pollution by Solid Waste. The **Measures for the Administration of Permit for Operation of Dangerous Wastes** governs business activities of collection, storage and disposal of dangerous wastes and preventing the dangerous wastes from polluting the environment, and requires an operation permit for entities to engage in activities of dangerous wastes' collection, storage and disposal within the territory of the PRC.[51] Environmental protection departments of local governments at the county and above level are responsible for issuing the permit for operating dangerous wastes and relevant supervision and administration work.[52]

Law on the Prevention and Control of Environmental Pollution by Solid Waste regulates the collection, storage, transportation and disposal of urban consumer wastes.[53] According to the Law, the entities discharging, collecting, storing, transporting, using or treating hazardous wastes are required to develop risk reduction measures and report breaches of compliance.[54] Violations of the law causing an accident of environmental pollution are subject to fines, administrative sanctions, and the closure of their operations.[55]

The WRI-Tsinghua CCS regulatory projects specifically identified the **Law on Prevention and Control of Radioactive Pollution** as a possible model for CCS regulation in China. Pursuant to the law, "radioactive pollution means the radioactive substance or rays caused by human activities on the surface of or inside the materials, human bodies, sites or environmental media, which exceed the national standards."[56] "Radioactive source means the solid radioactive material permanently sealed in the container or tightly wrapped, except for the materials in the category of nuclear fuel circulation in research reactors and

[47] Article 4, Law on the Prevention and Control of Atmospheric Pollution.
[48] Article 6, Law on the Prevention and Control of Atmospheric Pollution.
[49] Article 12, Law on the Prevention and Control of Atmospheric Pollution.
[50] Article 15, Law on the Prevention and Control of Atmospheric Pollution.
[51] Article 2, The Measures for the Administration of Permit for Operation of Dangerous Wastes.
[52] Article 4, The Measures for the Administration of Permit for Operation of Dangerous Wastes.
[53] Article 10, Law on the Prevention and Control of Environmental Pollution by Solid Wastes.
[54] Article 62, Law on the Prevention and Control of Environmental Pollution by Solid Wastes.
[55] Article 82, Law on the Prevention and Control of Environmental Pollution by Solid Wastes.
[56] Article 62, Law on Prevention and Control of Radioactive Pollution.

power reactors."[57] According to the law, the relevant department under the State Council arranges for the environmental monitoring network, and implement monitoring administration over radioactive pollution.[58] An entity operating transportation of nuclear facilities needs to submit an application to the relevant administrative department under the State Council for examination and approval before obtaining the permit for construction and operation of nuclear facilities or retiring facilities.[59] An entity producing, selling or using radioisotope or related activities must obtain a permit, and register in accordance with the relevant provisions of the State Council on prevention of radioactivity from the radioisotope and ray devices.

3.5 CO_2 Transportation

Law on the Protection of the Oil and Natural Gas Pipelines applies to the protection of pipelines transporting oil and natural gas within the territory of the PRC. Oil is defined to include crude oil and finished oil; natural gas includes natural gas, coal bed gas (煤层气) and coal based syngas (煤制气); and pipelines include pipelines and facilities associated with pipelines.[60] The energy administrative department under the State Council are responsible for the protection of pipelines throughout the country; and the energy administrative departments at the county levels and above are responsible for protection of pipelines in their respective administrative jurisdictions.[61] Regulators are required to conduct examination, maintenance, and ensure the good condition of pipelines, and adopt measures to prevent pipeline accidents from occurring.[62] The law requires an environmental impact assessment for construction of new pipelines.[63] It requires compensation to be paid to third parties if pipelines are sited on collectively-owned land or other State-owned land that is subject to third party user rights.[64] Violation of the law are subject to financial and other punishments.

3.6 Health and Safety

Workplaces are required under the **Labor Law** to establish systems to ensure labor safety.[65] For industries involving hazardous operations, employers must conduct regular physical examinations.[66] The general obligations under the Labor Law are supplemented by requirements under the **Law on Prevention and Treatment of Occupational Diseases** and the **Production Safety Law**.

Pursuant to the **Law on Prevention and Treatment of Occupational Diseases**, employers are required to take precautionary measures to protect against "occupational diseases" which is defined to include any workplace dieses that is induced by contact with dust, radioactive

[57] Article 62, Law on Prevention and Control of Radioactive Pollution.
[58] Article 10, Law on Prevention and Control of Radioactive Pollution.
[59] Article 20, Law on Prevention and Control of Radioactive Pollution.
[60] Article 3, Law on the Protection of Oil and Natural Gas Pipelines.
[61] Article 4 and 5, The Production Safety Law.
[62] Article 23, The Production Safety Law.
[63] Article 13, The Production Safety Law.
[64] Article 14, The Production Safety Law.
[65] Article 52, Labor Law.
[66] Article 52, Labor Law.

materials and other toxic or harmful substances.[67] Occupational diseases are designated by the Ministry of Health and Ministry of Labor and Social Security.[68] Precautionary measures include undertaking a feasibility study as a condition of project approval, and adoption of preventative technology.[69]

The **Production Safety Law** governs production safety of all entities that are engaged in production and business activities within the territory of the PRC.[70] Under the Law, mines and construction entities, those engaged in the production, selling and storage of hazardous substances, and those entities with 300 or more employees are required to establish an administrative organ for production safety or have full-time personnel for the administration of production safety. Entities with fewer than 300 employees are required to have full-time or part-time personnel for the administration of production safety or designate qualified technical personnel to provide services in the administration of production safety.[71] Any entity or individual is entitled to report to the department responsible for the supervision and administration of production safety about any potential accident or any violation of statutory provisions concerning production safety.[72] Governments at the county level and above are required to organize emergency rescue plans for serious production safety accidents within their respective administrative jurisdictions, and establish their own systems of emergency rescue.[73]

3.7 Power Sector Laws

The State Council department in charge of electric power is responsible for the nationwide supervision and control of electric power operations. The NDRC acts on behalf of the State Council in regulating electric power in China and approving new large electricity infrastructure. Development Reform Commissions at the county and municipal level regulate the electricity sector for smaller, local level projects. [74]

The **Electricity Law** allows for independent electricity companies to operate generation and power grids, subject to supervision and regulation.[75] Electricity system operating bodies are obligated to supply electricity to consumers pursuant to State regulation using public procedures and standards.[76] Generators enter into electricity supply and consumption contracts,[77] which contain both technical and commercial terms negotiated with the grid operator.

Power generators in consultation with the power grid operator propose specific tariffs within the NDRC's framework, which must be approved by the department in charge of commodity prices

[67] Article 2, Law on Prevention and Treatment of Occupational Diseases.
[68] Notice concerning the Catalog of Occupational Diseases, Ministry of Health and Ministry of Labor and Social Security, April 1, 2002.
[69] Articles 15 and 21, Law on Prevention and Treatment of Occupational Diseases.
[70] Article 2, The Production Safety Law.
[71] Article 19, The Production Safety Law.
[72] Article 64 and 65, The Production Safety Law.
[73] Article 68, The Production Safety Law.
[74] Article 6, Electric Power Law.
[75] Article 7, Electric Power Law.
[76] Article 26, Electric Power Law.
[77] Article 27, Electric Power Law.

with price control authority approval.[78] The State Council, acting through the NDRC, sets tariffs based on consumer type and time.[79] Electricity tariffs are reviewed and approved by the NDRC and must reflect reasonable compensation for costs, reasonable profit and taxes.[80] Power purchase agreements usually contain a capacity charge to cover fixed capital and operating costs and an energy charge to cover variable costs. In addition to these criteria, the NDRC's review and approval of electricity prices must take account of affordability.[81] Prices are typically revised annually. In relation to CCS power projects, high capital costs resulting in high costs of electricity has been specifically cited by the NDRC as a significant barrier to adoption of the technology.[82]

China possesses five main power grids, each of which serve several provinces and are organized as subsidiaries of the State Power Corporation of China. Grid operators are subject to national as well as provincial regulation for the provinces they serve. County and municipal level grids also exist, which serve local generators or act as distribution systems.

Electric power enterprises that violate or otherwise fail to provide the specified quality of electricity to be supplied are liable under electricity supply and consumption contracts.[83] This liability extends to coverage of losses suffered by consumers, subject to exceptions for certain circumstances or fault by the consumer.[84]

Pursuant to the Electric Power Law, electric power constitution, power generation, electricity supply and consumption must safeguard the environment. New technologies must be adopted to reduce the emission of "harmful substances and prevent pollution."[85] The State encourages and supports the generation of power using renewable energy resources and clean energy, however this provision has not been interpreted to mean that CO_2 reductions are compulsory for the power industry.

3.8 Oil, Gas and Mining Laws

The **Mineral Resources Law** regulates "exploring and mining mineral resources within the territory of the PRC and the marine areas under its jurisdiction."[86] The Mineral Resources Law governs petroleum and mining operations. The State Council is responsible for supervision and administration of the exploration and mining of the mineral resources throughout the country, supported by provincial or local government.[87] According to the Law, mineral resources belong to the State, "the rights of State ownership in mineral resources is exercised by the State Council," and State ownership of mineral

[78] Article 38, Electric Power Law. See also Articles 39-41.
[79] Article 41, Electric Power Law.
[80] Article 36, Electric Power Law.
[81] Article 21, Price Law.
[82] See C. Hart and H. Liu, Advancing Carbon Capture and Sequestration in China: A Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).
[83] Article 59, Electric Power Law.
[84] Article 60, Electric Power Law.
[85] Article 5, Electric Power Law of the People's Republic of China, adopted 28 December 1995 by the Seventeenth Session of the Standing Committee of the Eighth National People's Congress, promulgated 28 December 1995.
[86] Article 2, Mineral Resources Law.
[87] Article 11, Mineral Resources Law.

resources, "either near the earth's surface or underground, will not change with the alteration of ownership or right to the use of the land which the mineral resources are attached to." Under the Law, approval for the right of exploration or mining mineral resources is required,[88] and the exploration and mining rights require compensation to be paid to the State. However, the State may, in light of specific conditions, prescribe reduction of or exemption from the compensation for acquiring the exploration and mining right.[89] The State Council formulates specific measures and implementation procedures. The Law lists areas and places where exploration and mining of mineral resources is prohibited.[90]

Oil and gas operations in China are dominated by the **China National Petroleum Company** (CNPC), its subsidiary **PetroChina**, and **Sinopec**, which are the largest petroleum exploration and production companies on the mainland. **China National Offshore Oil Corporation** operates offshore and foreign oil and gas operations. A number of smaller companies also operate in China. As noted above, CNPC and Sinopec are conducting research in enhanced oil recovery on the mainland, would likely be responsible for the sequestration phase of any CCS project in mainland China, and could become major consumers of CO_2.

Upstream oil and gas operations are regulated by several government agencies.

National Energy Administration, created in 2008 under the NDRC, awards blocks, approves block development plans and budgets, and appoints the top management of China's major oil companies.

Ministry of Land and Natural Resources reviews applications for blocks by foreign investors.

Ministry of Commerce reviews and must approve foreign investment.

Ministry of Environmental Protection regulates environmental aspects of oil and gas operations.

State Maritime Commission regulates maritime safety and environmental pollution.

State Energy Committee formulates State energy development strategies.

The State Administration of Work Safety regulates workplace safety, together with the **China Offshore Oil Operations Safety Office**, which regulates offshore petroleum operations safety.

In addition to these agencies, the **NDRC** possesses authority over the overall direction of the economy and its Energy Bureau remains a key policy body for energy security and development issues.

[88] Article 3, Mineral Resources Law.
[89] Article 5, Mineral Resources Law.
[90] Article 20, Mineral Resources Law.

Foreign investment in China's oil and gas sector is permitted, however foreign companies must partner with one of the major petroleum companies.[91] The foreign oil company would enter into a production sharing contract (PSC) for a particular block with one of the major Chinese petroleum companies, usually after a competitive tender process and approval by the Ministry of Commerce. PSCs are for a limited duration, usually about 7 years, and may be renewed if provided for in the contract. Under a PSC, the foreign operator never takes title to the land or the petroleum resources. The PSC requires the operator to invest specified amounts in developing the block. The parties typically split production in a negotiated proportion after the operator receives a share of production adequate to recover taxes, costs for appraisal and development costs, and operating costs. Typically, all physical infrastructure built by the operator and data would belong to the State-owned oil company. The PSC would also specify environmental care and closure requirements.

As noted above, natural and mineral resources, waterway and maritime water belong to the State pursuant to the Property Rights Law.[92] The Law of the People's Republic of China on the Exclusive Economic Zone and the Continental Shelf reserves all rights to explore, exploit, conserve or manage natural resources in the exclusive economic zone and continental shelf to the State.[93] The exclusive economic zone extends 200 nautical miles from the baseline used for calculating the width of the territorial sea.

3.9 Public Participation

The **Law of the People's Republic of China on the Environmental Impact Assessment** calls for public participation in "appropriate ways."[94] It requires projects that could have an adverse environmental impact to seek the opinion of the public. Construction projects that could have a significant impact on the environment are required to explain how they addressed comments from the public; other projects are required to note whether the opinions were accepted. Consulting public opinion may take the form of "meetings, hearings or any other means". Public hearing requirements and disclosure are subject to confidentiality provisions.[95]

According to the **Law on the Prevention and Control of Water Pollution**, "all entities and individuals have the obligation to protect water environment, and have the right to report to authorities acts polluting or damaging water environment."[96] Similarly, in the **Law on the Prevention and Control of Atmospheric Pollution,** "all units and individuals shall have the obligation to protect the atmospheric environment and shall have the right to report on or file charges against units or individuals that cause pollution to the atmospheric environment."[97].

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[91] Article 13, Regulations of the People's Republic of China on Sino-Foreign Cooperation in the Exploitation of Continental Petroleum Resources. See also, Article 7, Regulations of the People's Republic of China on Offshore Petroleum Resources in Cooperation with Foreign Parties.
[92] Articles 46 and 48, Property Rights Law.
[93] Article 3, Law of the People's Republic of China on the Exclusive Economic Zone and the Continental Shelf.
[94] Article 5, Law of the People's Republic of China on the Environmental Impact Assessment.
[95] Articles 11 and 21, Law of the People's Republic of China on the Environmental Impact Assessment.
[96] Article 10, Law on the Prevention and Control of Water Pollution.
[97] Article 5, Law on the Prevention and Control of Atmospheric Pollution.

Under the **Production Safety Law,** news, publishing, broadcasting, movie and television agencies are obligated to publicize and educate the public on production safety.[98]

3.10 Foreign Investment

According to the Catalogue of Industries for Guiding Foreign Investment 2011, China encourages foreign investment in such areas as the construction and operation of IGCC, clean coal, hydropower, and new energy power generation facilities; energy-saving technology development; renewable energy technology; and environmental pollution treatment technology. China limits foreign investment in the construction and operation of petroleum refineries of a certain size; the construction and operation of coal-fired thermal power generation of a certain size and in certain provinces; and the construction and operation of power grids, subject to Chinese investors retaining controlling shares.[99]

The 12th Five-Year Plan encourages the introduction of foreign investment into the areas of hi-tech technology, energy-saving and environmental protection and new energy, and encourages foreign investment to participate mergers and reorganization of domestic enterprises through stock-sharing and M&A, and thus promote the development of foreign equity investment and foreign venture investment. The Plan also encourages foreign enterprises to set up R&D center, and encourages the protection of foreign investors' legal rights.[100]

It is not clear whether technology transfer is a requirement for establishing a joint venture. However, the government has been encouraging the introduction and importation of advanced technologies. China has been "encouraging technological achievements of research and development [R&D] center to be industrialized in China; encouraging technology transfer from foreign-invested enterprises to state-owned enterprises and private enterprises."[101] In addition, pursuant to law, the Ministry of Finance and State Administration of Taxation grant income reductions or exemptions from taxes for income obtained through technology transfer from foreign enterprises.[102]

State Administration of Foreign Exchange must approve foreign investment in China.

[98] Article 67, The Production Safety Law.
[99] Catalogue for the Encouragement of Foreign Investment Industries.
[100] Chapter 52, The Outline of the 12th Five-Year Plan for Economic and Social Development of the PRC.
[101] Several Opinions Regarding Encouraging Technology Introduction and Innovation; Promoting Transformation of Foreign Trade Growth, Ministry of Commerce, NDRC, MOST, MOF, General Administration of Customs, State Administration of Taxation, State Intellectual Property Office, and State Administration of Foreign Change, Oct. 2006.
[102] Several Opinions Regarding Encouraging Technology Introduction and Innovation; Promoting Transformation of Foreign Trade Growth, Ministry of Commerce, NDRC, MOST, MOF, General Administration of Customs, State Administration of Taxation, State Intellectual Property Office, and State Administration of Foreign Change, Oct. 2006

3.11 Financial Incentives

Currently China has no laws that grant tax or other incentives specifically to CCS technology or projects.

China has, however, aggressively funded R&D in other areas closely related to CCS, which have promoted CCS projects. Two leading examples are China's 863 Program and 973 Program. The Chinese government's 863 Program advances a wide range of strategic technologies with the goal of making China technologically independent. MOST, which administers the 863 Program, has mandated and partially funded the development and construction of two IGCC coal-to-liquids plants, three IGCC demonstration power plants, and one gas turbine demonstration project for use with IGCC. MOST is providing up to 350 million Yuan in seed funding for these projects. None of the plants will sequester carbon dioxide upon completion; sequestration would require further modifications to these plants and development of transportation and sequestration infrastructure. However, these projects are an important step in developing the capture component of CCS in China.[103]

China's 973 Program conducts basic research on the geological, physical and chemical aspects of geologic carbon sequestration and EOR, non-linear flow mechanics problems of EOR and carbon capture and anti-corrosion problems. Funding for the research program is 35 million Yuan. The program's objectives are to enhance oil recovery ratios through the use of CO_2, increase profitability of oil operations and mitigate CO_2 emissions. [104]

In addition to these programs, the Chinese government supports a wide range of CCS-related research and has given grants to specific companies such as Shenhua Group.[105]

Further, as noted above, the Ministry of Finance and State Administration of Taxation grant income reductions or exemptions from taxes for income obtained through technology transfer from foreign enterprises.[106]

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[103] Hart and Liu, Advancing Carbon Capture and Sequestration in China: a Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).
[104] Hart and Liu, Advancing Carbon Capture and Sequestration in China: a Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).
[105] For further discussion of government-supported research, see Hart and Liu, Advancing Carbon Capture and Sequestration in China: a Global Learning Laboratory, China Environment Series, Woodrow Wilson Center for Scholars (2010).
[106] Several Opinions Regarding Encouraging Technology Introduction and Innovation; Promoting Transformation of Foreign Trade Growth, Ministry of Commerce, NDRC, MOST, MOF, General Administration of Customs, State Administration of Taxation, State Intellectual Property Office, and State Administration of Foreign Change, Oct. 2006

REPUBLIC OF KOREA REGULATORY ASSESSMENT

1. POLITICAL AND LEGAL SYSTEM

The government of the Republic of Korea (hereafter "Korea") is comprised of three branches: the executive, the legislature, and the judiciary.

The executive branch headed by the President who is the head of state and commander in chief of the armed forces, and is solely responsible for deciding all important government policies. The President is elected by popular vote for a single term of five years. The Prime Minister is appointed by the President with the approval of the National Assembly. The President performs executive functions through the Cabinet made up of 15 to 30 members. Under the President, 15 executive ministries and 16 independent agencies, including the Jeju-Special Self-Governing Province, formulate and carry out national policies.[1] The President appoints the heads of ministries and agencies.

Korea's National Assembly is the nation's legislative body. It is unicameral and has 273 members elected to four-year terms. Pursuant to the Constitution, the National Assembly's powers include making the nation's laws, approving the national budget, and declaring war.[2]

The judicial branch is composed of the Supreme Court, appellate courts, local courts, and the Constitutional Court. It is an independent branch.[3]

Korea has nine provinces (Kangwon, Kynggi, North Ch'ungch'ng, South Ch'ungch'ng, North Cholla, South Cholla, North Kyngsang, South Kyngsang, and Cheju) and seven separately administered cities (Seoul, Busan, Incheon, Daegu, Gwangju, Daejeon, Ulsan).[4]

Provincial and local government is divided into 16 provincial-level governments and 235 municipal governments (72 city governments, 94 county governments, and 69 district governments). Although elected independently, the primary function of provincial and local governments is to implement policies and programs created and directed by central government ministries.[5]

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[1] Korea.net Gateway to Korea, available at www.korea.net, accessed on Aug. 29, 2011.
[2] South Korea Government and Politics, available at www.mongabay.com/reference/country-profiles/2004-2005/2-South_Korea.html, accessed on Aug. 30, 2011.
[3] South Korea Government and Politics, available at www.mongabay.com/reference/country-profiles/2004-2005/2-South_Korea.html, accessed on Aug. 30, 2011.
[4] U.S. Department of State website, available at www.state.gov/r/pa/ei/bgn/2800.htm, accessed on Aug. 30, 2011.
[5] South Korea Government and Politics, available at www.mongabay.com/reference/country-profiles/2004-2005/2-South_Korea.html, accessed on Aug. 30, 2011.

Certain government ministries would play a major role in the development of CCS regulation and the approval of a CCS project in Korea. Key government ministries and agencies include:

Ministry of Knowledge Economy (MKE) is an amalgamation of the former Ministries of Commerce, Industry and Energy; Information and Communication; and Science and Technology. It is tasked with creating a more business-friendly environment and promoting new areas of growth by supporting information and communications technologies and high-end manufacturing; foreign trade; foreign direct Investment, efficient markets. In addition, MKE engages in energy cooperation projects, expands renewable resources and distribution networks, and develops environmentally-friendly economic policies.[6]

Ministry of Environment (ME) has the authority to establish and implement its own policies. Its tasks include enactment and amendment of environmental laws and regulations; introduction of environmental institutions; drafting and implementation of mid-long term comprehensive measures for environmental conservation; setting standards for regulations; providing administrative and financial support for environmental management to local governments; inter-Korean environmental cooperation; and environmental cooperation with other countries.[7] The Commission on Sustainable Development, which was originally established in September 2000 as a Presidential consultative body, is now part of the Ministry of Environment.[8]

Ministry of Strategy and Finance (MOSF), the result of consolidating the Ministry of Finance and Economy and the Ministry of Planning and Budget in 2008, is responsible for planning and establishing mid-to-long-term national development strategies; formulating and coordinating economic and fiscal policies; planning, executing and managing budgets and public funds and monitoring and reviewing expenditures; developing and administering policies in regard to taxes, tariffs, the national treasury, government accounting, lottery, and pubic fund management; overseeing public organizations, evaluating their performances, and promoting management innovation; and others on international cooperation in finance and economic development.[9]

Ministry of Education, Science & Technology (MEST) is tasked with promoting private sector led innovation and improving the efficiency of national R&D investments. To realize these goals by 2025, the government launched the 21st Century Frontier R&D Program and enacted the Science and Technology Framework Law enacted in 1999. Pursuant to this law, the government formulated the Five-year Science and Technology Plan and National Technology Road Map. The government also developed a Five-year Comprehensive Regional Science and Technology Promotion Plan. One of the two Vice Ministers is responsible for R&D projects and policy and international cooperation.[10]

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[66] Ministry of Knowledge Economy, available at www.mke.go.kr, accessed on Aug. 30, 2011.
[7] Ministry of Environment, available at www.eng.me.go.kr, accessed on Aug. 30, 2011.
[8] Ministry of Environment, at www.eng.me.go.kr, accessed on Aug. 31, 2011.
[9] Ministry of Strategy and Finance, available at www.english.mosf.go.kr, accessed on Aug. 30, 2011; and epicos.com Business Directory at www.epicos.com, accessed on Aug. 30, 2011.
[10] Ministry of Education, Science and Technology, available at www.eng.mest.go.kr, accessed on Aug. 30, 2011.

Ministry of Land, Transport and Maritime Affairs (MLTM) is responsible for regulating land use, transportation and maritime affairs. One of the two Vice Ministers is responsible for land, water and construction including policy planning for land and water resources as well as technology and safety policy.[11]

Korea Institute of Energy Technology Evaluation and Planning (KETEP), created pursuant to the Energy Act, plans, evaluates and manages energy technology development-related projects and fosters cooperation in the development of energy technology.[12]

Korea Institute of Environmental Industry and Technology, created pursuant to the Development of and Support for Environmental Technology Act, supports the development of environmental technology.

Presidential Committee on Green Growth was launched in February 2009 to carry out tasks implementing the national vision for "low carbon, green growth". The Prime Minister and a person nominated by the President serves as co-Chairs of the Committee.[13] Major functions of the Committee include deliberating the national basic strategies and implementation plans as well as reviewing laws and administrative plans for sustainable development.[14]

National Science and Technology Council (NSTC) is the nation's highest decision-making body for S&T policy and is chaired by the President of ROK. NSTC is responsible for planning and coordinating major R&D programs, budgets and policies for promoting S&T across agencies.

Presidential Advisory Council on Science & Technology (PCAST) is composed of thirty members representing prominent industries, academia and research institutes. The President appoints members for a one-year term.

New and Renewable Energy Policy Council under the Ministry of Knowledge Economy deliberates on technological development for new and renewable energy, including energy from fossil fuels that utilize new technologies, and the price of electricity from new and renewable energy sources.[15]

KEPCO, the state power company, has launched two of four planned national CCS RD&D projects and is expected to lead the other two projects. The **Korea National Oil Company (KNOC)** together with the **Korea Institute of Geoscience and Mineral Resources** and the **Ministry of Land, Transportation and Maritime Affairs** are undertaking geologic assessment of potential sequestration sites. The **Korea CCS Association** was formed pursuant to the Master CCS Plan in order to support CCS technology RD&D, assist in the development of regulations and enhance knowledge sharing. KCCSA's President is the President of KEPCO and its members include KEPCO subsidiaries, several major Korean engineering companies, KNOC, and over two-dozen research institutes and universities.

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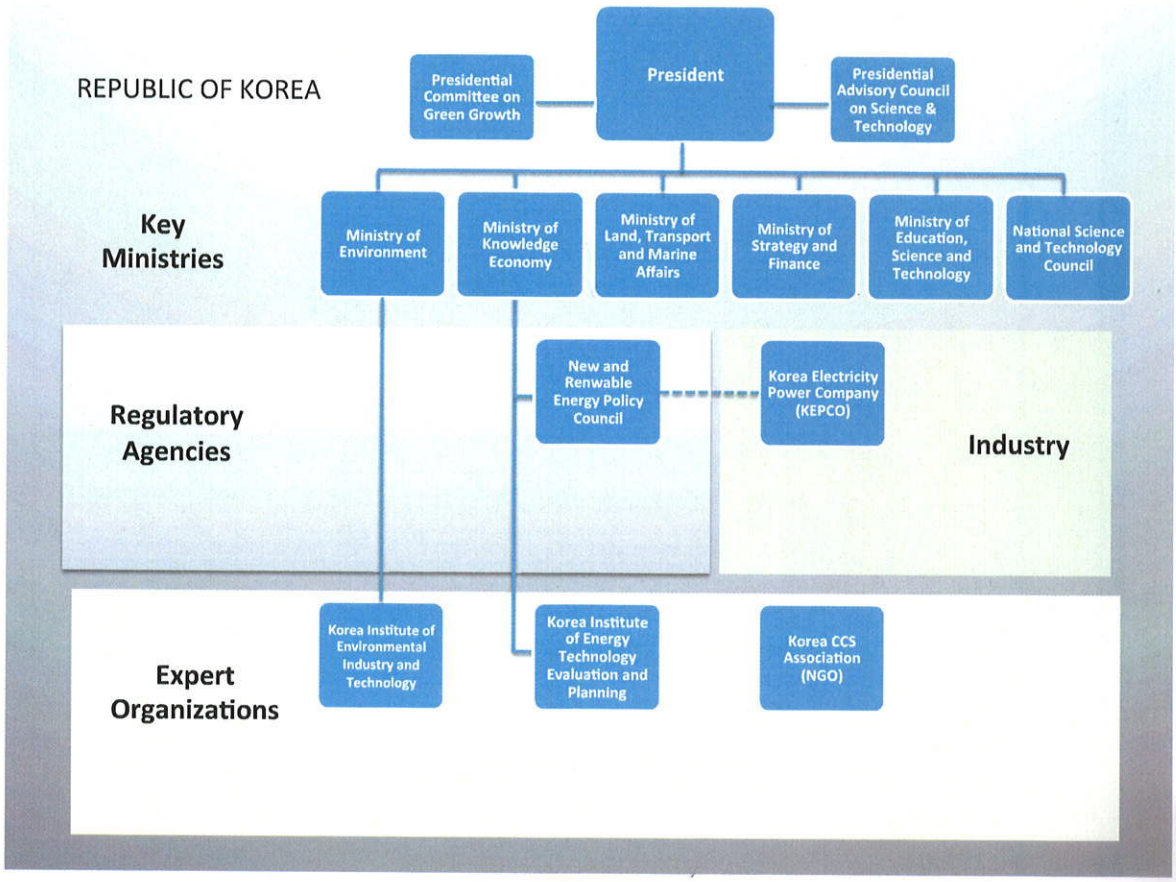
[11] Ministry of Land, Transportation and Maritime Affairs, at www.english.mltm.go.kr, accessed on Aug. 31, 2011.
[12] Article 13, Energy Act.
[13] Article 14, Framework Act on Low Carbon, Green Growth.
[14] Article 15, Framework Act on Low Carbon, Green Growth.
[15] Article 8, Act on Promotion of the Development, Use and Diffusion of New and Renewable Energy.

The diagram below shows selected central government entities and stakeholders that would be involved in regulating or undertaking a CCS project. Regional or local government entities are not shown on the diagram.



2. CLIMATE CHANGE LAW AND POLICY

Korea is an Annex II country under the UNFCCC, and is party to the Kyoto Protocol.

Korea has been actively initiating aggressive climate policies to reduce GHG remissions such as promoting waste to energy and smart grid technologies, carbon taxes and cap and trade.[16] Korea has been also actively participating in GHG mitigation activities through the Clean Development Mechanism (CDM).

[16] "Fact Sheet: South Korea Climate Change Policies," *Climate Connect,* available at www.climate-connect.co.uk, Feb. 2011.

In August 2008, the government announced its "Low Carbon, Green Growth" plan, a broad-based mandate for green growth initiatives. Under the plan, the government supports expanding the use of solar and wind energy, smart grid, and carbon capture and storage technologies.[17] "Low Carbon, Green Growth (LCGG)" is viewed as the core of the nation's new vision. It sets out 17 new national growth engines divided into three categories: green technology industries, state-of-the-art fusion industries, and high value-added industries. The Presidential Committee on Green Growth was created in February 2009 to carry out tasks implementing the national vision. The government plans to invest KRW 6.3 trillion (US$5.88 billion) in the 17 growth engines over the next four years.[18]

The Framework Act on Low Carbon, Green Growth, enacted in February 2010, sets a national target to reduce greenhouse gas emissions by 30 percent of business-as-usual projection by 2020.[19] Under the Act a national strategy for LCGG is to be established and the Greenhouse Gas Information Center was created under the Minister of Environment to establish and manage the national integrated information management system for GHGs. "Controlled entities" defined by Presidential Decree are required to periodically report their greenhouse gas emissions.[20] The national strategy includes matters concerning the realization of the green economic system, green technology, and green industries; policies on climate change, energy, and sustainable development; and international negotiation and cooperation in relation to LCGG. According to the Act, a basic plan will be established and implemented every five years within a 20-year planning framework for climate change and energy. As described further below, the first 5-year strategy includes CCS as one of the 27 core technologies that must be promoted for green growth.[21]

As noted above, a bill is pending in the National Assembly proposing an Emissions Trading Scheme (ETS), which would launch starting 2015 under the bill. It is one of the means by which Korea aims to reduce GHG emission by 30 percent from projected levels by 2020. Although the national target is voluntary, the government would impose regulations under the ETS to force major emitters to comply.[22] Stakeholders noted that industry and government are currently discussing the appropriateness and details of the proposed ETS, with the launch date being one of the critical issues.[23]

Korea adopted a **CCS Master Plan** in July 2010, which identifies priorities for CCS research and goals for capture technologies, creates a timetable for the development of at least two CCS

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[17] "Climate Change Comes to South Korea," Steven Borowiec, *asiasentinel,* available at www.asiasentinel.com/index.php?option=com_content&task=view&id=3371&Itemid=395, Aug. 8, 2011.
[18] Office of the President at www.english.president.go.kr/government/greenpolicy/greenpolicy.php, accessed on Aug. 30, 2011.
[19] Framework Act on Low Carbon, Green Growth, *Ministry of Government Legislation,* Jan. 2010.
[20] Articles 42 and 45, Framework Act on Low Carbon, Green Growth.
[21] Hee Yong Thomas Kim, Green Technology Policy of Korea, PowerPoint Presentation, December 2009, Korea Institute S&T Evaluation and Planning.
[22] "Fact Sheet: South Korea Climate Change Policies," *Climate Connect,* available at www.climate-connect.co.uk, Feb. 2011.
[23] Stakeholder Consultations, September 26, 2011.

RD&D projects, calls a geologic assessment of potential geologic sequestration sites, and requires the development of regulation by 2014.

As further described below, **Marine Environment Management Act** specifically allows offshore storage of CO_2 and provides regulations for its purity and the recovery of costs associated with sequestration.[24]

3. LAWS AND REGULATION APPLICABLE TO CCS

Korea has adopted a Master CCS Plan that calls for the development of CCS regulations by 2014. The Ministry of Land, Transport and Maritime Affairs has issued a ministerial order permitting CO2 sequestration offshore subject to the development of standards and other requirements. In addition, existing laws and regulations could be applied to CCS-related projects or inform the CCS regulations that will be developed pursuant to the Master CCS Plan.

3.1 Classification of CO_2

The Korean government has not specifically identified CO_2 as a waste or pollutant. However, several Korean laws require the reduction of greenhouse gases in accordance with national policy and Korea's environmental laws and regulations contain definitions of "waste", "pollutant" or similar concepts that could potentially apply to CO_2.

The **Framework Act on Environmental Policy** defines "environmental pollution" as air pollution, water pollution, soil pollution, sea pollution, radioactive contamination, noise, vibrations, malodor, sunshine interception, etc., which are caused by industrial activities and other human activities, and which inflict damage on human health or the environment.[25]

The **Wastes Control Act** defines "waste" as "such materials as garbage, burnt refuse, sludge, waste oil, waste acid, waste alkali, and carcasses of animals, which have become no longer useful for human life or business activities." It defines "commercial wastes" as "any wastes generated from places of business with discharging facilities installed and managed in accordance with the Clean Air Conservation Act, the Water Quality and Ecosystem Conservation Act, or the Noise and Vibration Control Act or any other place of business specified by Presidential Decree." Under the Act, "control wastes" are defined as "the commercial wastes specifically enumerated by Presidential Decree as harmful substances such waste oil and waste acid, which may contaminate environs."[26] This Act does not apply to "gaseous substance not contained in a container." According to the Act, a license is required from the Mayor/Governor for collecting, transporting, and disposing waste and from the Minister of Environment to engage in a waste management business for handling controlled wastes.[27] Under the Act, the Minister of Environment may determine and publicly notify the prices for disposal of commercial wastes.[28]

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[24] Articles 12(3) and 23, Marine Environment Management Act Enforcement Rules, April 11, 2011.
[25] Article 3, Framework Act on Environmental Policy, *Ministry of Environment*, last revised in Mar. 2008.
[26] Article 2, Wastes Control Act, *Ministry of Environment,* Dec. 1986 and wholly amended in 2007.
[27] Article 25, Wastes Control Act.
[28] Article 24, Wastes Control Act.

Water Quality and Ecosystem Conservation Act defines the term "water-quality pollutants" as substances that "pollute water quality and that are specified by the Ministry of Environment."[29]

For sequestration conducted below the sea floor or CO_2 transported by ship or ocean pipeline, the **Marine Environment Management Act** defines the term "pollutant" to mean "waste, oil, noxious liquid substances or harmful substances in package form which adversely affect or are feared to adversely affect the marine environment when flowing or discharged into the sea."[30] A ministerial order issued pursuant to the Marine Environment Management Act provides for the Ministry of Land, Transport and Maritime Affairs to develop standards for geologic sequestration in marine environments and to impose charges or recover costs for the source of CO_2.[31] A supplementary order requires verification of the purity of CO_2 generated on land and could require treatment as a waste for purposes of storage in offshore geologic sequestration.[32]

The **Clean Air Conservation Act** contains a definition of "greenhouse gases" which is distinct from the definition of "air pollutants," the latter being defined as "gas or granular matter causing air pollution, determined by Ordinance of the Ministry of Environment."[33] Greenhouse gases are defined as "gaseous matter in the air, which induces the greenhouse effect by absorbing or re-emitting infrared heat radiation, including carbon dioxide, methane, nitrous oxide, hydrofluorocarbon, perfluorocarbon, and sulfur hexafluoride."[34] Greenhouse gases are not currently considered "air pollutants" under the Clean Air Conservation Act.

3.2 Surface Rights and Subsurface Rights

Article 23 of the Constitution guarantees rights of property, which shall be determined by statute. Korean law allows for fee simple ownership of land, including the subsurface as well as mineral or other resources contained in the subsurface. Pursuant to the Civil Act, "An owner has the right, within the scope of law, to use, take the profits of, and dispose of, the article owned."[35] The Civil Act further states, "Within the scope, where a justifiable profit exists, the ownership of land extends both above and below its surface."[36]

Notwithstanding Korea's private property system, land use in Korea for a CCS project would likely be subject to land use planning standards and policies at the national, provincial and Local levels. According to the **Framework Act on Environmental Policy**, the Government may develop environment-friendly planning requirements and standards for the utilization and development of land; and the Minister of Environment may draw and disseminate an environmental nature assessment map that indicates the current environmental state by grade

[29] Article 2, Water Quality and Ecosystem Conservation Act.
[30] Article 2, Marine Environment Management Act.
[31] Articles 12(3) and 23, Marine Environment Management Act Enforcement Rules, April 11, 2011.
[32] Schedule 6 to Marine Environment Management Act Ministerial Order, September 6, 2010.
[33] Article 2, Clean Air Conservation Act.
[34] Article 2, Clean Air Conservation Act.
[35] Article 211, Civil Act.
[36] Article 212, Civil Act.

after assessing the environmental value of the national land.[37] Under the Act, the Minister of Environment may restrict the utilization of land and the installation of facilities.[38]

Further, the **Framework Act on the National Land** provides for national, provincial and local governments to develop comprehensive land use plans to ensure the environmentally friendly development of national land in order to preserve the balance between industry, living areas and ecosystems.[39] Land planning is to be carried out in accordance with standards developed by the Ministry of Land, Transport and Maritime Affairs.[40]

The Ministry of Land, Transport and Maritime Affairs, however, possess authority to streamline the permitting process for qualifying industrial complexes.[41] Approval of an industrial complex generally requires public consultation, however the designation as an industrial complex could exempt the facility from this requirement.[42] The designation "industrial complex" appears to be broad in scope and could potentially include a CCS demonstration project.[43] Land used for an industrial complex is, however, subject to restrictions on lease period and disposition.[44]

3.3 Long-Term Stewardship and Liability for Stored CO_2

The **Constitution** provides all citizens with a right to a "healthy and agreeable environment."[45]

Framework Act on Environmental Policy states that any person causing environmental pollution or environmental damage due to his or her acts or business activities are in principle liable for the prevention, recovery and restoration of such pollution or damages, and for bearing the expenses for the relief of suffering from environmental pollution or environmental damages.[46] According to the Act, if any suffering is caused by environmental pollution or damage generated from a business place, the enterprise must indemnify injured parties. The Act provides for joint and several liability if more than one enterprise contributed to environmental damage and the extent of respective damages cannot be proven.[47]

The **Civil Act** imposes civil liability on corporations and other juristic persons that cause damage to third parties. According to the Civil Act, "A juristic person shall be liable for any damages done to other persons by its directors or other representatives in the performance of their duties."[48] Where the act of a corporation or other juristic person is ultra-vires, the

[37] Article 15-2, Framework Act on Environmental Policy.
[38] Article 22, Framework Act on Environmental Policy.
[39] Article 5, Framework Act on National Land.
[40] Article 6, Framework Act on National Land.
[41] See Act on Special Cases Concerning the Simplification of Authorization and Permission Procedures for Industrial Complexes.
[42] Articles 9-12, Enforcement Decree of the Industrial Sites and Development Act.
[43] See Articles 5-6, Enforcement Decree of the Industrial Cluster Development and Factory Establishment Act.
[44] See, e.g., Articles 27 and 38, Industrial Sites and Development Act; and Article 48-4, Enforcement Decree of the Industrial Cluster Development and Factory Establishment Act.
[45] Article 35, Constitution of the Republic of Korea. See also Articles 6(g) and 7, Industrial Sites and Development Act, and Enforcement Decree of the Industrial Sites and Development Act.
[46] Article 7, Framework Act on Environmental Policy, *Ministry of Environment,* Aug. 1990 and last revised in Mar. 2008.
[47] Article 31, Framework Act on Environmental Policy.
[48] Article 35(1), Civil Act.

members, directors, and other representatives who have supported a resolution for such ultra-vires act, or have carried it out, shall be joint and severally liable for the damages caused.[49]

Wastes Control Act contains provisions for landfill operations that could inform regulations for CCS or even be extended to apply to CCS. Under the Wastes Control Act, the Minister of Environment may require the person having installed a landfill facility for wastes that requires remediation to deposit the full or partial amount of funds necessary remediate the site. This may take the form of a performance guarantee bond. The Wastes Control Act also provides general liability for disposal of wastes in a landfill facility that may result in serious hazard to the health or property of residents or surrounding environment due to seepage of water, etc. after the discontinuation of its operation or closedown of the facility.[50]

In addition, the relevant Mayor/Do governor may order a waste recycling business to be suspended and impose a penalty surcharge of not more than 50 million won, in lieu of the suspension of such recycling business, as prescribed by Presidential Decree in situations where hazards occurs or anticipated to occur to the health of residents.[51]

As described further below, sequestration conducted below the sea floor or CO_2 transported by ship or ocean pipeline would be subject to the **Marine Environment Management Act**, which contains a "Polluter Pays" liability provision that requires polluters to restore the marine environment at their expense.[52]

Act on Special Measures for the Control of Environmental Offenses subjects operators to criminal penalties for unlawfully discharging pollutants pursuant to Korea's various laws governing the environment, including injecting pollutants that endanger water sources or otherwise in violation of the Wastes Control Act.[53]

Korea's **Nuclear Damage Compensation Act** provides a potential model for sharing liability for CCS projects. The Act provides for indemnification to injured parties from nuclear accident, while requiring operators of nuclear facilities to obtain insurance and limits their liability within a specified amount provided the operator has not acted or failed to act in a willful or reckless manner.[54] The **Compensation for Oil Pollution Damage Guarantee Act** limits the liability of vessel operators to specific amounts resulting from oil spills provided the operator has not acted willfully or recklessly in causing pollution.[55]

3.4 Environmental Protection

Framework Act on Environmental Policy governs environmental preservation and prevention of environmental harms. Under the Act, the Minister of Environment is required to develop the comprehensive national environmental plan to preserve the environment every ten years, and a mid-term comprehensive plan every five years. Provincial and city governors are responsible for drawing up and implementing the environmental preservation plan for their political

[49] Article 34(2), Civil Act.
[50] Article 51, Wastes Control Act.
[51] Article 46-2, Wastes Control Act.
[52] Article 7, Marine Environment Management Act.
[53] Article 3, Act on Special Measures for the Control of Environmental Offenses.
[54] Article 3-2, Nuclear Damage Compensation Act.
[55] See Article 8, Compensation for Oil Pollution Damage Guarantee Act.

subdivision according to the comprehensive national environmental plan and mid-term plans, as are the heads of Si/Gun/Gu at lower levels.[56]

According to the Act, provincial and local governments and business operators should make every effort to minimize harmful environmental impacts arising from their administrative plans and development projects.[57] The national government is required to establish environmental standards and revise such standards according to any changes in environmental conditions; and the special metropolitan city, metropolitan city or Do are to set local environmental standards appropriate to their area.[58] The Act requires the government to regulate the discharge of substances causing the pollution of air, water, soil or sea, the generation of malodor, the treatment of wastes, and damage to the natural environment.[59]

The Act requires the heads of administrative agencies to conduct assessments of environmental conditions prior to certain categories of projects being approved with the goal of enabling the implementation of administrative plans and development projects in an environmentally sustainable manner.[60] The business operator of a project subject to the prior examination requirement may not carry out construction for a project before the procedures for conducting consultation with government officials and the public.[61]

Wastes Control Act regulates the disposal of household wastes, commercial wastes, and controlled wastes. The Act does not contain provisions governing underground injection of substances. However, some of the Act's provisions could inform regulations of a CCS project. According to the Act, a license is required from the Mayor/Governor of a political subdivision for collecting, transporting, and disposing waste and from the Minister of Environment to engage in a waste management business for handling specifically-enumerated controlled wastes.[62] The Minister of Environment may also determine and publicly notify the prices for disposal of commercial wastes.[63] With respect to commercial waste, the Act requires measures to reduce the volume of waste and imposes reporting requirements.[64] A person who discharges, transports or disposes of any commercial wastes specified by the Ministry of Environment is subject to reporting requirements.[65]

The Act establishes a waste management business operators associations and allows operators to establish a mutual aid association for the waste management businesses to guarantee their compliance with applicable law.[66]

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[56] Article 12, 14-2, 14-3, and 14-4, Framework Act on Environmental Policy, *Ministry of Environment,* last revised in Mar. 2008.
[57] Article 7-2, Framework Act on Environmental Policy.
[58] Article 10, Framework Act of Environmental Policy.
[59] Article 19, Framework Act of Environmental Policy.
[60] Article 25, Framework Act on Environmental Policy.
[61] Article 27, Framework Act on Environmental Policy.
[62] Article 25, Wastes Control Act.
[63] Article 24, Wastes Control Act.
[64] Article 17, Wastes Control Act.
[65] Article 25, Wastes Control Act.
[66] Article 41 and 43, Wastes Control Act.

Environmental Impact Assessment Act requires an assessment of environmental impacts to be conducted to ensure no damage made to the environment when carrying out and executing operations or plans, particularly on contents regarding discharge density of pollutants. Under the Act, projects subject to the assessment of environmental impacts include energy development projects, wastes disposal facility installation projects, and others.

Development of & Support for Environmental Technology Act contributes to environmental conservation and the sustainable development of the national economy by promoting the development, support, and spread of environmental technologies and by fostering the environmental industry.[67]

Water Quality and Ecosystem Conservation Act governs water pollution and the quality of public waters. In the Act, the term "water-quality pollutants" is defined as substances that pollute water quality and that are specified by the Ministry of Environment.[68] According to the Act, state and local governments are subject to take policy steps to prevent and control the instances of contamination of water and aquatic ecosystems, and manage and preserve public waters. Under the Act, the Minister of Environment has the authority to determine certain measures to regulate water pollutant-related matters. The Minister of Environment or the head of local government in charge of quantity regulation of pollutants may impose and collect charges from any person who has discharged in excess of the allotted loading quantity for contamination; and the heads of relevant administrative agencies are prohibited from granting approval and permission to any local government that exceeds the loading quantity for contaminants.[69] The Act prohibits anyone from engaging releasing or dumping substances including specific substances and other designated substances harmful to water quality.

Groundwater Act protects potential sources of drinking water. The Groundwater Act provides the designation of groundwater preservations zones, and prohibits the discharge of substances into those zones without permission of government authorities.[70] The Groundwater Act requires public consultation as part of the process of designating groundwater preservation zones or modifying their status.[71] Activities in these zones is subject to a requirement to restore areas to their original state, and performance bond requirements. [72]

Management of Drinking Water Act governs businesses that sell or process water and provides for the issuance of licenses for springs. While the Act protects natural sources of drinking water in relation to businesses that exploit water resources, it does not contain provisions for protection of groundwater from non-water businesses.

Sequestration conducted below the sea floor or CO_2 transported by ship or ocean pipeline would be subject to the **Marine Environment Management Act**, which is administered by the

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[67] Development of & Support for Environmental Technology Act, *Ministry of Environment,* Dec. 1994 and revised Jan. 2009.
[68] Article 2, Water Quality and Ecosystem Conservation Act.
[69] Article 4-7, Water Quality and Ecosystem Conservation Act.
[70] Articles 12 and 13, Groundwater Act.
[71] Article 12-2, Groundwater Act.
[72] Article 14-15

Ministry of Land, Transport and Maritime Affairs who sets standards for the marine environment taking into account standards created pursuant to the Framework Act on Environmental Policy.[73] A ministerial order issued pursuant to the Marine Environment Management Act provides for the offshore geologic storage of CO_2 and requires the Ministry of Land, Transport and Maritime Affairs to develop standards for geologic sequestration in marine environments, and to impose charges or recover costs for the source of CO_2.[74] A supplementary order requires verification of the purity of CO_2 generated on land and could require treatment as a waste for purposes of storage in offshore geologic sequestration.[75] The Act defines the term "pollutant" to mean "waste, oil, noxious liquid substances or harmful substances in package form which adversely affect or are feared to adversely affect the marine environment when flowing or discharged into the sea."[76] The Act contains a "Polluter Pays" liability provision that requires polluters to restore the marine environment at their expense.[77]

The **Clean Air Conservation Act** defines the term "greenhouse gases" and requires the Ministry of Environment to develop a comprehensive plan for reducing their emission into the atmosphere from point sources and transportation.[78] The Clean Air Conservation Act does not contain limits, enforcement or liability provisions for greenhouse gases.

Environment Improvement Expenses Liability Act imposes environmental improvement charges on facilities that directly cause environmental pollution through the discharge of large quantities of environmental pollutants (including air and water pollutants) and on motor vehicles.[79]

3.5 CO_2 Transportation

Compression and transport of high pressure CO_2 would be subject to the **High-Pressure Gas Safety Control Act**, which governs the production, storage, sale and transportation of gases under pressure.[80] For a CCS project, this Act could govern the compression and transport phases of the project. Further, although the Act only contains provisions for storage of high-pressure gas in man-made containers, these provisions could be adapted for use with geologic storage. The Act provides standards for equipment, and imposes a regime for registration, reporting and inspection for safety purposes.

Ministry of Land, Transport and Maritime Affairs sets standards for transportation of substances by vessel or ocean pipeline.[81]

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[73] Article 8, Marine Environment Management Act.
[74] Articles 12(3) and 23, Marine Environment Management Act Enforcement Rules, April 11, 2011.
[75] Schedule 6 to Marine Environment Management Act Ministerial Order, September 6, 2010.
[76] Article 2, Marine Environment Management Act.
[77] Article 7, Marine Environment Management Act.
[78] Articles 2, 11 and 77-2, Clean Air Conservation Act.
[79] Environment Improvement Expenses Liability Act, *Ministry of Environment*, last revised in May 2007
[80] Article 1, High-Pressure Gas Safety Control Act.
[81] Article 8, Marine Environment Management Act.

Pursuant to the **Wastes Control Act**, a license is required from the Mayor/Governor for collecting, transporting, and disposing waste and from the Minister of Environment to engage in a waste management business for handling controlled wastes.[82] Under the Act, a person who discharges, transports or disposes of any commercial wastes specified by Ordinance of the Ministry of Environment is subject to reporting requirements.[83]

The Urban Gas Business Act, which governs the wholesale and retail distribution of natural gas and related products provides for detailed regulation concerning the siting, protection, operation and third party access to natural gas pipelines, which could provide a model for CO_2 pipelines.[84]

3.6 Health and Safety

The **Industrial Safety and Health Act** governs the safety and health of workers in the workplace.[85] It is intended to promote a safe and healthy workplace by reducing accidents in the workplace. Its requirements include complying with standards developed by government, preparing accident reduction plans, adopting safety and health management systems, reporting and training.[86] Employers are obligated to pay compensation to workers for injuries sustained in the workplace under the **Labor Standards Act**, which do not preclude claims under other statutes such as the Civil Act, except to the extent of compensation received under the Labor Standards Act.[87]

The Ministry of Knowledge Economy regulates the health and safety of electric power facilities.[88]

3.7 Power Sector Laws

The Ministry of Knowledge Economy regulates the electricity sector. It licenses and regulates plants[89] and sets the standard price of electricity, and subsidizes the price of electricity generated by new and renewable sources when its cost is higher than that of the standard price.[90] The Electrical Affairs Commission, whose members are appointed by the President and may only be removed for cause, deliberate over preservation of a fair market environment for electricity, consumer interests, and disputes among electricity sector participants.[91] The Korea Power Exchange, created pursuant to the Electric Utilities Act, acts as the system operator.[92]

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[82] Article 25, Wastes Control Act.
[83] Article 25, Wastes Control Act.
[84] Chapter V-2, Urban Gas Business Act.
[85] Industrial Health and Safety Act; Article 76, Labor Standards Act.
[86] Articles 4, 8, 10, 13, 36, Industrial Health and Safety Act.
[87] Articles 81-90, Labor Standards Act.
[88] Article 61, Electric Utilities Act.
[89] See Electric Utilities Act.
[90] Article 17, Electric Utilities Act; Article 17, Act on Promotion of the Development, Use and Diffusion of New and Renewable Energy.
[91] Articles 53-56, Electric Utilities Act.
[92] Section 2, Electric Utilities Act.

The power sector is dominated by the state-owned electricity utility, Korean Electric Power Corporation (KEPCO). While the state unbundled KEPCO's generation, transmission and distribution businesses, it has not carried out its original plan of fully privatizing KEPCO. In 2001, KEPCO's generation assets were split into six subsidiary companies: Korea South-East Power (KOSEP), Korea Midland Power (KOMIPO), Korea Western Power (WP), Korea East-West Power (EWP), Korea Hydro & Nuclear Power (KHNP), and Korea Southern Power Co (KOSPO). These subsidiaries, which are still controlled by the parent KEPCO, account for over 90% of Korea's electricity generation.[93] KEPCO maintains a monopoly on transmission and distribution and is the sole buyer of power in the country. Power is supplied to a single national grid. A few independent power producers (IPPs) exist, however investment has been difficult to attract in light of the uncertainty concerning the privatization of KEPCO.

Pricing is based on the cost-based pool concept. Generators submit details of their production costs, which are reviewed and approved by the Electrical Affairs Committee. Based on this information, the Korea Power Exchange prepares a Price Setting Schedule and calculates the marginal price (SMP) based on the principle of minimizing the system variable cost. The market price is composed of the system marginal price (SMP), a capacity payment (CP) and any other applicable payments pursuant to regulation, with a price cap for base load generating units such as coal and nuclear energy. The marginal price is the most expensive generation available for the trading period. After real-time dispatching, the settlement price of electricity is determined equal to Output × SMP + Capacity × CP + Other Payment.[94]

KEPCO has acquired interests in several Australian coalmines. Coal accounts for approximately 22% of Korea's energy mix and supply is heavily affected by demand from China.[95]

The Energy Act created the KETEP and establishes a reporting requirement to the National Assembly of progress in meeting the government greenhouse gas reductions goals.[96] The Energy Use Rationalization Act promotes energy efficiency and greenhouse gas mitigation through government and demand management planning, adoption of standards, product designations and inspections. It requires government at all levels to adopt energy use plans, energy suppliers to develop demand management investment plans, and provides for voluntary agreements with industry accompanied by greenhouse gas reporting in order to reduce greenhouse gases.[97]

The Framework Act on Low Carbon, Green Growth identify "introduction of elements of market competition to energy prices and energy industries" as one of the basic principles guiding policy for energy.[98]

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[93] "IBM Expands Global Intelligent Utility Network", available at http://www.rdmag.com/News/Feeds/2011/03/information-tech-ibm-expands-global-intelligent-utility-network-coa/ (accessed September 27, 2011).

[94] Junki Kim and Kyuhyun Kim, The Electricity Industry Reform in Korea: Lessons for Further Liberalization, in Jarvis et al., eds., Infrastructure Regulation: What Works, Why and How Do We Know?: Lessons from Asia and Beyond (World Scientific 2011).

[95] Energy Profile of South Korea, http://www.eoearth.org/article/Energy_profile_of_South_Korea (accessed September 19, 2011).

[96] Articles 13 and 20, Energy Act.

[97] Articles 8-9, 28-29, Energy Use Rationalization Act.

[98] Article 39, Framework Act on Low Carbon, Green Growth.

3.8 Oil, Gas and Mining Laws

Pursuant to the Mining Act, the government grants right to explore and exploit oil, gas and mineral deposits. Except for petroleum, concessionaires are limited to a period of 25 years, subject to renewal.[99]

Without any oil reserves, Korea is completely reliant on oil imports, which has led to a policy of securing and diversifying the country's oil supply. The state-owned Korea National Oil Corporation (KNOC) managed the country's strategic oil reserve and pursues equity stakes and exploration and production projects internationally. KNOC is also exploring domestic offshore exploration blocks. Korea possesses several refineries operated by third party companies.

Korea imports almost all of its natural gas, and only produces a small quantity of natural gas from KNOC's domestic offshore Donghae-1 development project in southeastern Korea estimated to contain 240 Bcf of reserves. Donghae-1 would satisfy only about 2 percent of Korea's natural gas demand.[100] The Korea Gas Company (KOGAS) possesses a monopoly on the country's natural gas business.

Korea does not possess detailed laws concerning oil and gas exploration and production. The Ministry of Knowledge Economy regulates petroleum and petroleum substitute refinery and distribution business, including natural gas processing and ethanol production facilities.[101]

3.9 Public Participation

Environment Impact Assessment Act requires environmental impact assessments for certain types of enumerated projects that have potentially harmful impact on the environment. Assessments examine the impact on the natural and living environment, including social and economic factors, and requires analysis of measures to mitigate these impacts. The act imposes a duty on the state and any person who executes projects.[102] Energy, industrial and transportation projects are among those subject to the act.[103]

The Act requires that project proponents hold an explanatory rehearing to collect the opinion of residents in the affected area, and to include an assessment of the impact upon them in the environmental impact assessment.[104] Residents may request that document relating to the impact assessment be made publicly available to them.[105] Assessments must be provided to the agency granting approval as well as the mayor's office of the municipal subdivision in which the project is located.[106]

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[99] Articles 9 and 12, Mining Act.
[100] Energy Profile of South Korea, http://www.eoearth.org/article/Energy_profile_of_South_Korea (accessed September 19, 2011).
[101] Article 5, Petroleum and Petroleum Substitute Fuel Business Act.
[102] Article 3, Environmental Impact Assessment Act.
[103] Article 4, Environmental Impact Assessment Act.
[104] Article 6, Environmental Impact Assessment Act.
[105] Article 6-2, Environmental Impact Assessment Act.
[106] Article 17, Environmental Impact Assessment Act.

The reviewing agency may require adjustment to the impact assessment. The Ministry of Environment shall consult the options of experts and the Korea Environment Institute, as well as other ministries and municipal heads.[107] An approving agency may make an objection, which may trigger modification of the environmental impact assessment.[108]

The Enforcement Decree of the Environment Impact Assessment Act provides rules for notice and conducting explanatory meetings with affected persons.[109]

Framework Act on Environmental Policy requires local implementation of national policies in a manner appropriate to the local area.[110] In addition, the Act requires the prior examination of environmental conditions by heads of administrative agencies, who are required to seek the opinions of residents, experts in the field, environmental organizations, nongovernmental organizations and interested parties when they each prepare the examination.[111] These requirements are waived if the opinions of residents and other stakeholders are heard pursuant to other laws or regulations governing environmental impact.[112]

Framework Act on the National Land requires public hearings "listen to the opinions of the people and specialists" as part of the approval process for national, provincial and local land plans.[113]

As noted above, if a site is designated an "industrial complex", the Ministry of Land, Transport and Maritime Affairs possess authority to streamline the permitting process,[114] which would ordinarily require public hearings on the complex as a whole but could exempt the facility from the public hearing requirement.[115] Stakeholders believed, however, that as a practical matter the government would not likely seek to use this provision to exempt a CCS project from public consultation requirements.[116]

Official Information Disclosure Act requires public institutions to disclose information to Korean citizens and foreigners (subject to restrictions) provided the information does not compromise national security, confidentiality, law enforcement efforts or other limited exceptions.[117]

3.10 Foreign Investment

In general, foreign investment is not restricted in the Republic of Korea except where it

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[107] Article 19, Environmental Impact Assessment Act.
[108] Articles 22-24, Environmental Impact Assessment Act.
[109] Articles 16-17, Enforcement Decree of the Environmental Impact Assessment Act.
[110] Article 12, 14-2, 14-3, and 14-4, Framework Act on Environmental Policy, *Ministry of Environment,* last revised in Mar. 2008.
[111] Article 25-5, Framework Act of Environmental Policy.
[112] Article 25-5, Framework Act of Environmental Policy.
[113] Articles 11 and 14, Framework Act on the National Land.
[114] See Act on Special Cases Concerning the Simplification of Authorization and Permission Procedures for Industrial Complexes.
[115] Articles 9-12, Enforcement Decree of the Industrial Sites and Development Act.
[116] Stakeholder consultations, September 26, 2011.
[117] Article 9, Official Information Disclosure Act.

threatens national security or public order, affects public hygiene or environmental preservation, or otherwise violates statute.[118] Foreign ownership of generation purchased by KEPCO shall not exceed 30% of total domestic generation. Foreign investment in electricity transmission and distribution is restricted to a minority position of less than 50% and the foreign ownership with voting rights shall be a smaller percentage than the largest domestic shareholder.[119]

3.11 Financial Incentives and Support

The **CCS Master Plan** calls for the investment of 2.3 trillion Korean Won (USD 2.3 billion) during the period 2012 to 2019 for CCS. The government has since reduced the estimated amount to 1.8 trillion Won (USD 1.8 billion) due to budget considerations. Under the plan, approximately half of this amount will be funded directly by the national government, and the other half from private industry. KEPCO is expected to provide the majority of private funding in connection with its leadership in RD&D projects, which is in turn subsidized by the national government as KEPCO operates at a deficit each year.[120] About 80% of the projected budget is expected to fund four RD&D projects, of which two are post-combustion, one oxy-fuel and one IGCC project. Of these four, two will be selected for further support. Other funds will support a comprehensive geologic assessment and testing, and research in amine and chemical looping technologies.

The **Korea Energy Management Company (KEMCO**), a government funded entity, offers 5,000 Korean Won (USD 5) per tonne of CO_2 avoided. The incentive is primarily intended for energy efficiency measures, however it is available to any technologies that reduce CO_2.[121]

According to the **Framework Act of Environmental Policy**, the State or local governments may adopt tax measures and grant other financial supports necessary to support the installation and operation of facilities for environmental preservation by businesses; and may also grant financial support for scientific research, study, and technical development related to environmental preservation.[122]

The **Framework Act on Low Carbon, Green Growth** provides for voluntary, early-movers that their greenhouse gas reduction efforts and requires the government to recognize these efforts or "an entity to trade the results of such performance."[123] Although suggesting that CCS could be credited under the planned

The **Energy Act** established the **Energy Technology Development Project Fund**, which is administered by the KETEP. The Fund is supported by government loans, charges on energy industry and other sources established by regulation. Among the Fund's objectives is to support greenhouse reduction technologies.[124]

Pursuant to the A**ct on Promotion of the Development, Use and Diffusion of New and Renewable Energy**, the Ministry of Knowledge Economy receives government appropriations to fund implementation projects, research and capacity building for new and renewable energy

[118] Article 4(2), Foreign Investment Promotion Act.
[119] Regulations on Foreign Investment and Technology (Ministry of Knowledge Economy Notice No. 2010-63).
[120] Stakeholder consultations, September 28, 2011.
[121] Stakeholder consultations, September 28, 2011.
[122] Article 34, Framework Act of Environmental Policy.
[123] Article 43(1), Framework Act on Low Carbon, Green Growth.
[124] Article 14, Energy Act.

sources, which include energy from fossil fuels using new technologies designated by regulation.[125] The Ministry of Knowledge Energy can also provide support to project through leases of land as well as operating projects directly.[126]

The **Act on Promotion of the Conversion into Environmentally Friendly Industrial Structure** also calls for subsidization of environmentally friendly equipment and financial support for projects.[127] The **Industrial Development Act** promotes the development of advanced technologies, including with sustainability as a goal, however its objective include international competiveness of national industries,[128] suggesting that pursuing support for CCS projects under the Industrial Act would require demonstrating the cost-effectiveness of technology for adoption domestically and/or the potential market for Korean exports.

[125] Articles 9-10, Act on Promotion of the Development, Use and Diffusion of New and Renewable Energy.
[126] Articles 26 and 28, Act on Promotion of the Development, Use and Diffusion of New and Renewable Energy.
[127] Articles 5-6, Act on Promotion of the Conversion into Environmentally Friendly Industrial Structure.
[128] Articles 5-7, Industrial Development Act.

MALAYSIA REGULATORY ASSESSMENT

MALAYSIA REGULATORY ASSESSMENT

1. POLITICAL AND LEGAL SYSTEM

Malaysia is a constitutional monarchy with a system of parliamentary democracy. The Federal *Constitution* is the supreme law of the land providing the legal framework for legislation, courts and administrative aspects of the law. It also defines the powers of the government and monarch, as well as the rights of citizens, and the separation of powers amongst the executive, judicial and legislative branches.

Below the Federal Constitution, legislative instruments are in the form of: Acts passed by Parliament; Regulations and other subsidiary legislations passed by the executive (Ministerial Regulations); and, State laws and regulations. Federal laws prevail over inconsistent state and Shariah laws.

Malaysia comprises 13 states as well as three federal territories. Nine of the states are ruled by hereditary rulers, among whom the "Yang di-Pertuan Agong" or King of Malaysia is elected for a five-year term on a rotating basis.[1] Each state is divided into districts.

The executive branch is formally headed by the King but executive authority is exercised through the Cabinet led by the Prime Minister and subject to the authority of Parliament. The Cabinet is selected from among members of Parliament.[2] The King is obligated to act upon the advice of the Cabinet.

The Federal Constitution provides for the separation of competencies between the Federation and the States. The federal government has legislative power over external affairs, including making laws and implementing treaties domestically, justice (except civil law cases among Malays or other Muslims and other indigenous peoples, adjudicated under Islamic and customary law), federal citizenship, finance, taxation, commerce, industry, and other matters. States enjoy legislative power over matters such as land, local government, Shariah law and Shariah courts. Article 75 of the Federal Constitution asserts that a federal law shall prevail over any inconsistent state laws. Federal laws enacted by the Parliament of Malaysia apply throughout the country, including making laws applicable to States as regards international agreements.[3]

State governments also have their own environmental regulations and are also are primarily responsible for protection of water resources, however the federal government is increasingly regulating this area. State territorial waters extend to 12 nautical miles of the coast, beyond which federal jurisdiction applies to the 200 nautical mile exclusive economic zone. Federal authority also governs any oil and gas operations within state territorial waters as well as any activities concerning the continental shelf.

[1] Article 32, Federal Constitution.
[2] Articles 39 and 43, Federal Constitution.
[3] Article 76, Federal Constitution.

The Federal Parliament comprises the House of Representatives and the Senate. The 222 members of the House of Representatives are elected for a maximum of five year terms based on voting districts.[4] Senators are elected for three-year terms, 26 of whom are elected by the 13 state assemblies, 40 are appointed by the King, two represent the federal territory of Kuala Lumpur, and one each represent the federal territories of Labuan and Putrajaya.[5]

Each of Malaysia's 13 states are governed by state governments, which have their own State Assembly and cabinet of Chief Ministers who are selected from their respective State Assembly by the majority party. Each state may enact its own environmental laws and regulations.

The superior courts are the High Court in the States of Malaya (High Court in Malaya, and the High Court in the States of Sabah and Sarawak (High Court in Sabah and Sarawak), Court of Appeal, and the Federal Court, while the Magistrates' Courts, the Sessions Courts, and other courts[6] are classified as subordinate courts. The Federal Constitution of Malaysia provides for a dual justice legal system of *Shariah* laws applying to Muslim citizens and secular criminal and civil laws applying to non-Muslims. The dual system applies to personal legal matters not commercial transactions.

The application of common law in Malaysian criminal cases is specified in section 5 of the *Criminal Procedure Code* (Act 593), which states that English law shall be applied in cases where no specific legislation has been enacted. In addition, sections 3 and 5 of the *Civil Law Act* 1956 allow for the application of English common law, equity rules, and statutes in Malaysian civil cases where no specific laws have been made. The principle of *stare decisis* also applies in Malaysian law whereby any decisions by a court higher in the hierarchy will be binding upon the lower courts.

Certain government ministries would play a major role in the development of CCS regulation and the approval of a CCS project in Malaysia. Key government ministries include:

• **Economic Planning Unit (EPU)** of the Prime Minister's Department is responsible for national planning and prepares the country's 5-year plans and advises the cabinet. It approves and endorses major infrastructure projects in the country based on the country's 5-year plan in consultation with other government ministries, the private sector and civil society. The EPU could help coordinate among government agencies, in particular cross-sectoral projects, and plays an important role in law and policy development.

• **Ministry of Natural Resources and Environment (MNRE)** is responsible for representing Malaysia at the UNFCCC, serves as the DNA, and prepares the country's climate change action plan. MNRE's Department of Environment (DOE) is responsible

[4] Article 46, Federal Constitution.
[5] Article 45, Federal Constitution.
[6] The Sessions Court, Magistrates' Court, Sharia Court, Juvenile Court, Penghulu Court and Native Court.

for carrying out the Environmental Quality Act.[7] MNRE's DOE issues environmental permits for projects and regulates discharge of pollutants in the environment. MNRE's Department of Mineral & Geosciences provides expertise to the government in assessing the suitability of storage sites and would serve as a resource for policymakers developing CCS law and regulation.

• **Ministry of Energy, Green Technology and Water (KeTTHA)** is the federal policy body for energy, green technology and water. In developing policy, KeTTHA would conduct consultation with stakeholders and would provide recommendations to the Cabinet in planning and reform efforts. Under KeTTHA, the Energy Commission regulates power and downstream gas and the National Water Services Commission regulates the water supply industry, each with responsibility pricing, technical standards and safety. Tenaga Nasional Berhad and Sabah Electricity Sdn. Berhad, among other government agencies, are also under the responsibility of KeTTHA. KeTTHA together with MNRE also acts secretariat for the National Green Technology and Climate Change Council. KeTTHA has been exploring CCS as part of Malaysia's Low Emissions Strategy.

• **Energy Commission** is responsible for regulating power and downstream gas supply, promote competition and the development of the energy industry. It plays a largely advisory role with major decisions made by the Cabinet. The Energy Commission reviews requests for rate increases, which would then be considered KeTTHA and the EPU, and then ultimately decided by the Cabinet.

• **Ministry of Science, Technology & Innovation (MOSTI)** sets R&D priorities for Malaysia and provides R&D grants. It could be asked to review the feasibility and soundness of new technologies, generally at the request of another agency. MOSTI operates some of Malaysia's national laboratories.

• **Ministry of International Trade and Industry** (**MITI**) regulates oil refining and foreign investment into Malaysia. MITI is also responsible for developing strategy on incentives for foreign and domestic companies.

• **Ministry of Domestic Trade and Consumer Affairs** (**MDTCA**) regulates the marketing and distribution of oil products in Malaysia. The MDTCA coordinates and issues permits for petroleum pipelines. It would also likely review the cost of CCS to manufacturers and consumers.

• **Department of Occupational Safety & Health** regulates workplace safety and would have jurisdiction over the work safety issues associated with a CCS facility.

• **National Green Technology and Climate Change Council** (MTHPI) is chaired by the Prime Minister to formulate policies and identify the strategic issues in the National Green Technology Policy development and climate change. It also coordinates,

[7] Pursuant to Section 3 of the Environmental Quality Act 1974, the Director General of Environmental Quality, who is appointed by the Minister of MNRE, is responsible for administering the Act and carrying out its functions, powers and duties.

monitors and evaluates the effectiveness of the National Green Technology Policy and Green Technology programmes and climate change at the national level. MNRE and KeTTHA jointly act as secretariat. The Council comprises eight working committees (Industry Working Committee, Human Capital Working Committee, Research and Innovation Working Committee, Promotion and Public Awareness Working Committee; Transportation Working Committee, Green Neighborhood Working Committee, Adaptation Working Committee, and Green Development Working Committee).

• **Petronas** is both the wholly state-owned upstream oil and gas production company, known as Petronas Carigali Sdn Bhd, and the regulator for upstream oil and gas industry through its Petroleum Management Unit. In its capacity as a regulator, the Petroleum Management Unit awards production sharing contracts for onshore or offshore oil and gas production areas to Petronas Carigali or third parties. For all oil and gas production sharing contracts awarded to third parties, Petronas Carigali is a compulsory partner. It also operates three of the country's five refineries and, through its domestic retail company, owns over 900 retail stations.[8] Petronas is wholly-owned by the State, and, under the Petroleum Development Act, is subject to the control of the Prime Minister.[9]

• **Tenaga Nasional Berhad (TNB)** is Malaysia's largest power generator and primary transmission and distribution company in Peninsular Malaysia. TNB is 70% owned by the State via diverse set of stakeholders and is the sole buyer of power in peninsular Malaysia. TNB also owns 80% of Sabah Electricity Sdn Bhd (SESB), the main utility in Sabah, east Malaysia.

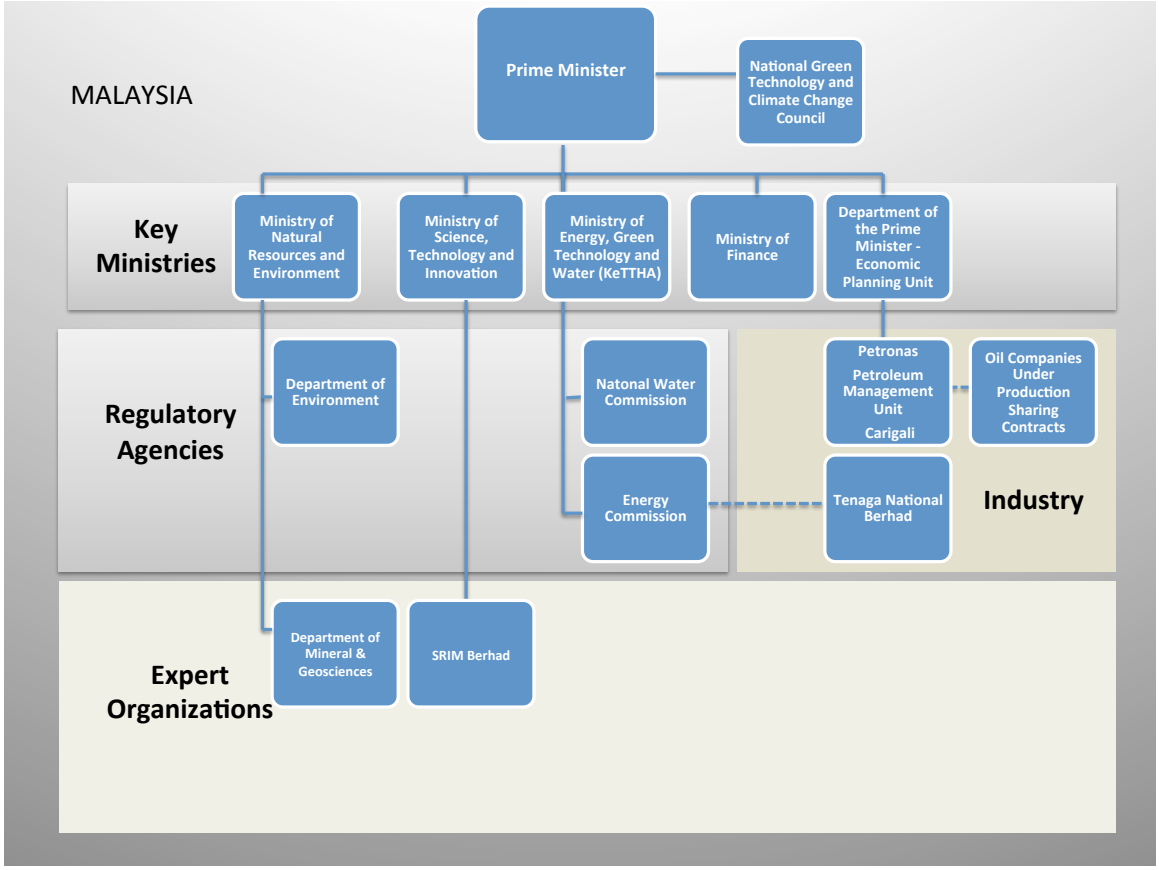
• **Khazanah Nasional Berhad**, the federal government investment company, holds approximaley 37% of TNB's shares, over half of the federal government total 70% stake in TNB.[10] As their largest shareholder, it influences TNB's direction and policies.

• **SIRIM Berhad** is a state-owned research institution operated as company under MOSTI. SRIM assists the MOSTI's Department of Standards of Malaysia in developing standards for technologies with environmental implications. SIRIM collaborates closely with KeTTHA and MNRE. SIRIM is currently developing life cycle-based standards for biofuels and could develop standards for CCS operations.

• **Planning, Coordinating and Implementing Committee on Electricity Supply and Tariff (**Jawatankuasa Perancangan Pelaksanaan Pembekalan Elektrik dan Tarif or "JPPPET"), chaired by KeTTHA, recommends to the Cabinet the plan for the country's electricity supply and changes to the electricity tariff structure. Its members include representatives from the EPU, Ministry of Finance, Petronas, TNB, Energy Commission, MITI, Malaysian Investment Development Authority (MIDA), the MNRE, and the State Governments of Sabah and Sarawak.

[8] Faizah Jamaludin, "Malaysia" in Oil Regulation 2010, Law Business Research.
[9] Article 3(2), Petroleum Development Act of 1974.
[10] Tenaga Nasional Berhad 2010 Annual Report.

The diagram below shows selected central government entities and stakeholders that would be involved in regulating or undertaking a CCS project. State or local government entities are not shown on the diagram.



2. CLIMATE CHANGE LAW AND POLICY

Malaysia is party to the UNFCCC and the Kyoto Protocol.[11] As a developing country, it has no obligations to reduce its greenhouse gas emissions under the Kyoto Protocol.

Malaysia's National Policy on Climate Change was launched on 30th August 2010 with three primary objectives: (1) mainstreaming climate change through wise management of resources and enhanced environmental conservation resulting in strengthened economic competitiveness and improved quality of life; (2) integration of responses into national policies, plans and programmes to strengthened the resilience of development from arising and potential impacts of climate change; and (3) strengthening of

[11] Ratified UNFCCC 13 June 1994 and Kyoto Protocol 4 September 2002.

institutional and implementation capacity to better harness opportunities to reduce negative impacts of climate change.[12]

Malaysia has adopted a voluntary target to achieve greenhouse gas reductions of up to 40% in terms of emissions intensity of GDP by 2020 compared to 2005 levels,[13] subject to the provision of financial assistance by developed countries through the UNFCCC.

Malaysia's emissions mitigation actions are developed in the context the country's longstanding efforts to diversify its energy mix. Driven by concerns over depleting oil and gas reserves, Malaysia adopted its National Depletion Policy in 1980 to restrict production levels, and its Four Fuel Diversification Policy focusing on oil, gas, hydropower and coal in 1981, both adopted with the objective of preventing over-dependence on oil and to ensure security of energy supply. The Eighth Malaysia Plan (2001-2005) introduced the Five Fuel Policy that added renewable energy. Malaysia's Third Outline Perspective Plan (2001-2010), Tenth Malaysia Plan (2011-2015) and New Energy Policy (2011-2015) identify the following national energy priorities:[14]

- Greater utilisation of natural gas in power and non-power sectors;
- Development of renewable energy, particularly in power generation;
- Improve energy efficiency through law and regulation;
- Ensure adequate, reliable, affordable and quality energy supply; and
- Adopt market-based pricing for energy.

In order to meet these goals and increase the share of renewable energy, Malaysia adopted a sophisticated feed-in-tariff with differentiated rates for solar photovoltaic, biomass, biogas and mini-hydro technologies.[15]

Malaysia has not yet started collecting data on large point sources of greenhouse gases. The Sustainable Development Energy Authority (SEDA) was created and granted the authority to mandate GHG emissions reporting for the power sector; thus far reporting has been on a voluntary basis.[16]

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[12] Honourable Prime Minister of Malaysia, Dato' Seri Najib Abdul Razak at Copenhagen (COP 15) on December 17, 2009, as cited in Sumiani Tusoff, Development of a National Policy on Climate Change: Malaysia's Experience, Powerpoint presentation to the International Conference on the Changing Environment: Challenges for Society, November 20-12, 2010.
[13] Honourable Prime Minister of Malaysia, Dato' Seri Najib Abdul Razak at Copenhagen (COP 15) on December 17, 2009, as cited in Sumiani Tusoff, Development of a National Policy on Climate Change: Malaysia's Experience, Powerpoint presentation to the International Conference on the Changing Environment: Challenges for Society, November 20-12, 2010.
[14] The Third Outline Perspective Plan can be found at http://www.epu.gov.my/third. The Tenth Malaysia Plan can be found at http://www.epu.gov.my/html/themes/epu/html/RMKE10/rmke10_english.html
[15] Renewable Energy Act 2011.
[16] Stakeholder consultations, July 8, 2011.

MNRE is considering CCS as a possible technology to meet Malaysia's voluntary emissions intensity reduction targets,[17] however implementation would start no sooner than 2020 as the government has prioritized mitigation technologies that they believe are lower cost. Implementation of CCS would thus depend upon its cost and impact on the competitiveness of domestic industry and the feasibility of other technologies such as nuclear, wind and full exploitation of Malaysia's hydropower resources, all of which are currently being reviewed in terms of their potential contribution to achieving greenhouse gas reductions.[18] Stakeholders observed that evaluation of the safety of CCS could also be a factor in its adoption.[19]

3. LAWS AND REGULATION APPLICABLE TO CCS

Malaysia currently has no laws that specifically govern CCS, however various existing laws and regulations would be relevant to a CCS project.

3.1 Classification of CO_2

Malaysia currently has no laws that specifically classify CO_2 as a waste or pollutant, however the Environmental Quality Act 1974 contains definitions for "pollution" and "pollutants", which could potentially apply to CO_2 in the context of geologic sequestration. Under the Environmental Quality Act 1974, "pollution" means "any direct or indirect alteration of the physical, thermal, chemical, or biological properties of any part of the environment by discharging, emitting, or depositing environmentally hazardous substances, pollutants or wastes so as to affect any beneficial use adversely, to cause a condition which is hazardous or potentially hazardous to public health, safety, or welfare, or to animals, birds, wildlife, fish or aquatic life, or to plants . . .."

The term " pollutant" is defined broadly: "any natural or artificial substances, whether in a solid, semi-solid or liquid form, or in the form of gas or vapour, or in a mixture of at least two of these substances, or any objectionable odour or noise or heat emitted, discharged or deposited or is likely to be emitted, discharged or deposited from any source which can directly or indirectly cause pollution and includes any environmentally hazardous substances." Finally, the term waste" is defined as "any matter prescribed to be scheduled waste, or any matter whether in a solid, semi-solid or liquid form, or in the form of gas or vapour which is emitted, discharged or deposited in the environment in such volume, composition or manner as to cause pollution."[20]

Notwithstanding the general definitions contained in these laws, the Environmental Quality Act 1974 contains lists of the specific substances that are covered by the law, which do not presently include CO_2.

[17] Stakeholder consultations, July 8, 2011.
[18] Stakeholder consultations, July 8, 2011.
[19] Stakeholder consultations, October 5, 2011.
[20] Section 2, Environmental Quality Act 1974.

3.2 Surface Rights and Subsurface Rights

Immoveable Property Laws: Currently, there are no specific Malaysian laws applicable to the ownership of captured and stored CO_2 and property rights relating to the sub-surface pore space in which injected CO_2 would be stored.

In Malaysia, other than for federal lands, land issues are regulated by the states pursuant to the Malaysian Constitution. However, several federal laws define property rights in circumstances relevant to CCS.

Malaysia's National Land Code provides that individuals or bodies that have rights to land have "the exclusive use and enjoyment of so much of the column of airspace above the surface of the land, and so much of the land below that surface, as is reasonably necessary to the lawful use and enjoyment of the land."[21] The National Land Code further provides certain rights to land rights holders to "extract, move or use within the boundaries of the land any rock material in or upon the land."[22] However, the grant is not absolute; the Code further states "No person or body to whom land has been disposed of as aforesaid shall be entitled (a) to extract any metal or mineral for any rock materials in or upon the land, or (b) to remove beyond the boundaries of the land any rock material or forest produce extracted or taken form the land or anything obtained or manufactured therefrom."[23] These provisions remain subject to mining and mineral rights regimes which grant limited rights by permit for a specified period of time to exploit the subsurface,[24] which are discussed further below. Importantly, when land use rights expire, the rights revert back to, and are owned by, the State.[25]

The National Land Code thus provides limited rights to the subsurface necessary to use and enjoy the land, but does not provide an absolute right to exploit the subsurface. Whether the National Land Code would authorize the use of pore space without an explicit grant of authority for such use is not precisely clear from the above provisions, however minerals rights and rock resources are commonly understood to belong to the State[26] and in the case of mineral rights are addressed by specific laws such as the Petroleum Development Act described below. It would appear that a specific grant of authority by the State or legislative clarification as to the ownership rights to pore space would be desirable before proceeding to inject CO_2 under existing Malaysian law.

Malaysia's state governments have broad general power to acquire land for themselves or for third parties when it serves a "public purpose" and facilitates "economic

[21] Section 44, National Land Code.
[22] Section 45(1)(a), National Land Code.
[23] Section 45(2), National Land Code.
[24] Section 45, National Land Code.
[25] Section 46, National Land Code.
[26] Stakeholder consultations, July 8 and October 5, 2011. See also Commentary to Section 45 of the National Land Code in Judith Sihombing, The National Land Code: A Commentary, Malayan Law Journal (2004).

development."[27] State governments are obligated to pay compensation to the landowner for such property.

The Petroleum Development Act irrevocably grants Petronas the "[t]he entire ownership in, and the exclusive rights, powers, liberties and privileges of exploring, exploiting, winning and obtaining petroleum whether onshore or offshore of Malaysia . . .."[28] Under this broad grant, Petronas' Production Management Unit exercises ownership of property rights associated with oil and gas exploration and production fields by granting exploration and production rights through production sharing contracts. Under production sharing contracts, Petronas can require operators to unitize production reservoirs if they are exploiting a single geological structure.[29] The Petroleum Mining Act similarly authorized the federal minister in charge of land and mines the power to grant rights to enter and operate in exploration areas which comprise "onshore-land" in Peninsular Malaysia and "offshore-land," meaning all offshore areas; these powers are now exercised by Petronas with respect to petroleum resources.[30]

Pursuant to the Continental Shelf Act, all rights to the exploration of the continental shelf and the exploitation of its natural resources are vested in Malaysia and exercised by the federal government.[31] The continental shelf is defined as "the sea-bed and subsoil of submarine areas adjacent to the coast of Malaysia but beyond the limits of the territorial waters of the States, the surface of which lies at a depth no greater than two hundred meters below the surface of the sea, or, where the depth of the super adjacent waters admits of the exploitation of the natural resources of the said areas, at any greater depth."[32]

Similarly, jurisdiction over Malaysia's Exclusive Economic Zone, which extends to 200 nautical miles from the baselines from which the breadth of its territorial seas are measured is exercised by the Malaysian federal government.[33] This authority includes exploiting resources, constructing facilities or laying pipelines in the Continental Shelf and the exclusive economic zone.[34]

If the storage site is located under a national park, any approval will be subject to the National Parks Act, which would be subject to special permits from the state authority that exercises jurisdiction over these parks.[35]

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[27] Section 3, Land Acquisition Act of 1960.
[28] Section 2(1), Petroleum Development Act of 1974. Section 2(1) states: "The entire ownership in, and the exclusive rights, powers, liberties and privileges of exploring, exploiting, winning and obtaining petroleum whether onshore or offshore of Malaysia shall be vested in a Corporation to be incorporated under the Companies Act 1965 or under the law relating to incorporation of companies."
[29] Faizah Jamaludin, "Malaysia" in Oil Regulation 2010, Law Business Research.
[30] Sections 1 and 2, Petroleum Mining Act 1966, as amended.
[31] Section 3, Continental Shelf Act 1966.
[32] Section 2, Continental Shelf Act 1966.
[33] Article 3, Exclusive Economic Zone Act 1984.
[34] Sections 5, 21 and 22, Exclusive Economic Zone Act 1984.
[35] Section 11, National Parks Act.

3.3 Long-Term Stewardship and Liability for Stored CO_2

Issues concerning responsibility for long-term stewardship of CO_2 and associated liabilities are not contemplated under Malaysian law, and should be addressed in order to undertake a CCS project. Resolution of stewardship and liability issues could be addressed by several mechanisms, including government leases of pore space rights, CCS regulation issued under existing laws, dedicated CCS legislation, or reliance on existing Malaysian laws, particularly environmental and tort laws.

As described below, general environmental protection laws contain provisions that could impose liability for CCS activities. Further, Malaysia's civil law provides for compensation as a result of damages caused by tort or negligence.[36] Malaysia civil law adopts English law for questions concerning commercial matters, however it explicitly excludes application of English law to immoveable property (land).[37]

Malaysia operates a government-managed national Environment Fund that supports prevention and remediation of environment damage from oil spills and hazardous waste. Although the Environment Fund does not cover CCS, it could serve as a domestic model for a CCS liability fund to defray costs of monitoring and remediation to support a liability transfer scheme. The Environment Fund is partly funded by fees collected from industry and is used to cover the costs of preventing and remediating pollution.[38]

As a practical matter, the State would likely have responsibility for injected CO_2 following abandonment and could be deemed to take ownership of the CO_2 under the general principle that the State owns all rights to the deep subsurface. For oil and gas operations, a transfer of liability could occur due to the fact that production sharing contracts generally will contain a provision that requires the operator to turn over the block and all built infrastructure on it to Petronas at the end of the term, unless Petronas requires the removal of facilities.[39] However, under Petronas guidelines, liability for abandoned structures are determined by Petronas in consultation with other government agencies until such time as national policy on liability is adopted.[40]

3.4 Environmental Protection

Environmental Quality Act 1974: The Environmental Quality Act 1974 contains several provisions that are broad enough to possibly cover CO_2 injection and could regulate a CCS project or impose liability for CCS activities. It also provides general authority for specific regulations to be developed.

Under the Act, MNRE's DOE has authority to issue environmental permits for projects. As a condition of the permit, it can impose conditions such as construction of new equipment to specification, operating requirements, monitoring programs, and

[36] See, e.g., Parts III and IV, Civil Law Act 1956.
[37] Sections 5 and 6, Civil Law Act 1956.
[38] Section 36B, Environmental Quality Act 1974.
[39] Stakeholder consultations, October 7, 2011.
[40] Section 16.7.6, Petronas Procedures and Guidelines for Upstream Activities, August 2008.

remediation.[41] The Act also provides broad authority to develop regulations and standards for activities that fall within the scope of its regulatory authority under the Act.[42]

The Act prohibits discharge of specific scheduled wastes;[43] CO_2 is not listed. No discharge into soil or Malaysian waters (which includes sources of drinking water) is permitted without a license.[44] The Act provides DOE with authority to specify "acceptable conditions for the emission, discharge or deposit of environmentally hazardous substances, pollutants or wastes or the emission of noise into any area, segment or element of the environment and may set aside any area, segment or element of the environment within which the emission, discharge or deposit is prohibited or restricted."[45]

The permitting regime includes provisions for enforcement and collection of fees based on factors including the amount of waste or pollutant discharged.[46] The Act provides for recovery of compensation for loss or damage to property[47] and recovery of government costs for remediating any damage to the environment.[48] The Act also provides for civil and criminal penalties for violation of permitting and other provisions.

As described above, the definition of "pollutant" and "pollution" read together include natural substances that can alter the "physical, thermal, chemical, or biological properties of any part of the environment."[49] However, even if CO_2 is not deemed a pollutant, the liability provisions for environmental tort and trespass appear broad enough to impose liability for harm caused directly to the environment by a CCS project as a result of leakage or migration of CO_2 in the subsurface.

The Act also established the Environmental Fund and authority for the DOE to impose appropriate charges upon various activities including oil and gas operations and the storage of waste.[50] The fund is managed by a government-appointed committee and the funds may be used for various purposes including preventing spillage of waste or disposing or mitigating pollution.[51]

Groundwater Protection: As noted above, Malaysia regulates discharge of pollutants into groundwater sources under the Environmental Quality Act 1974 prohibiting discharge of pollutants into inland waters (which includes groundwater).[52] Under the Environmental Quality Act 1974, no discharge into soil or Malaysian waters is permitted

[41] Section 11, Environmental Quality Act 1974.
[42] Section 51, Environmental Quality Act 1974.
[43] Section 34B, Environmental Quality Act 1974.
[44] Section 24(1), 27(1) and 29(1), Environmental Quality Act 1974.
[45] Section 21, Environmental Quality Act 1974. See also Article 33, Environmental Quality Act 1974.
[46] Sections 16 and 17, Environmental Quality Act 1974.
[47] Section 46E, Environmental Quality Act 1974.
[48] Section 47, Environmental Quality Act 1974.
[49] Section 2, National Environmental Quality Act 1974.
[50] Sections 36A, 36B and 36D, Environmental Quality Act 1974.
[51] Section 36C and 36E, Environmental Quality Act 1974.
[52] Section 25, Environmental Quality Act 1974.

without a license.[53] Further, as described below, MNRE's DOE adopted specific regulations governing discharge of industrial effluents and requires an environmental impact assessment be prepared for specified activities that may cause pollution to groundwater.[54] In addition, the Water Services Industry Act 2006 provides KeTTHA with authority to prescribe minimum water quality standards for water supplied to the consumer by the water operators.

In addition to federal law, some states have passed laws on ground water protection. For example, the Selangor Waters Management Authority Enactment 1999 authorizes the state regulatory authority to designate ground water areas as well as river basins, catchment areas, wetlands and water bodies in order to conserve any water source.[55]

Industrial Effluents Regulations*:* Pursuant to its authority under the Environmental Quality Act, the MNRE's DOE has adopted regulations for discharge of pollutants on land and water from industrial sources. The Regulation is intended to protect water sources among its objectives and contains a list of regulated substances and locations of known water sources. CO_2 is not currently regulated under these regulations.[56]

Environmental Impact Assessment. The MNRE's DOE is authorized, after due consultation, to designate those activities that may have significant environmental impact as "Prescribed Activities" requiring submission of an environmental impact assessment (EIA).[57] An EIA must be prepared by a consultant registered with the DOE and must assess the impact such activity will have or is likely to have on the environment and to propose measures to prevent, reduce or control such adverse impact.[58] There are two EIA procedures, a Preliminary EIA and a Detailed EIA for projects with major/significant impacts to the environment.[59] Preliminary EIAs are reviewed by the MNRE's Department of Environment at the state level, whereas Detailed EIAs are reviewed by the Director General of Environmental Quality of the MNRE's DOE. Although there are differences in the review process for these two types of EIA, in both cases the DOE reviews EIAs, may request additional information or propose changes, and must approve the EIA in order for the project to apply for approval by other federal or state government authorities.[60] Once EIA approval has been obtained, the project may apply for approval for implementation to the relevant government authority:

- National Development Planning Committee for federal projects;
- Respective State Planning authority for state government sponsored projects;
- Regional Development Authorities for the State Executive Committee; and

[53] Sections 24(1), 25, 27(1) and 29(1), Environmental Quality Act 1974. See also Section 2, Environmental Quality Act 1974's definition of "inland waters".
[54] Section 34A, Environmental Quality Act 1974; Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.
[55] Section 56(1), Selangor Waters Management Authority Enactment 1999.
[56] Environmental Quality (Industrial Effluent) Regulations 2009.
[57] Section 34A, Environmental Quality Act; Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.
[58] Section 34A(2), Environmental Quality Act 1974.
[59] Environmental Impact Assessment (EIA): Procedure and Requirements in Malaysia, Department of Environment, Ministry of Natural Resources and Environment, Malaysia (October 2007).
[60] Section 34A(3)-(8), Environmental Quality Act 1974.

- Ministry of International Trade and Industry (MITI), in consultation with the Malaysia Industrial Development Authority (MIDA), for industrial projects.[61]

The DOE has designated nineteen categories of activities as Prescribed Activities, including several activities relevant to the capture, transportation and sequestration phases of a CCS project. These include industry, infrastructure, mining, petroleum, power generation and transportation. Many of the activities are designated as Prescribed Activities based on project size (area) or capacity.[62]

Detailed EIAs are available at all Department of Environment Offices and public libraries, and the public is notified through the media of locations where EIAs can be viewed.[63] As described further below, members of the public have certain rights to comment as part of the EIA review process.

Of particular importance to the storage aspects of a CCS project, guidance issued by the DOE advised that for all projects EIA review prioritizes the issue of site suitability and whether it is "developed and managed with environmentally sound control measures."[64]

Local Permitting Requirements: Planning and construction permits are approved at the district level and are subject to state and federal laws. Municipal authorities may impose fees or bonding requirements in respect of such permits.[65] MNRE's DOE approval of the EIA is a requirement for state and local approval. At the federal level, the DOE will determine as part of its EIA review whether the project is consistent with local zoning requirements and the nature of the community. Although the DOE makes an initial assessment of local zoning requirements, the state or local authority would make the final determination.[66]

Local laws could have independent requirements beyond those required in the EIA. The Town and Planning Act requires project proponents to submit plans to local authorities, including social impact assessments.[67] Note that some laws do not apply to Sabah and Sarawak. For example, the Town and Country Planning Act only applies to Peninsular Malaysia[68] whereas the Environmental Quality Act applies to the whole of Malaysia.[69]

3.5 CO_2 Transportation

There is currently no regulator for CO_2 pipelines. Petronas's Petroleum Management Unit regulates the operation of upstream oil and gas pipelines. The Energy Commission

[61] Environmental Impact Assessment (EIA): Procedure and Requirements in Malaysia, Department of Environment, Ministry of Natural Resources and Environment, Malaysia (October 2007).
[62] Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order 1987.
[63] Environmental Impact Assessment (EIA): Procedure and Requirements in Malaysia, Department of Environment, Ministry of Natural Resources and Environment, Malaysia (October 2007).
[64] Environmental Requirements: A Guide for Investors, Department of Environment, Ministry of Natural Resources and Environment, Malaysia, October 2008.
[65] Sections 105 and 107, Local Government Act.
[66] Stakeholder consultation, July 8, 2011.
[67] Sections 7(3) and 21A(1A), Town and Country Planning Act.
[68] Section 1(1), Town and Country Planning Act.
[69] Section 1(1), Environmental Quality Act 1974.

regulates natural gas pipelines for distribution to consumers under the Gas Supply Act 1993 and the Energy Commission Act 2001. The Energy Commission also regulates electricity tariffs, which would be relevant for CO_2 pipelines for projects involving power generation to the extent that the power plant operator seeks recovery of costs through the rate base.

Petronas Carigali owns all of the country's upstream oil and gas pipelines, and operates them either directly or through production sharing contracts with third parties. Petronas must still obtain rights of way to land that it does not own, which could require negotiation with landowners. MDTCA licenses the right to construct and operate upstream pipelines, and coordinates approval from as many as 13 different government agencies.[70] Access to the natural gas distribution grid is regulated by the Energy Commission.[71]

The Petroleum (Safety Measures) Act 1984 governs the safety aspects of transportation of oil and gas pipelines and requires permits for the construction of pipelines.[72]

Pipelines would be sited on land to transport CO_2 from power plants to storage sites. The fact that CO_2 is under pressure could be cause of concern in obtaining approvals. For pipelines under 50 km, no EIA would be required, however a pipeline would still be required to obtain local and state approvals.

3.6 Health and Safety

The Department of Occupational Safety and Health (DOSH), under the Ministry of Human Resources, is responsible for administering and enforcing legislation to ensure the safety, health and welfare of workers and others at places of work.[73] The Director General of DOSH carries out enforcement activities for industrial activities under the Occupational Safety and Health Act (OSHA) 1994, Factories and Machinery Act 1967, and Petroleum Act (Safety Measure) 1984.

OSHA provides the legislative framework to promote standards for safety and health at work. OSHA defines the general duties of employers, employees, manufacturers and others. OSHA's regulatory scope is broad and would cover workplaces engaged in CCS. The term "premises" includes "any installation on land, offshore installation or other installation whether on the bed of or floating on any water . . .."[74] Under OSHA, "plant" includes any machinery, equipment, appliance, tool and component, and "substance" means any natural or artificial substance whether in solid, liquid, gas, vapor or combination thereof, form. Under OSHA, risks to health from the use, storage or transportation of substances must be minimized.[75]

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[70] Stakeholder consultations, October 7, 2011; see also Faizah Jamaludin, "Malaysia" in Oil Regulation 2010, Law Business Research.
[71] Section 11(3), Gas Supply Act 1993.
[72] Part V, Petroleum (Safety Measures) Act 1984, as amended.
[73] Section 4, Occupational Health and Safety Act of 1994, as amended.
[74] Section 3, Occupational Health and Safety Act of 1994, as amended.
[75] Section 21, Occupational Health and Safety Act of 1994, as amended.

An employer employing 40 or more persons must establish a safety and health committee at the workplace. The committee's primarily function is to review safety and health measures and to investigate any health and safety incidents.[76] Employers must notify the DOSH of any accident, dangerous occurrence, occupational poisoning or disease which has occurred or is likely to occur at the workplace.

The Factories and Machinery Act (FMA) 1967 regulates the safety, health and welfare of persons working with machinery. All factories and general machinery must be registered with DOSH and certain machinery posing high risks such as boilers and unfired pressure vessels must be certified and inspected by DOSH.

The Petroleum (Safety Measures) Act 1984 governs the safety aspects of transportation, storage and handing of petroleum, and the use of related equipment. This law applies to transportation of petroleum by road, railway, water air and pipeline. Among its provisions, it requires permits for the construction of petroleum pipelines[77] and notice of and inquiry into any accidents involving petroleum that cause personal injury or loss of life.[78] The MDTCA, which is responsible for overseeing the safety of the petroleum sector, is authorized to establish regulations for cases in which substances mixed with petroleum present a safety or health issue.[79] In addition to these requirements, the Petroleum Mining Act provides a form of license which specifies that the licensee shall comply with health and safety requirements that may from time to time be imposed by the federal government, which authority is exercised by Petronas for offshore projects or state governments for onshore projects.[80]

In addition, as described above, the Environmental Quality Act requires permits for certain activities and could be used to regulate health and safety issues relating to CCS.

3.7 Power Sector Laws

Malaysia's power sector is dominated by the TNB, a majority state-owned entity that is the largest power generator, and sole transmission and distribution operator in Peninsular Malaysia. The system operator is housed within TNB.[81] Sabah Electricity Sdn. Bhd. and Sarawak Energy Berhad serve Sabah and Sarawak, respectively. Malaysia has allowed IPPs, which are all majority-owned by Malaysian nationals.

The Energy Commission, under KeTTHA, regulates the electricity sector and the downstream gas sector. It implements the Electricity Supply Act 1990, the principle law on the power sector, advises the government on power policies, and promotes the use of renewable energy and the conservation of non-renewable energy, among its responsibilities.[82] Consumer power tariffs are decided by the Cabinet based on the

[76] Section 30, Occupational Health and Safety Act of 1994, as amended.
[77] Part V, Petroleum (Safety Measures) Act 1984, as amended.
[78] Sections 22 and 23, Petroleum (Safety Measures) Act 1984, as amended.
[79] Section 21, Petroleum (Safety Measures) Act 1984, as amended.
[80] Second Schedule, Section 15, Petroleum Mining Act 1966, as amended; Stakeholder consultations, October 7, 2011.
[81] Stakeholder consultations, July 8, 2011.
[82] Section 14, Energy Commission Act 2001.

advice of the Energy Commission in response to a request for rate increase typically by TNB.[83] In practice, TNB has presented rate cases to the Economic Planning Unit under the Prime Minister.[84] The Energy Commission provides input into the process and may coordinate the case, however more recently the coordination function appears to have been conducted by the Planning, Coordinating and Implementing Committee on Electricity Supply and Tariff, which is chaired by KeTTHA.[85] The tariff is based on a rate of return taking into consideration projected capital and operating expenditures.

Power tariffs are the subject of public debate. IPPs have been criticized for charging above-market prices for electricity, further benefitting from fuel subsidies, and the IPP licenses having been granted preferentially, as opposed to competitively.[86] Wholesale power prices between transmission/distribution companies and IPPs are determined by negotiation under long-term power purchase agreements. The high prices that TNB purchases electricity from IPPs has placed a financial burden in TNB, depressed its stock, and affected its ability to raise capital.[87]

Malaysia sources most of its fuel for power generation from domestically produced natural gas. Petronas sells natural gas prices for power generation at heavily discounted rates pursuant to government regulation, by some estimates as much two thirds less than benchmark prices.[88]

The government has committed to review electricity tariffs every six months to reflect the global prices of gas and coal. According to stakeholders, these reviews have commenced but price changes will be gradual to market prices with an ambitious goal of 2015.[89] TNB has proposed that review of electricity tariffs should take place more frequently to take into account fluctuations in gas and coal prices.

Policies to promote renewable energy and energy efficiency have been developed. Peninsular Malaysia charges differentiated rates for peak and off-peak hours, however it does not have other forms of demand side management. In 2011, Malaysia enacted a feed-in-tariff, which includes solar photovoltaic, biomass, biogas and mini-hydro technologies, under which the newly created Sustainable Energy Development Authority sets prices.[90] The feed-in-tariff is limited to renewables and would not cover CCS,

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[83] Stakeholder consulttions, July 7, 2011.
[84] Section 26, Electricity Supply Act.
[85] Stakeholder consultations, July 8, 2011.
[86] Anita Gabriel, "Old issues, new minister," The Star, available at http://thestar.com.my/news/story.asp?file=/2009/7/11/business/4291712&sec=business (accessed July 9, 2011).
[87] Jeff Rector, The IPP Investment Experience in Malaysia, Working Paper #46, Program on Energy and Sustainable Development, Stanford University, 2005.
[88] See, e.g., Elaine Ang, "More Power Plants Needed." The Star Online, May 5, 2010. http://biz.thestar.com.my/news/story.asp?file=/2010/5/5/business/6188057&sec=business (accessed March 5, 2012); Yow Hong Chieh, DAP: "Remove IPP subsidies." The Malaysian Insider, May 18, 2011. http://www.themalaysianinsider.com/malaysia/article/dap-remove-ipp-subsidies-first/ (accessed March 7, 2012); Jeff Rector, The IPP Investment Experience in Malaysia, Working Paper #46, Program on Energy and Sustainable Development, Stanford University, 2005.
[89] Stakeholder consultations, October 5, 2011.
[90] Rnewable Energy Act 2011.

however it does provide a possible model to achieve cost recovery for CCS through the making process.

3.8 Oil, Gas and Mining Laws

Petroleum Laws. Under the Petroleum Development Act, the Federal Government vested all of Malaysia's petroleum resources in Petronas. Through delegation by the Prime Minister under the Petroleum Development Act, Petronas is also responsible for planning, investment and regulation of all up-stream oil and gas activities.[91] Petronas operates fields itself and enters into production sharing contracts with other exploration and development companies. Petronas reports directly to the Prime Minister.

Under the Petroleum Mining Act, all exploration activity requires a permit or agreement with the appropriate authority.[92] For offshore exploration, the Yang di-Pertuan Agong issues permits, whose responsibilities in this area are exercised by Petronas; for onshore activities, the state ruler license exploration activities.[93] Exploration permits are granted for a minimum period of 2 years and may be extended thereafter.[94] The Petroleum Mining Act provides for petroleum agreements to be entered into for exploring, prospecting or exploiting petroleum, and specifically reserves the right of the authority to make modifications of exclusions to these agreements to cover "ancillary matters" that it may deem appropriate.[95] Further, the form of license contained in the schedules to the Petroleum Mining Act explicitly reserves the right of the licensor to exclude other mineral rights and other "parts" of the grant area, which presumably is broad enough to cover pore space.[96] The license also contains general requirements for abandonment and plugging wells.[97]

Malaysia has no specific legislation governing gas storage, however such activity would require approval of the MNRE's Department of Environment.[98] Malaysia also has no specific laws concerning abandonment or decommissioning of oil or gas production facilities. Petronas does, however, maintain guidelines governing abandonment and decommissioning that provides guidance to operators[99] and internal technical standards, which provide greater detail.[100] Under Petronas guidelines, liability for abandoned structures are determined by Petronas in consultation with other government agencies until such time as national policy on liability is adopted.[101]

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[91] Sections 7 and 7A, Petroleum Development Act 1974.
[92] Section 3, Petroleum Mining Act 1966, as amended.
[93] Section 4, Petroleum Mining Act 1966, as amended.
[94] Section 7(3), Petroleum Mining Act 1966, as amended.
[95] Section 8(2), Petroleum Mining Act 1966, as amended.
[96] Second Schedule, Sections 3 and 4, Petroleum Mining Act 1966, as amended.
[97] Second Schedule, Section 10, Petroleum Mining Act 1966, as amended.
[98] Stakeholder consultations, October 7, 2011.
[99] Section 16, Petronas Procedures and Guidelines for Upstream Activities, August 2008.
[100] Stakeholder consultations, October 7, 2011.
[101] Section 16.7.6, Petronas Procedures and Guidelines for Upstream Activities, August 2008.

3.9 Public Participation

Public participation is promoted through the Local Authority Act 1976, which requires the appointment of local councils, a majority of whose members must reside in the area they serve.[102] In addition, the public has certain rights to be provided with information, to comment, and to a hearing as part of the state and local planning process.

Under the Town and Country Planning Act, State Directors are required during the preparation of a draft structural plan to ensure that "persons who may be expected to desire an opportunity of making representations to the State Director in respect of those matters are made aware that they are entitled to, and are given, an opportunity of doing so . . ." and to take into account such representations in preparation of the plan.[103] State authorities are required to give the public notice of draft structural plans once received by the State Planning Committee through public announcement and publication in at least two local newspapers, make plans available for inspection at their offices and other places, and provide a public comment period of at least one month.[104] Persons filing an objection are entitled to a public hearing.[105] The State Planning Committee must seek the advice of the National Physical Planning Council and, if it approves the plan, submit it to the State Authority for its assent.[106] The Town and Country Planning Act states that the State Planning Committee may but is *not* obligated to seek the opinion of local people beyond the requirements noted above.[107] Once approved, structural plans must be reviewed every 5 years.[108]

Prior to the adoption of the state structural plan, the local planning authority may prepare a local plan to be submitted to the same State Planning Committee and State Authority for its assent.[109] Once a state structural plan has been adopted, the local planning authority is required to prepare a local plan.[110] The local plan is to provide for the development and use of land, and the protection and improvement of the environment.[111] Significantly, the term "land" is defined to include surface and "all substances below the surface of the earth".[112]

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[102] Section 10(2), Local Government Act 1976.
[103] Section 9(1), Town and Country Planning Act.
[104] Section 9(2), Town and Country Planning Act.
[105] Section 10(3), Town and Country Planning Act.
[106] Section 10(4) and (6), Town and Country Planning Act.
[107] Section 10(4), Town and Country Planning Act, states "the Committee . . . may consult with, or consider the views of, any other authority or any other persons but shall not be under any obligation to consult with, or consider the views of, any other authority or any other persons or, except as provided by that subsection, to afford an opportunity for the making of any objections or other representations, or to cause a local inquiry or other hearing to be held.".
[108] Town and Country Planning Act, Section 11.
[109] Town and Country Planning Act, Section 12(1).
[110] Town and Country Planning Act, Section 12(2).
[111] Town and Country Planning Act, Section 12(3).
[112] The definition of land also includes "all things, whether on or below the surface of the earth, that are attached to the earth or permanently fastened to any thing attached to the earth." Section 2, Town and Country Planning Act.

Publicity requirements for the local plan are similar to those described above for the state structural plan.[113] The local plan must conform to the state structural plan.[114] Objection to the local plan triggers a local inquiry conducted by a committee appointed by the State Planning Committee.[115]

MNRE's DOE issues guidelines for conducting EIAs for various types of projects. While not strictly requiring public hearings, these guidelines describe the purpose of scoping the EIA to include understanding public opinion.[116] The guidelines provide various options for facilitating public participation during the EIA process, including holding local hearings with the public.[117] Stakeholders commented that public hearings for detailed EIAs are typically carried out at the site in order to enable local stakeholders to present their views.[118] Although local authorities lack the authority to approve the EIA itself, their views are generally considered in the final EIA approval.

3.10 Foreign Investment

Malaysia limits foreign ownership in strategic sectors to a 30% stake, which has been applied to the power sector.[119] The limit is not contained in any statute, but rather is implemented as a de facto policy through the regulatory approval process.[120] Oil and gas concessions are competitively tendered to domestic and foreign operators, however Petronas is a mandatory partner in all concessions.

3.11 Financial Incentives

Government incentives have been primarily focused on energy efficiency measures. Malaysia has provided tax incentives for energy conservation measures adopted by companies, including investment tax allowances, and import duty and sales tax allowances. Companies providing energy conservation services also could qualify for an income tax exemption. Companies that import energy efficient products were eligible for

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[113] Sections 12A and 13, Town and Country Planning Act.
[114] Section 15(5), Town and Country Planning Act.
[115] Section 14, Town and Country Planning Act.
[116] See, e.g., Section 5.2, MNRE, Environmental Impact Assessment Guidelines for Thermal Power Generation, ("Scoping is a process applied at the early stages of project assessment with the following objectives: . . .(iii) to inform potentially affected people of the proposal; (iv) to understand the values held by individual and groups about he qualify of the environment that might be affected by the proposal . . . ." See also Section 4.5, MNRE, Environmental Impact Assessment Guidelines for Industrial Projects ("Social/cultural: Avoid populated areas, parks and scenic areas. Public participation and local interest groups consultation to gain local acceptance and an assessment of the impact on cultural resources would be necessary.").
[117] See, e.g., Section 5.3.2, MNRE, Environmental Impact Assessment Guidelines for Thermal Power Generation; Section 5.3, MNRE, Environmental Impact Assessment Guidelines for Petroleum Industries ("Scoping is a multi-disciplinary task and should seek input from the proponent, architects, engineers, designers, planners, environmental consultants, risk consultants and affected local community with the advice of DOE and local authorities.");
[118] Stakeholder consultations, October 5, 2011.
[119] Jeff Rector, The IPP Investment Experience in Malaysia, Working Paper #46, Program on Energy and Sustainable Development, Stanford University, 2005.
[120] Jeff Rector, The IPP Investment Experience in Malaysia, Working Paper #46, Program on Energy and Sustainable Development, Stanford University, 2005.

exemption of import duty and sales tax and companies that manufacture energy efficiency products could qualify for a sales tax exemption.[121]

[121] Suruhanjaya Tenaga, Guidelines in Applying Energy Efficiency Incentives, available at http://www.st.gov.my/index.php?option=com_content&task=view&id=4080&Itemid=1238 (accessed October 13, 2011).

MEXICO REGULATORY ASSESSMENT

1. POLITICAL AND LEGAL SYSTEM

The United Mexican States (Mexico) is a Federal Republic comprised of 31 states and a Federal District (Mexico City). The Federal Republic has three branches: Executive Branch, Legislative Branch, and Judicial Branch. Each state elects its own governor and legislature; municipal authorities are chosen at the local level.[1]

The Executive Branch is led by the President of Mexico. The president is directly elected by a simple majority of registered voters in the 31 states and the Federal District for a six-year term, and cannot be reelected. There is no vice president. There is a hierarchy of influence among the different cabinet posts, and the power of a minister or secretary varies, depending on the priorities set by a particular president. Traditionally, the secretary of interior has been an influential figure and often has been chosen to succeed the president.[2]

The Legislative Branch consists of a bicameral congress divided into an upper Senate chamber and a lower chamber called the Chamber of Deputies. Both chambers are responsible for the discussion and approval of legislation and the ratification of high-level presidential appointments. The Chamber of Deputies has 500 members, elected for a three-year term; 300 elected by simple majority in single-member districts, and 200 elected by proportional representation in five 40-member regional districts. The Senate has 128 members, elected for a six-year term. Each state elects three senators, and in addition 32 are elected by proportional representation on a single nation list. All members of the congress are barred from immediate reelection but may serve nonconsecutive terms. In theory, the power of introducing bills is shared with the executive, although in practice the executive initiates about 90 percent of all legislation.[3]

The Judicial Branch is divided into federal and state systems. The Supreme Court of Justice, Mexico's highest court, has eleven justices, all appointed by the President and confirmed by the Senate. There are three levels of federal courts under the Supreme Court of Justice: twelve Collegiate Circuit Courts; nine Unitary Circuit Courts; and 68 District Courts. The Mexican legal system is based on Spanish civil law with some influence from common law systems.

Municipal governments are responsible for a variety of public services, such as water and sewerage. Municipalities also assist state and federal governments in the provision of elementary education, emergency fire and medical services, environmental protection, and the maintenance of historical landmarks.[4]

Mexico's legal system is based on the civil law tradition. Mexico's federal government and state governments have authority to adopt their own laws, subject to the supremacy of federal law.

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[1] "The Mexican Political System," *International IDEA* available at www.idea.int, accessed on Aug. 1, 2011.
[2] Ibid.
[3] "The Mexican Political System," *International IDEA* available at www.idea.int, accessed on Aug. 1, 2011.
[4] Ibid.

Mexico's modern Federal Civil Code of 2000, based on the Civil Code of 1928, has been adopted almost verbatim by all of Mexico's 31 states and the Federal District.[5]

Certain government ministries would play a critical role in the development of CCS regulation and the approval of a CCS project in Mexico. These government ministries include:

Secretariat of Energy **(SENER)** is the government department responsible for energy production and regulation in Mexico. SENER is primarily a policy body, with enforcement being carried out by the National Hydrocarbon Commission and the Energy Regulatory Commission, which are within SENER. SENER supervises the state-owned power generation company CFE, state-owned oil production company PEMEX, and the Mexican Petroleum Institute. SENER organized and chairs a CCS working group of government CCS stakeholders in Mexico.

> **National Hydrocarbon Commission** is a semi-autonomous technical branch of SENER that has regulatory authority specifically related to the optimization of hydrocarbon resources. The Commission also approves PEMEX standards for oil and gas production and has developed standards for such matters as gas flaring. The Commission will be independently funded based on a percentage of PEMEX starting in 2012.[6]
>
> **Energy Regulatory Commission** regulates the downstream electricity and natural gas business. The Commission is responsible for administering the wholesale power pricing scheme for independent power producers that generate electricity using renewable energy and natural gas. The Commission does not approve consumer electricity tariffs, which are determined by the Secretariat of Finance & Public Credit.

Secretariat of Environment and Natural Resources (SEMARNAT) is Mexico's environmental regulator. It is responsible for the protection, restoration and conservation of ecosystems and natural resources, as well as environmental goods and services, in order to promote their sustainable use and development.[7] While state and local agencies and officials have the power to enforce laws under their jurisdiction, SEMARNAT is the principal agency responsible for enforcement of environmental laws in Mexico.[8]

> **The Federal Attorney of Environmental Protection (PROFEPA)** is an agency with technical and operational autonomy within SEMARNAT. Its main task is enforcement of environmental regulation.[9]
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> **The National Water Commission (Conagua)** is an agency within SEMARNAT created through a presidential mandate in January 1989. Its main task is to manage and preserve national waters in order to ensure its sustainable use.[10]

Secretariat of Finance & Public Credit (SHCP) proposes, directs, and controls the Federal Government's economic policies on finance, taxation, and the budget. It approves annual

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[5] Jorge Vargas, Mexican Civil Code Annotated, 2009 Edition, Thomson Reuters.
[6] Article 254 quater, Federal Royalties Law.
[7] *Secretaria De Medio Ambiente Y Recursos Naturales* available at www.semarnat.gob.mx/English/Pages/home.aspx, accessed on Aug. 2, 2011.
[8] "Mexican Law", Stephen Zamora, Jose Ramon Cossio, Leonel Pereznieto, Jose Roldan-Xopa, and David Lopez, *Oxford University Press,* 2004.
[9] *Secretaria De Medio Ambiente Y Recursos Naturales* available at www.semarnat.gob.mx/English/Pages/home.aspx, accessed on Aug. 2, 2011.
[10] *Secretaria De Medio Ambiente Y Recursos Naturales* available at www.semarnat.gob.mx/English/Pages/home.aspx, accessed on Aug. 2, 2011.

budgets for PEMEX and CFE, which are then included in the government budget submitted to Congress for approval. SHCP's support would be essential for approval of PEMEX and CFE budgets for demonstration projects that involve significant expenditure and do not pay for themselves. SHCP reviews large project allocations based on rates of return as well as social and environmental impacts of a project. SHCP sets electricity tariffs and subsidies for CFE.

Secretariat of Transportation & Communications regulates infrastructure, roads, highways, pipeline, truck and marine transportation.

Federal Regulatory Improvement Commission (COFEMER) is charged with reviewing all draft regulations, and proposals to amend regulations, before they are finalized by the federal agency proposing them. In proposing the new regulation, the agency must submit a Manifestation of Regulatory Impact to assess the impact of the regulation on society.[11] COFEMER is advised by a council made up of the Secretaries of the Economy, Treasury, Public Administration, Labor, and the Legal Counsel to the president; other federal officials designated by the President (governor of the Bank of Mexico, the chairman of the Federal Competition Commission, and the Attorney General for Consumer Affairs); and representatives from the business, labor, agricultural, and academic sectors.

Mexico Geological Survey under the Secretariat of the Economy is responsible for general survey and mapping of geologic resources in Mexico. The Survey is currently engaged in mapping potential CO_2 sinks in collaboration with the U.S. Geologic Survey and Natural Resources Canada under an international agreement between the three countries to identify potential CO_2 sinks based on common methodologies.

Federal Electricity Commission (CFE) is the state-owned power generation and distribution company and is responsible for planning the national electrical system. CFE is the sole purchaser and distributor of electricity in Mexico and acts as the system operator. CFE is actively developing its capacity in CCS, including a CCS demonstration project with PEMEX.

Petreoleos Mexicanos (PEMEX), formed in 1938, is a government-owned company that holds a monopoly on the exploration, production, marketing, and sale of oil and gas, and of basic petro-chemicals in Mexico. PEMEX is Mexico's largest company and the greatest single contributor to the country's revenues. PEMEX is organized as four subsidiaries: PEMEX Exploration and Production; PEMEX Refining; PEMEX Gas and Basic Petrochemicals; and PEMEX Petrochemical. PEMEX is actively developing enhanced oil recovery projects with the support of IMP and is developing a CCS pilot project with CFE using CO_2 from a power plant.

Several research institutes are important for developing CCS capacity and supporting other stakeholders, primarily the Mexican Petroleum Institute, Electric Research Institute, the National Ecology Institute and the Mario Molina Center.

Mexican Petroleum Institute (IMP) is a public organization dedicated to basic and applied scientific research and engineering to develop technologies primarily to support PEMEX in hydrocarbon recovery.[12] IMP's applied research includes demonstration projects in petroleum technologies and characterizing and assessment of reservoirs specifically for hydrocarbon recovery purposes. IMP operates 34 laboratories and maintains research divisions for pipeline

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[11] "Mexican Law", Stephen Zamora, Jose Ramon Cossio, Leonel Pereznieto, Jose Roldan-Xopa, and David Lopez, *Oxford University Press,* 2004.

[12] *Instituto Mexicano Del Petroleo* at www.imp.mx/acerca/EstructuraOrganica-en.pdf, accessed on Aug. 2, 2011.

integrity, reservoir modeling, chemical engineering, geology and hydrocarbon recovery.[13] IMP's technical capabilities includes enhanced oil recovery research and test injections, natural gas processing and purification, seismic conditions and conducting training programs across a broad range of petroleum applications.

Electric Research Institute is a government research laboratory to support the electricity sector, primarily CFE. The Institute also conducts research for electricity-intensive industries as part of its mandate. The Institute is experimenting with capture technologies using amines and oxyfuel combustion (using a 35 KW oxyfuel test project). The Institute is developing a potential demonstration project with the cement sector on potential emissions reductions technologies using chemical looping technology.

National Ecology Institute is a government research center and think tank under the direction of SEMARNAT. The Institute has capability in climate change.

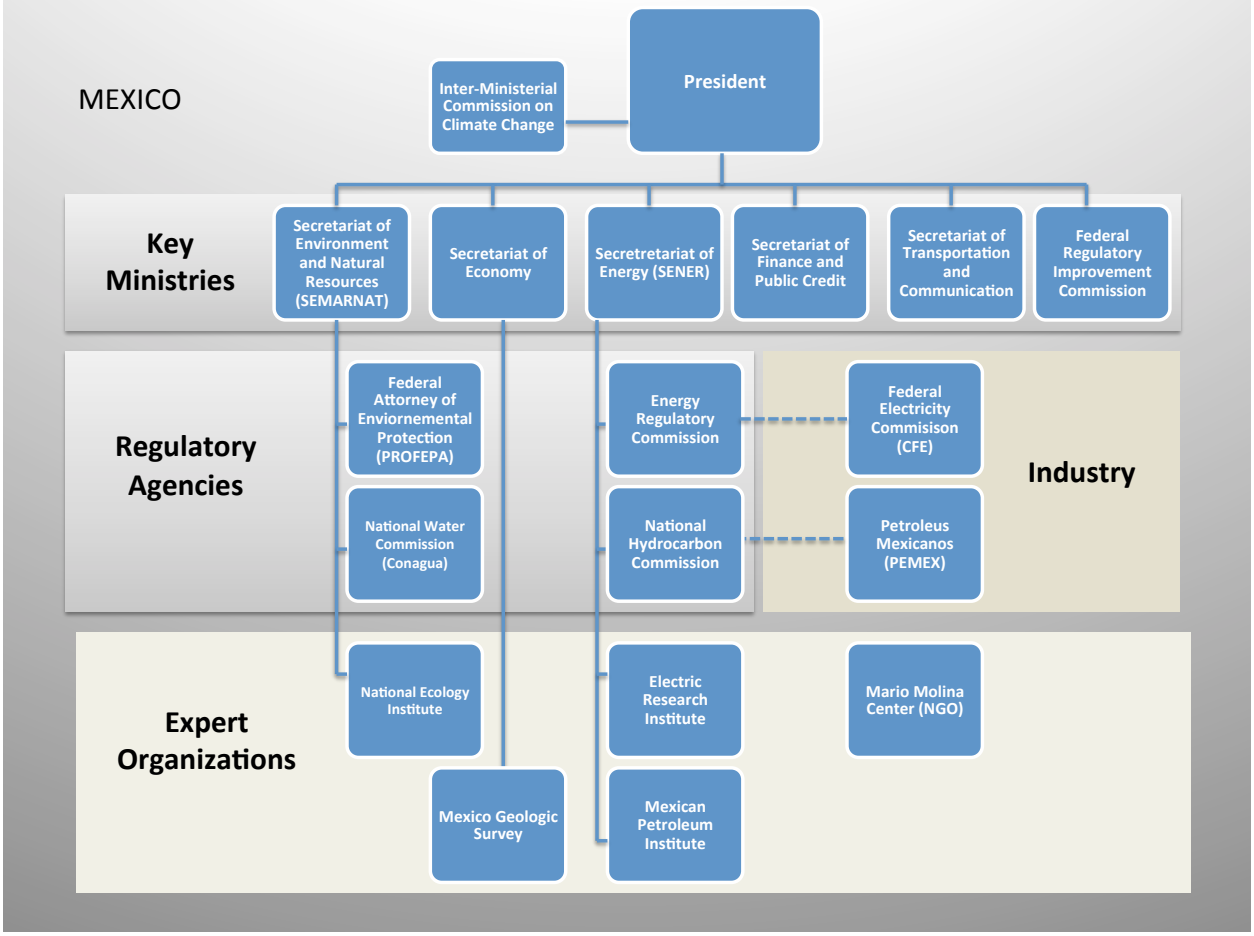
Mario Molina Center is a non-profit research center partly funded by the Mexican government dedicated to environmental and energy issues. The Mario Molina Center supports CFE in developing its capacity for CCS and is influential in government and policy circles in Mexico.

The Inter-Ministerial Commission on Climate Change (CICC) was established in April 2005 to coordinate the formulation of policies on climate action. In 2006, CICC published the Toward a National Climate Action Strategy (HENAC), which provides the basis for the National Climate Change Strategy, which was issued in 2007.[14] The Chairman of the Commission is the Minister of the Environment and Natural Resources. Other members of the Commission include: Minister of Agriculture, Livestock, Rural Development; Minister of Communications and Transportation; Minister of the Economy; Minister of Social Development; Minister of Energy; Minister of Foreign Affairs; Vice Minister of Planning and Environment Policy of SEMARNAT; Director-General for Climate Change Projects of SEMARNAT; President of the Climate Change Advisory Council; and Secretary of the Climate Change Advisory Council.

[13] Stakeholder consultations, August 30, 2011.

[14] *National Climate Change Policy – Mexico,* available at www.cambioclimatico.gob.mx/index.php/en/politica-nacional-sobre-cambio-climatico.html, July 22, 2010.

The diagram below shows selected central government entities and stakeholders that would be involved in regulating or undertaking a CCS project. State or local government entities are not shown on the diagram.



2. CLIMATE CHANGE LAW AND POLICY

Mexico, as a Non-Annex 1 country to the United Nations (UN) Convention on Climate Change (UNFCCC), does not have legally binding greenhouse gas (GHG) emission reduction targets. Nonetheless, the Mexican government has developed a National Climate Change Strategy (National CC Strategy) to reduce the emission of GHGs. In addition, Mexico has been active in the UNFCCC as one of the founding members of the Environment Integrity Group. Mexico set a goal to reduce its greenhouse gas emissions by 50% from 2000 levels by 2050.[15]

[15]The National Climate Change Strategy, 2007.

National Climate Change Strategy, prepared by SEMARNAT in 2007, identified CCS projects as a priority field of research: "Feasibility of secondary oil recovery by CO2 injection into extinct or low pressure oilfields; and carbon capture and geological storage."[16]

Special Climate Change Program (PECC) 2009-2012 is a voluntary initiative led by SENER that commits federal government departments to meet national mitigation and adaptation objectives and goals for the 2009-2012 period. The PECC also includes a long-term vision in which goals are established for mitigation projections extended toward 2020, 2030, and 2050.

Closely related to Mexico's climate change policies is Mexico's ongoing energy reform. Starting in 2008, Mexico commenced an energy reform designed to enhance energy security by optimizing the use of traditional fossil fuels and increasing the use of renewable and clean energy. The reform includes a restructuring of the regulatory institutions that govern the energy complex. Under the reform, which is still in the process of implementation, regulatory authority for energy is to become centralized under SENER in coordination with the Electricity Regulatory Commission and the recently created National Hydrocarbon Commission.[17] As part of this reform, Mexico has enacted the Law for the Development of Renewable Energy and Energy Transition Financing and the Law for the Sustainable Energy Development, which is essential to its efforts to address climate change.

In addition to the CICC described above, several working groups are responsible for carrying out climate change policy. Working groups that could address CCS are:

Working Group on Special Climate Change Program (GT-PECC), administered by the Under-Secretary's Office for Environmental Planning and Policy of the Ministry of Environment and Natural Resources, complies the information from the CICC's Annual Public Reports on Climate Action. [18]

Mexican Committee for Emission Reduction and Greenhouse Gas Capture Projects (COMEGEI) was launched in 2004, and is coordinated by the Under-Secretary's Office for Environmental Planning and Policy. The Committee serves as the Designated National Authority to the UNFCCC for the Clean Development Mechanism.

Mitigation Working Group (GT-MITIG) proposes mitigation policies, strategies, and actions to the CICC.[19]

Working Group on International Climate Change Negotiations (GT-INT) is coordinated by Mexico's Ministry of Foreign Affairs, through its global affairs department. This group supports the inter-departmental coordination of Mexico's positions at the UNFCCC.[20]

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[16] National Strategy for Climate Change Executive Summary available at www.semarnat.gob.mx/english/Documents/Executive Summary.pdf, 2007.
[17] Article 33, Organic Law for Federal Public Administration.
[18] National Climate Change Policy – Mexico, available at www.cambioclimatico.gob.mx/index.php/en/politica-nacional-sobre-cambio-climatico.html, July 22, 2010.
[19] Ibid.
[20] National Climate Change Policy – Mexico, available at www.cambioclimatico.gob.mx/index.php/en/politica-nacional-sobre-cambio-climatico.html, July 22, 2010.

3. LAWS AND REGULATION APPLICABLE TO CCS

Currently, Mexico has no legislation or regulation that specifically governs CCS projects, however, existing laws and regulations may be applicable to particular CCs activities.

3.1 Classification of CO_2

Several laws and regulations define waste or similar concepts in a broad manner, which could provide a foundation for a regulatory determination that CO_2 is a "waste" in the context of geologic sequestration.

The General Law of Ecological Equilibrium and Environmental Protection defines the term "waste" broadly to mean "Any material generated in the processes of extraction, dressing, transformation, production, consumption, use, control or treatment that, due to its quality, can not be used again in the process where it was produced."[21] Hazardous waste is defined as "All those wastes, in any physical state, that due to its corrosive, reactive, explosive, toxic, flammable or biological-infectious characteristics represent a risk to ecological balance or the environment."[22]

The Regulations on National Water Law does not define the term "waste", however it does prohibit discharges into receiving bodies. The Regulations define discharges as "the act of pouring, infiltrating, depositing, or injecting waste waters into a receiving body".[23] Receiving bodies are any "natural or current deposit of water" including aquifers. [24] While the Regulations speak mostly in terms of wastewater, its purpose is to protect water resources. It contains a general prohibition against polluting waters, including groundwater, and requires their remediation.[25]

The General Law for Prevention and Integral Waste Management provides for the designation of "waste" and "hazardous waste" in the context of integrated waste management. [26] This law would rely upon the definitions of wastes in the General Law of Ecological Equilibrium and Environmental Protection. As described below, it contains provisions regulating injection of substances in subsurface geologic formations, which could be applied to CO_2, thereby effectively treating it as a waste.

The Environmental Law of the Federal District, which applies only to Mexico City, defines "hazardous materials or waste" as "substances, compounds or waste and mixtures thereof which, due to their corrosive, toxic, reactive, explosive, flammable or biological-infectious characteristics, represent a hazard to the environment in accordance with applicable Official

[21] Article 2, The General Law of Ecological Equilibrium and Environmental Protection.
[22] Article 2, The General Law of Ecological Equilibrium and Environmental Protection.
[23] Article 2, Regulation of the National Waters Law
[24] Article 27, Constitution of Mexico.
[25] Article 134, Regulation of the National Waters Law.
[26] Article 1 and Title 3, General Law for Prevention and Integral Waste Management.

Mexican Norms."[27] Similarly, the law defines "polluting emissions" as "Generation or discharge of any amount of material or energy in any physical state of form, that negatively affects the composition or natural condition of living beings, the atmosphere, water, soil, subsoil or any natural element, when it is incorporated, accumulated or acts upon them."[28]

3.2 Surface Rights and Subsurface Rights

The Constitution of Mexico states that that "all land and water within national territory is originally owned by the Nation, who has the right to transfer this ownership to particulars."[29] It further states, "All natural resources in national territory are property of the nation, and private exploitation may only be carried out through concessions."[30]

As a result of these provisions, Mexico holds title over all oil and gas reservoirs as well as other natural resources. As a result, a private landowner in Mexico has no right to exploit subsoil resources located on his property. The federal government holds the right to exploit the natural resources located on private property, and may only authorize their exploitation.[31]

Pore space would similarly appear to be owned by the State assuming it would be deemed a "natural resource". Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector supports this interpretation as it explicitly states the "surface and subsurface" are to be exploited by the national government for the public good and provides the government with imminent domain rights to develop the national oil industry.[32] Article 838 of the Federal Civil Code reiterates this principle, "All minerals or other substances mentioned in the Fourth Paragraph of Article 27 of the Constitution of the United Mexican States and the waters referred to in Paragraph Five of the same Article shall not belong to the owner of the parcel of land, and title to them vests in the Nation."[33]

Mexico's Federal Civil Code, described further below, defines real property to include "all wells, pools, reservoirs and waterways, as well as aqueducts and piping ducts of any type used for carrying liquids or gases to an estate or for their extraction therefrom" and "all rights relating to real property."[34]

3.3 Long-Term Stewardship and Liability for Stored CO_2

As described further below, the General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) provides for general civil liability for causing damage to the environment with a five year statute of limitations to bring causes of action counted from the time the fact, act or omission occurred.[35] Further, when the generation, management or final disposal of hazardous materials or wastes pollutes the soil, the parties responsible for those operations

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[27] Article 6, The Environmental Law of the Federal District, *Department of Federal District of Mexico*.
[28] Article 6, The Environmental Law of the Federal District, *Department of Federal District of Mexico*.
[29] Article 27, Constitution of Mexico.
[30] Article 27, Constitution of Mexico.
[31] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.
[32] Article 10, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[33] Article 838, Federal Civil Code.
[34] Article 750 (IX and XII), Federal Civil Code.
[35] Article 203, General Law of Ecological Equilibrium and Environmental Protection.

must remediate the area.[36] Similarly, regulations issued under National Water Law require polluters to take remedial actions and authorizes the National Water Commission to require compensation for damage caused.[37]

The General Law for Prevention and Integral Waste Management and the regulations promulgated thereunder provides for injection of waste and other substance in underground geologic formations, including saline formations. If CO_2 were deemed a hazardous waste and this were applied to CCS, the law would require those engaged in providing services such as transport, storage or reuse of dangerous substances would be required to obtain a license from SEMARNAT, which would include development of emergency response plans and deployment of best practices and technology.[38] For storage operations, operators are required to provide guarantees and the law specifically provides for the operator to remain liable for the site a minimum of 20 years after site closure for dangerous substances.[39] If CO_2 were treated as a "pollutant" under this law, it could also potentially trigger obligations to remediate sites for damage caused.[40] Violations of the law are subject to administrative fines, suspension of operating licenses and remediation measures, and temporary administrative arrest, and possible criminal action.[41] As described further below, SEMARNAT has issued detailed regulations and NOMs that define specific obligations under the General Law for Prevention and Integral Waste Management relating to injection of substances in saline and other geologic formations.

SEMARNAT investigates environmental complaints and can impose administrative sanctions for violations of regulations and NOMs. As further described below, if SEMARNAT proceeds with an investigation, SEMARNAT will determine whether administrative sanctions or corrective measures are warranted based on whether the subject of the complaint has complied with applicable regulations and NOMs.[42] Thus, compliance with national standards would act as a bar to administrative liability to the extent of compliance. SEMARNAT could still pursue an action against a party under provisions in LGEEPA and other environmental laws requiring remediation, however SEMARNAT would likely pursue remediation of environmental conditions only to the extent of existing pollution standards.[43] SEMARNAT's administrative investigation would not preclude a party pursuing a civil case.

Further, under the Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector, PEMEX is obligated to repair any damage it does to the environment or ecological balance.[44] Pursuant to these regulations, any issues not covered by the regulations are governed by the Commercial Code and, by extension, the Federal Civil Code.[45]

The Federal Civil Code provides for liability for damages caused to property or otherwise under concepts of usufruct or contract. Because ownership of the subsurface vest in the State, rights to the use of the subsurface would necessarily be granted through one of these legal concepts.

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[36] Article 152, The General Law of Ecological Equilibrium and Environmental Protection.
[37] Article 150, Regulation of the National Waters Law.
[38] Articles 80, General Law for Prevention and Integral Waste Management.
[39] Articles 82, General Law for Prevention and Integral Waste Management.
[40] Articles 68, General Law for Prevention and Integral Waste Management.
[41] Articles 108, 110, 111, 112, General Law for Prevention and Integral Waste Management.
[42] Stakeholder Consultations, August 31, 2011.
[43] Stakeholder Consultations, August 31, 2011.
[44] Article 7 bis, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[45] Article 12, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.

A usufruct is a "temporary right in real property to enjoy property belonging to another."[46] Under the concept of usufruct, the beneficiary of a usufruct is liable for any damages or diminution of value of an assets caused by its negligence.[47] Failure of the beneficiary to notify the owner of the need to make repairs could also result in liability for damages.[48]

General contractual obligations for the temporary conveyance of the use of an asset my also give rise to liability.[49] Liability for deterioration of an asset generally falls upon the party who has possession and use of the asset, and the deterioration is presumed to have occurred as result of the possessor's fault unless proven otherwise.[50]

The Civil Code also provides for general liability under tort theories. Under the Code, "Whoever, by acting illicitly or against the good customs, causes damage to another shall be obligated to compensate him/her, unless he/she can provide that the damage was caused a result of the fault or inexcusable negligence of the victim."[51] The reference to "good customs" is broad, potentially creating liability for failure to follow accepted industry practices or perhaps a more general duty of care as conceptualized in common law jurisprudence. Inherently dangerous activity give rise to strict liability, again with a defense that injury was caused by the "fault of inexcusable negligence of the victim."[52] The damage award for tortious acts is either, at the election of the victim, restoration or compensation, with additional amounts for death or disability.[53]

Finally, the Civil Code imposes liability for business enterprises for injuries resulting from employment accidents suffered by workers as result of their employment.[54]

Claims under the Civil Code are subject to a ten year statute of limitations, subject to certain exception, including a two year limit for tort claims.[55]

Consultations with government stakeholders revealed concern about their potential personal liability for failure to comply with any laws that could be adopted requiring reductions to greenhouse gas emissions reductions.[56] Government officials were also concerned with potential liability associated with undertaking projects involving new technologies and novel risks.

Government employees, including employees of PEMEX and CFE, are subject to the Federal Law of Responsibilities of Public Servants (*Ley Federal de Responsabilidades de los Servidores Publicos*) and the Federal Law of Administrative Responsibilities of Public Servants (*Ley Federal de Responsabilidades Administrativas de los Servidores Publicos*).[57]

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[46] Article 980, Federal Civil Code.
[47] Article 1012, Federal Civil Code.
[48] Article 1023, Federal Civil Code.
[49] See Article 2011, Federal Civil Code.
[50] Articles 2017 and 2018, Federal Civil Code.
[51] Article 1910, Federal Civil Code.
[52] Article 1913, Federal Civil Code.
[53] Article 1915, Federal Civil Code.
[54] Articles 1935-1937, Federal Civil Code.
[55] Articles 1159 and 1161, Federal Civil Code.
[56] Stakeholder Consultations, August 29 – September 2, 2011.
[57] Article 111, Constitution of Mexico; Article 5, Federal Law of Administrative Responsibilities of Public Servants (Ley Federal de Responsabilidades Administrativas de los Servidores Publicos); Articles 2 and

The Federal Law of Responsibility of Public Servants subjects public servants to potential liability for failure to comply with laws or systematic acts that result in serious financial losses to the government.[58] It includes detailed provisions for periodic reporting of financial information, investigation and impeachment of senior public servants.

Pursuant to the Federal Law of Administrative Responsibilities of Public Servants, public servants have a general duty to perform their duties without act or omission that causes deficiency in their performance.[59] Violation of duties could result in termination and financial sanctions.[60]

The Board of PEMEX can also be held liable for any damages they cause to PEMEX if they breach their duty of care or duty of loyalty to the corporation, however they also benefit from provisions that approximate a business judgment rule similar to common law jurisdictions.[61]

The Federal Civil Code further states, "The State is liable for damages and injuries caused by its officers in the exercise of their duties." The provision further clarifies that the State's responsibility to indemnify victims is joint and several with the officer if the act was unlawful or in bad faith. In all other cases, the State's responsibly is secondary and only triggers if the individual officer is unable to compensate the victim.[62]

3.4 Environmental Protection

General Law of Ecological Equilibrium and Environmental Protection (LGEEPA) establishes the jurisdictional authority of federal, state, Federal District, and municipal governments with regard to environmental protection of the atmosphere, water systems, soil, hazardous activities, hazardous wastes and materials, and other forms of pollution.

LGEEPA provides for general civil liability for causing damage to the environment with a five year statute of limitations to bring causes of action.[63] According to Article 203 of LGEEPA, **"**Without prejudice to the corresponding criminal or administrative sanctions, any individual who pollutes or damages the environment or affects natural resources or biodiversity, shall be responsible and obliged to repair the damage caused pursuant to the applicable civil legislation. The time period to file a complaint regarding environmental responsibility shall be five years counted from the moment in which the corresponding fact, action or omission occurred."

LGEEPA directs SEMARNAT to compile an inventory of atmospheric emissions, discharge of waste into water bodies or into the sub-soil, dangerous materials and residues under its

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80, Federal Law of Responsibility of Public Servants (Ley Federal de Responsabilidades de los Servidores Publicos).

[58] Article 7, Federal Law of Responsibility of Public Servants (Ley Federal de Responsabilidades de los Servidores Publicos).

[59] Article 8(I), Federal Law of Administrative Responsibilities of Public Servants (Ley Federal de Responsabilidades Administrativas de los Servidores Publicos).

[60] Article 13, Federal Law of Administrative Responsibilities of Public Servants (Ley Federal de Responsabilidades Administrativas de los Servidores Publicos).

[61] Articles 37-42, Law of Petroleos Mexicanos.

[62] Article 1927, Federal Civil Code.

[63] Article 203, General Law of Ecological Equilibrium and Environmental Protection.

jurisdiction, and maintain a system of licenses or permits for such emissions and discharges.[64] SEMARNAT is authorized to regulate emissions and discharges through a variety of means including establishing limits, monitoring, and setting standards through Official Mexican Standards (NOMs), developing programs with state and local authorities, and the imposition of penalties.[65] SEMARNAT's enforcement powers include the ability to close down polluting sources and operations that pose an imminent risk to the environment.[66]

LGEEPA specifies the criteria for prevention and control of soil pollution.[67] All discharge, deposit or infiltration of polluting substances or material into the soil is subject to LGEEPA, the Law of National Waters, their regulatory provisions, and official Mexican technical standards issued for such purpose by the Minister.[68]

SEMARNAT is required to consult the Ministers of Commerce and Industrial Encouragement, of Health, of Energy, of Communications and Transport, of the Navy and Ministry of Interior in developing regulations for hazardous waste. The Regulation and the official Mexican standards shall contain the criteria and listings that classify the hazardous materials and wastes identifying them by their degree of being hazardous and considering their characteristics and volumes.[69]

LGEEPA requires the regulation of discharge of industrial and other wastes into water sources.[70] Pursuant to LGEEPA, the Law of National Water protects surface and groundwater. It penalizes "allowing materials or substances that pollute waters of the subsoil to leak out."[71] The penalties applicable to such offences include fines and the closure of facilities or eviction from unlawfully occupied property.[72] The Regulations on National Water Law contains a general prohibition against polluting waters and requires their remediation.[73] It further prohibits the deposit of various kinds of waste in receiving bodies (e.g., garbage, sludge, materials, refuse, etc.) that could pollute waters. [74] The Regulations require a permit for waste water discharge and periodic monitoring and reporting,[75] which in practice is required for any kind of discharge that could pollute water. The Regulations require polluters to take remedial actions and authorizes the National Water Commission to require compensation for damage caused.[76]

LGEEPA requires the SEMARNAT to identify "high risk" activities in respect of the environment based on such factors as impact of potential extraordinary events, proximity to population centers.[77] Those engaged in high risk activities are require to submit an environmental risk

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[64] Article 109bis, General Law of Ecological Equilibrium and Environmental Protection.
[65] Article 111, General Law of Ecological Equilibrium and Environmental Protection.
[66] Article 170, General Law of Ecological Equilibrium and Environmental Protection.
[67] Article 134, General Law of Ecological Equilibrium and Environmental Protection.
[68] Article 139, General Law of Ecological Equilibrium and Environmental Protection.
[69] Article 150, General Law of Ecological Equilibrium and Environmental Protection.
[70] Articles 120-121, General Law of Ecological Equilibrium and Environmental Protection.
[71] The Law of National Water*,* 1992.
[72] The Law of National Water*, Article 20-122,* 1992.
[73] Article 134, Regulation of the National Waters Law.
[74] Article 151, Regulation of the National Waters Law.
[75] Article 135, Regulation of the National Waters Law.
[76] Article 150, Regulation of the National Waters Law.
[77] Article 145, General Law of Ecological Equilibrium and Environmental Protection.

study to SEMARNAT, SENER and other ministries.[78] SEMARNAT has issued two lists of highly risky activities, neither of which contain CO_2.[79]

General Law for Prevention and Integral Waste Management is an integrated waste management law that governs the prevention, generation, transport, disposal, import, and registration of waste. Among its objectives, the law contemplates the valuation of residues, as well as the development of by-product markets.[80] Regulations issued pursuant to the law provides for the disposal of certain wastes in geologically stable formations, including saline formations, that isolate waste from water sources and the general environment.[81] Containment sites must be geologically stable, meaning that it would contain injected substances including given seismic events, and may not be within protected areas unless specifically permitted under the terms governing the protected area.[82] The regulations require detailed hydrological, geological and seismic site assessment, information on processes and qualification of personnel, emergency response plans, comprehensive risk assessment and information on potential migration of injectants be submitted as part of the permitting process.[83] The operator must demonstrate compliance with applicable Official Mexican Standards, which are described further below, or a vulnerability study showing that the injection formation is geologically and mechanically stable, and possesses an impermeable containment layer.[84] Well design and construction must meet these standards and the facility must be evaluated following construction and prior operation, including mechanical integrity test, stability and volume confinement tests.[85] The regulations provide general operating guidelines that require injectants not to contaminate water or hydrocarbon resources, monitoring and reporting of injectants, and suspension of well operations when the geologic or mechanical integrity of a well is compromised.[86] Upon cessation of injection, the well must be sealed and equipment removed.[87] The regulations also provide for emergency response, remediation and administrative enforcement provisions.[88]

Pursuant to the General Law for Prevention and Integral Waste Management and the regulation issued thereunder, SEMARNAT has developed several Official Mexican Standards (NOMs) for various aspects of the injection of substances underground, which could be adapted for injection of CO_2.

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[78] Article 147, General Law of Ecological Equilibrium and Environmental Protection.

[79] See ACUERDO POR EL QUE LAS SECRETARÍAS DE GOBERNACIÓN Y DESARROLLO URBANO Y ECOLOGÍA, CON FUNDAMENTO EN LO DISPUESTO POR LOS ARTÍCULOS 5O. FRACCIÓN X Y 146 DE LA LEY GENERAL DEL EQUILIBRIO ECOLÓGICO Y LA PROTECCIÓN AL AMBIENTE; 27 FRACCIÓN XXXII Y 37 FRACCIONES XVI Y XVII DE LA LEY ORGÁNICA DE LA ADMINISTRACIÓN PÚBLICA FEDERAL, EXPIDEN EL PRIMER LISTADO DE ACTIVIDADES ALTAMENTE RIESGOSAS; and ACUERDO POR EL QUE LAS SECRETARÍAS DE GOBERNACIÓN Y DESARROLLO URBANO Y ECOLOGÍA, CON FUNDAMENTO EN LO DISPUESTO POR LOS ARTÍCULOS 5O. FRACCIÓN X Y 146 DE LA LEY GENERAL DEL EQUILIBRIO ECOLÓGICO Y LA PROTECCIÓN AL AMBIENTE; 27 FRACCIÓN XXXII Y 37 FRACCIONES XVI Y XVII DE LA LEY ORGÁNICA DE LA ADMINISTRACIÓN PÚBLICA FEDERAL, EXPIDEN EL SEGUNDO LISTADO DE ACTIVIDADES ALTAMENTE RIESGOSAS.

[80] Article 1, General Law for Prevention and Integral Waste Management.

[81] Articles 2 and 91, Regulations to the General Law for Prevention and Integral Waste Management.

[82] Article 100, Regulations to the General Law for Prevention and Integral Waste Management.

[83] Articles 50 and 51, Regulations to the General Law for Prevention and Integral Waste Management.

[84] Articles 98 and 101, Regulations to the General Law for Prevention and Integral Waste Management.

[85] Article 102, Regulations to the General Law for Prevention and Integral Waste Management.

[86] Article 103, Regulations to the General Law for Prevention and Integral Waste Management.

[87] Article 104, Regulations to the General Law for Prevention and Integral Waste Management.

[88] Articles 144-153, 154-163 Regulations to the General Law for Prevention and Integral Waste Management.

Official Mexican Standard 145 on the Confinement of Residuals in Cavities Constructed for Dissolution in Stable Geological Saline Domes establishes the specifications for site selection, well construction, operation, confinement integrity testing, water monitoring, and closing of injection wells to confine residual substances in geologically stable saline or limestone formations. The NOM contains general provisions except those concerning underground water quality and testing which are more detailed. The NOM is clearly intended for injection of non-CO2 substances and would require substantial modification for this purpose, how does provide a jurisdictional and programmatic basis upon which CCS regulation could be adopted.

NOM 145 relies on several other NOMs for specifics aspects of injection of substances underground. NOM-055-SEMARNAT-1993 specifies geologic and other requirements for the siting of underground confinement of highly dangerous substances, which are defined to include reactive or corrosive substances or substances in amounts that if released would significantly affect the atmosphere, the population or property. Geologic specifications include those relating to seismic stability, porosity, permeability and potential impacts on groundwater. Parameters for the quality of water sources and water sampling requirements are set out in NOM-001-SEMARNAT-1996. The construction, construction and operation of injection and monitoring wells must comply with requirements developed by Conagua in NOM-004-CNA-1996, in order to meet water quality specifications. Injection substances must also comply with standards that ensure that dangerous or otherwise incompatible substances are not injected in the formation, as determined in accordance with NOM-054-SEMARNAT-1993. NOM-058-SEMARNAT-1993 provides certain operating, monitoring and record keeping requirements for the operation of injections of dangerous residues. NOM-056-SEMARNAT-1993 establishes the requirements for the design and construction of infrastructure for controlled confinement of dangerous residues in man-made storage facilities, such as access roads, monitoring and emergency areas.

Environmental impact assessments (EIA) are required to be carried out for activities that might cause ecological imbalance or exceed the limits and conditions established in applicable regulations to protect the environment.[89] The activities that require an environmental impact assessment and SEMARNAT approval include: pipelines; petroleum, petrochemical, and electrical industries; exploration, extraction and mining of minerals; storage or elimination of hazardous wastes.[90] There are two types of EIA, regional and private. Both require consideration of impacts, risk assessment and mitigation and prevention measures, however the regional EIA looks more broadly at the project in terms of regional planning. SEMARNAT may authorize, deny or approve an EIA specifying conditions that prevent, mitigate, and compensate for adverse environmental impacts.[91] For projects that SEMARNAT determines the environment may be seriously damaged, it can require the provision of insurance or guarantees.[92] Importantly, the regulations provide SEMARNAT with ongoing jurisdiction to monitor and take corrective actions in compliance with the EIA and the conditions imposed in connection with its approval.[93] EIAs must be made available to the public.[94] Regulations to the

[89] Article 28, General Law of Ecological Equilibrium and Environmental Protection.
[90] Article 5, Regulations to the General Law of Ecological Equilibrium and Environmental Protection in Matters Pertaining to Environmental Impact Evaluation.
[91] Article, 45, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[92] Articles 51-54, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[93] Articles 55-64, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[94] Article 34, General Law of Ecological Equilibrium and Environmental Protection.

LGEEPA concerning EIAs contain other requirements for the provision of public information and participation further described below.

SEMARNAT is directed to develop Official Mexican Standards on environmental matters, which are compulsory, however permit parties to submit request for approval of alternative processes and technologies than those specified in a particular NOM.[95] Importantly, LGEEPA relieves a party of the obligation to conduct an EIA "when there are Official Mexican Standards or other provisions regulating the emissions, discharges, natural resource exploitation and, in general, all the relevant environmental impacts caused by the works or activities."[96]

LEEGPA Regulation on Protected Natural Areas regulates ecologically sensitive areas. It states, "Special exploitation sub-zones may be established in reduced-size areas considered essential for the social and economic development of the region. In these sub-zones, public or private projects may only be carried out when related to the infrastructure installation or exploitation of natural resources that are a source of public benefit, which maintain the harmony of the countryside, do not cause severe ecological imbalance and are subject to strict usage regulations for the natural resources."[97] SEMARNAT must approve any projects with respect to environmental impact in sensitive areas.[98]

Reporting Requirements. SEMARNAT maintains a national Pollutant Release and Transfer Registry (PRTR), which compiles releases and transfers of over 100 substances. Stationary sources of listed substances under federal jurisdiction must report their emissions. Stationary sources subject to this requirement include petroleum, chemical and petrochemicals, power generation, steel and metal, cement, and various manufacturing industries.[99] Pursuant to an agreement between SEMARNAT and industry, which expired in 2010, industry voluntarily reported six greenhouse gases (carbon dioxide, methane, nitrous oxide, perfluorocarbons, hydrofluorocarbons and sulphur hexafluoride) if emissions met thresholds specified in the agreement. Since the expiration of the agreement, reporting is now mandatory for based on the thresholds set out below, the results of which SEMARNAT aggregates and publicly reports the data on an aggregated sectoral basis.[100]

Mexico Mandatory Greenhouse Gas Reporting Thresholds

Substance	Generation (KG/Year)	Emission (KG/Year)
Carbon dioxide		100,000
Methane		100,000
Nitrous oxide		100,000
Perfluorocarbons	100	1,000

[95] Articles 36, 37, 37bis, General Law of Ecological Equilibrium and Environmental Protection.
[96] Article 31, General Law of Ecological Equilibrium and Environmental Protection.
[97] Article 58, LEEGPA Regulation on Protected Natural Areas.
[98] Article 88, LEEGPA Regulation on Protected Natural Areas.
[99] Article 111 bis, General Law of Ecological Equilibrium and Environmental Protection; Reforma del Reglamento de la Ley General del Equilibrio Ecologico y la Proteccion al Ambiente en Materia de Prevencion y Control de la Contaminacion de la Atmosfere, publicado en el Diario Official de a Federacion, 3 de Junio de 2004.
[100] Reglamento de la Ley General del Equilibrio Ecologico y la Proteccion al Ambiente en Materia de Registro de Emisiones y Transferencia de Contaminantes, publicado en el Diario Official de a Federacion, 3 de Junio de 2004.

Hydrofluorocarbons	100	1,000
Sulphur hexafluoride	5,000	Any measurable amount

Source: Listado de Sustancias Sujetas a Reporte de Competencia Federal para el Registro de Emisiones y Tranferencia de Contaminantes, publicado en Diario Official de la Federacion, 31 de Marzo 2005.

3.5 CO_2 Transportation

Transportation of crude oil and products in Mexico is governed by the Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector. PEMEX is authorized to build, own and operate oil and gas pipelines within the country. All land and marine transportation of crude oil and its products is also conducted through PEMEX, or by a PEMEX contractor. PEMEX also acts as the regulator of oil and gas pipelines up to the point of sale to a third party.[101] Upon the first sale, SENER regulates oil pipelines and the ERC regulates natural gas and biofuels pipelines. The oversight of transportation of oil products in resale markets is regulated by the Secretariat of Economy.

SEMARNAT and the Ministry of Transportation and Communications regulate pipelines that transport dangerous and toxic substances. Permits for the transportation of hazardous materials (flammable or toxic) are granted by the SEMARNAT, pursuant to the Rules for Transporting Hazardous Materials and Waste.[102] The Secretariat of Communications and Transportation also regulates ground and marine vessel transportation.

NOM-007-SECRE-1999 establishes the technical specifications for materials, pipes, equipment, facilities and devices that are necessary for the design, construction, operation, maintenance and inspection systems for natural gas transportation pipelines and minimum requirements to be met by security measures and emergency response plans.[103] This standard could be adapted for CCS applications with relatively modest adjustments for CO_2. NOM-027-SESH-2010 governs the maintenance and administration of hydrocarbon pipelines. It requires a monitoring and maintenance program to prevent leakage and ensure the safety and integrity of pipelines for hydrocarbons. It also includes provisions for risk management and emergency response measures.[104] This standard also could be adapted to govern CO_2.

3.6 Health and Safety

The Federal Labor Law codifies basic labor law, including requirements for workplace health and safety. It imposes a duty on employers to provide a safe and healthy workplace[105] and authorizes the Ministry of Labor and Social Welfare to issue detailed regulations. The general regulations for workplace health and safety are contained in the Federal Regulation for Occupational Safety and Sanitation and the Environment. Specific issues are regulated under Official Mexican Standards (NOMs) pursuant to the Federal measures and Standards Act.

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[101] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.
[102] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.
[103] NOM-007-SECRE-1999, Transporte de gas natural.
[104] NOM-027-SESH-2010, Administracion de la integredad de ductos de recoleccion y tranporte de hidrocarburos.
[105] Article 132, Federal Labor Law.

As noted above, the Civil Code imposes liability for business enterprises for injuries resulting from employment accidents suffered by workers as result of their employment.[106]

Safety and Hygiene Conditions for Handling, Transporting and Storing Hazardous Chemical Substances in Workplaces (NOM-005-STPS-1998) regulates the handling of substances in the workplace that could affect the health and safety of workers. It defines "toxic substances" as "those in solid, liquid or gaseous state that can cause structural or functional disorders resulting in harm to health or death if they are absorbed by the worker even in relatively small amount."[107]

3.7 Power Sector Laws

SENER and the Energy Regulatory Commission jointly regulate the electricity sector in Mexico. While SENER acts as a policy body, the Commission has regulatory authority.

Pursuant to the Energy Regulatory Commission Law of 1995, the Energy Regulatory Commission is enjoys technical autonomy within SENER.[108] The Commission regulates the downstream electricity, natural gas and biofuels business.[109] It issues permits for the generation of electricity by independent power producers[110] and ensures that technical requirements such as grid interconnection requirements are satisfied. As described further below, the Commission is also responsible for administering the wholesale power pricing scheme for independent power producers that generate electricity using renewable energy and clean energy pursuant to the Law for the Development of Renewable Energy and Energy Transition Financing. While the Commission participates in the determination of wholesale rates,[111] its role is largely consultative and it does not approve consumer electricity tariffs,[112] which are determined by the Secretariat of Finance & Public Credit.[113]

Under the Mexican Constitution, the generation, transmission, distribution, and sale of power to the public-at-large are considered a "public service" to be rendered by the Mexican State,[114] through Federal Electricity Commission (CFE), a public utility wholly-owned by the Mexican federal government. CFE is a decentralized government agency, organized as a state-owned company, and controls its own assets. It generates, distributes and markets electric power for almost 34.9 million customers (almost 100 million people). It owns and operates 187 generating plants, with installed capacity of 52,506 MW. Of its plants, 22 plants were financed using private capital by Productores Independientes de Energia (PIE).[115] The CFE employs various technologies including thermoelectric, hydroelectric, coal-fired, geothermal and wind powered plants and facilities, as well as one nuclear power plant.

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[106] Articles 1935-1937, Federal Civil Code.
[107] Official Mexican NOM-005-STPS-1998. Safety and Hygiene Conditions for Handling, Transporting and Storing Hazardous Chemical Substances in Workplaces.
[108] Article 1, Energy Regulatory Commission Law of 1995.
[109] Article 2, Energy Regulatory Commission Law of 1995.
[110] See Article 36, Electric Power Public Services Act.
[111] Article 3, Energy Regulatory Commission Law of 1995.
[112] Stakeholder Consultations, September 1, 2011.
[113] Article 30, Electric Power Public Services Act.
[114] Article 27, Constitution of Mexico.
[115] Comision Federal de Electricidad at www.cfe.gob.mx/lang/en/Pages/thecompany.aspx, accessed on Aug. 2, 2011.

As the state-owned power company, CFE is responsible for planning the national electrical system. CFE is the sole purchase and distributor of electricity in Mexico and acts as the system operator.[116] CFE enjoys a broad grant of authority that effectively self-regulating in many respects. For example, the CFE does not require permit from the Energy Regulatory Commission to develop and operate a new power plant.[117] PEMEX also enjoys the right to generate electricity as part of its operations and to sell the excess to CFE.[118]

In 1992, the energy regulatory framework was amended to allow private participation in power generation. Independent power producers represent approximately 30% of electricity generation in Mexico.[119] But private parties in general may not carry out wheeling, distribution, and sale of electricity to the public-at-large. The Electric Power Public Service Law provides that supply of power as a public service includes the planning of the national electric system and carrying out of all works, installations, and construction required for the planning, operation, and maintenance of the National Grid.[120]

The Law for the Development of Renewable Energy and Energy Transition Financing provides a framework for the development of renewable and clean energy sources. It creates an Energy Regulatory Commission that will issue standards directives, and methodologies regulating power generation from renewable sources.[121]

The law introduced an important change to the way that electricity is to be priced. CFE's mandate is to produce electricity at the lowest cost taking into account reliability, quality and safety.[122] The law introduced a requirement that externalities are taken into account in pricing wholesale power purchased from independent power producers that generate electricity using clean and renewable energy sources and that SENER develop a methodology for calculating externalities.[123] Thus, CFE is required to produce electricity at lowest cost taking overall externalities into account. These provisions became effective June 1, 2011.[124]

The law specifies certain renewable technologies that enjoy the benefit of the renewable and clean energy wholesale pricing scheme. The law requires CFE to enter into long term contracts for renewable and clean energy sources, including co-generation that meets emissions standards.[125] Although clean coal is not listed as one of the technologies, the Energy Regulatory Commission has authority under the law to add technologies that qualify as a clean energy technology under criteria established for clean technology under the law and SENER has authority to update the National Strategy for Energy Transition and Sustainable Exploitation of Energy.[126] Further, although the law is not clear whether it applies to CFE's own generation facilities, the Energy Regulatory Commission is examining CFE's dispatch rules with the purpose of enhancing the competitiveness of renewable and clean energy power sources.[127]

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[116] Article 36 bis, Electric Power Public Services Act.
[117] See Article 36, Electric Power Public Services Act; Stakeholder Consultations, September 1, 2011.
[118] Article 3, Law of Petroleos Mexicanos.
[119] Energy Information System, http://sie.energia.gob.mx (accessed September 1, 2011).
[120] "Update: Mexican Energy Reform," David Jimenez Romero and Eduardo Ortega Castro, *LexisNexis,* Fall 2008.
[121] Article 7, Law for the Development of Renewable Energy and Energy Transition.
[122] Article 36 bis, Electric Power Public Services Act.
[123] Articles 10 and 12-14, Law for the Development of Renewable Energy and Energy Transition Financing.
[124] Stakeholder consultations, August 31, 2011.
[125] Articles 16 and 20, Law for the Development of Renewable Energy and Energy Transition.
[126] See Articles 20 and 26, Law for the Development of Renewable Energy and Energy Transition.
[127] Article 7, Law for the Development of Renewable Energy and Energy Transition.

The law also provides for public participation in the development and planning of renewable energy, including public consultation for siting of power generation great than 2.5 MW.[128] The law also created the Sustainability Fund and the Energy Transition Fund to promote the use of renewable sources and energy efficiency and the diversifying energy resources.[129]

3.8 Oil, Gas and Mining Laws

In accordance with Mexican law, Mexico maintains direct ownership over oil and all hydrocarbons, and only PEMEX is charged by law to develop Mexico's oil reserves on behalf of the nation.[130] PEMEX is managed by a board of directors appointed by the Executive Branch of the Mexican Government that is mandated to seek "economic value creation for the benefit of Mexican society" as well as other objectives including to enhance the environment and energy security.[131] PEMEX's annual budget is approved by the Secretariat of Finance & Public Credit, however PEMEX does have some flexibility in financial operations provided it meets financial targets approved by the Secretariat of Finance & Public Credit.[132] Through its four main subsidiaries, PEMEX undertakes all upstream, midstream and downstream oil industry activities either directly or through service agreements. In addition to oil exploration and production activities, PEMEX manufactures petrochemicals and is authorized to co-generate electricity as part of its operations.[133] PEMEX maintains a Committee on environment and Sustainable Development and a Committee on Development and Technological Research.[134] PMI Coercio Internacional SA de CV conducts the foreign trade operations of PEMEX and the Mexican Petroleum Institute supplies technological support in the oil extraction and production phases.[135] PEMEX is required to follow competitive tendering processes for contracts, subject to certain exceptions.[136]

The nation's direct ownership over all hydrocarbons is established by Article 27 of the Mexican Constitution, which provides that all natural resources, including hydrocarbons, are the property of the nation. PEMEX is granted exclusive authority to administer these resources on behalf of the State.[137] In addition to exploration and production, PEMEX is given responsibility for processing, transportation and storage activities related to exploration and production of hydrocarbons.[138] The Oil Law and the Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector, together with their respective regulations, are the key laws governing the Mexican oil industry. In addition, Official Mexican Standards (NOMs) set out obligatory technical, safety, environmental and quality requirements for all oil operations issued by the government agency that oversees specific activity of the industry pursuant to the Federal Metrology and Standardization Law.[139]

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[128] Article 21, Law for the Development of Renewable Energy and Energy Transition.
[129] Article 27, Law for the Development of Renewable Energy and Energy Transition.
[130] Article 4, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[131] Article 7, Law of Petroleos Mexicanos.
[132] Articles 49 and Ninth Transitional Provision, Law of Petroleos Mexicanos,
[133] Articles 6 and 3, Law of Petroleos Mexicanos.
[134] Articles 28 and 30, Law of Petroleos Mexicanos.
[135] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.
[136] Article 54, Law of Petroleos Mexicanos.
[137] Article 2, Oil Law.
[138] "Global Legal Update, The Country Series: Mexico," *Baker & McKenzie International,* June 2010.
[139] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.

Under the Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector, PEMEX is authorized to enter into services agreements with third parties.[140] Remuneration under these contracts is limited to cash payments; the law prohibits granting ownership to the hydrocarbons resources for the services rendered.[141] Accordingly, no concessions may be granted to private parties to explore and produce hydrocarbons in Mexico. Exploration, production and refining of oil and gas as well as production of basic petrochemicals in Mexico are, thus, conducted exclusively by PEMEX. In addition, under the Petroleum Regulatory Law, PEMEX is barred from entering into risk agreements or agreeing to a profits share or payment in kind of oil and gas.[142]

As a result of the 2008 energy reform, the National Hydrocarbon Commission was created to regulate, along with SENER, the exploration and extraction of hydrocarbons by PEMEX.[143] SENER is primarily a policy agency and has authority to approve and terminate areas designated for oil and gas exploration.[144] SENER and the National Hydrocarbon Commission have authority to approve new technologies and methods,[145] and the Commission acts as the regulatory and enforcement arm of SENER.[146] SENER and the Commission oversee health and safety for PEMEX upstream activities.[147] SEMARNAT regulates PEMEX with respect to environmental issues. PEMEX's downstream natural gas business is regulated by the Energy Regulatory Commission. PEMEX is required to price its products at competitive prices or is subject to regulation by the Federal Competition Commission.[148]

Exploration, production, processing, and first-hand sales of natural gas, as well as production of basic petrochemicals are carried out exclusively by PEMEX, however, private investment is allowed in downstream gas transportation, storage, local distribution, marketing, and carburetion stations. Foreign investment in such permitted activities is allowed up to 100 percent. Natural gas transportation, storage, and distribution include coal-bed methane and are regulated through permits issued by the Energy Regulatory Commission. PEMEX and private companies compete in the provision of transportation and marketing services, but PEMEX does not participate in the local distribution business. Marketing by private parties is not a regulated activity while first-hand sales by PEMEX are a regulated activity.[149]

PEMEX develops public standards and internal guidelines for various aspects of oil production that would be relevant to CCS. These include standards for safety, pipelines, environmental protection, measurement and monitoring. Although these standards would be relevant to CCS, they have not been adopted to regulate CCS and would require review and revision to apply them to CCS. PEMEX currently has no standards for decommissioning wells although it does have some guidelines for decommissioning offshore platforms. PEMEX is also subject to mandatory national standards for pipeline construction and safety.

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[140] Articles 6 and 7, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[141] See also Articles 60 and 61, Oil Law.
[142] "Update: Mexican Energy Reform," David Jimenez Romero and Eduardo Ortega Castro, *LexisNexis,* Fall 2008.
[143] Article 15, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[144] Article 5, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[145] Article 15(III)(g), Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[146] For example, one of the Commission's first acts as a regulatory body was to issue gas flaring rules in 2010.
[147] Article 15b, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[148] Article 14, Regulatory Law of Article 27 of the Mexican Constitution in the Oil Sector.
[149] "Update: Mexican Energy Reform," David Jimenez Romero and Eduardo Ortega Castro, *LexisNexis,* Fall 2008.

SENER has issued a NOM providing guidelines for conducting seismic evaluation of potential oil and gas productions sites.[150]

Other than liquid or gaseous hydrocarbons, coal and other minerals are subject tot the mining law, which regulates the exploration and production of minerals.[151] Unlike in the oil and gas sector, the Ministry of Economy which is responsible for administered the Mining Law grants concessions to private companies for exploration and production. Concessions are granted for an initial period of 50 years. [152] The Minerals Act contains a general requirement that concessionaires must take care of the environment and comply with applicable laws and standards and provisions for administrative sanctions for non-compliance.[153] The law also created the Mexican Geological Service.[154]

3.9 Public Participation

LGEEPA established the basis for citizen involvement in promoting public awareness of environmental problems, and in 1996 the LGEEPA was amended to promote more citizen involvement in environmental protection, through increased consultation with businesses, private citizens, and NGOs. LGEEPA contains general provisions encouraging public and media participation in environment information dissemination.[155]

Under LGEEPA, a citizen or group of citizens may file a compliant with SEMARNAT's Office of the Federal Attorney General for Environmental Protection (PROFEPA) at the state level, alleging acts or omissions that harm the environment and may constitute violations of environmental laws, which SEMARNAT is required to investigate if it determines it has some foundation or has not been filed in bad faith.[156] PROFEPA's practice is to handle complaints at the state level to make the initial determination of whether an investigation should be conducted. The state office will evaluate complaints based on whether it believes the subject of the complaint has complied with applicable law and regulation. There is no standing requirement as in common law jurisdictions and no requirement that the complainant meet a burden of proof. If SEMARNAT proceeds with an investigation, SEMARNAT will determine whether administrative sanctions or corrective measures are warranted based on whether the subject of the complaint has complied with applicable regulations and NOMs.[157] This is a purely administrative procedure that does not preclude a party pursuing a civil case.

Notwithstanding compliance with a regulation of NOM, we understand from stakeholder discussions that SEMARNAT's authority to regulate environmental issues under general prohibitions against pollution could provide an independent basis of authority to regulate beyond specific regulations or NOMs. It also does not preclude the possibility that other ministries, such as the Ministry of Health, would have jurisdiction over the health aspects of environmental issues.

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[150] NOM-026-SESH-2007, Lineamientos para los trabasjos de prospeccion simologica petrolera y especificaciones de los niveles maximos de energia.
[151] Article 5, Mining Law.
[152] Article 15, Mining Law.
[153] Article 39 and Chapter 7, Mining Law.
[154] Article 9, Mining Law.
[155] Articles 157-159, General Law of Ecological Equilibrium and Environmental Protection
[156] Articles 189-191, General Law of Ecological Equilibrium and Environmental Protection.
[157] Stakeholder Consultations, August 31, 2011.

In addition, in the absence of specific NOMS, SEMARNAT can proceed to review projects based on risk assessment. NOM-138-SEMARNAT and NOM-147-SEMARNAT relating to soil contamination provide that if there is environmental damage falling outside specific NOMS or regulations, SEMARNAT can still pursue administrative proceedings in the form of a risk assessment. Stakeholder discussion revealed that risk assessments provide less certainty for project developers than established NOMS.[158]

The Regulations to the LGEEPA provide certain rights to the public to participate in the EIA review process. LGEEPA requires EIAs to be made public immediately upon filing with SEMARNAT.[159] SEMARNAT's practice is to make the document available via internet for a period of 60 days in redacted form to protect commercially sensitive data, after which the document would be available upon request as specified in the regulations.[160] According to the regulations, SEMARNAT first publishes a summary describing the project, its location, the type of EIA prepared and other basic information in SEMARNAT's Ecological Gazette.[161] SEMARNAT's evaluation of the EIA shall be made public for inspection by any person, however the project proponent may request that commercially sensitive information be omitted from public display.[162] Within ten days of publication in the Ecological Gazette, members of the public may request SEMNARNAT to conduct a public inspection of the project, which it may decline to do.[163] If SEMARNAT elects to hold a public inspection, members of the public have ten days to request a full copy of the EIA and twenty days thereafter to propose the establishment of prevention and mitigation measures.[164] As part of the public inspection, SEMARNAT may elect to hold a public information meeting concerning the EIA.[165] The regulation also provide environmental NGOs and other public interest groups the right to file complaints for acts or omissions of public officials under the environmental laws.[166]

The Federal Transparency Law requires all federal government agencies, including SEMARNAT, to provide public access to information, subject to restrictions for such reasons as national security, law enforcement, or otherwise confidential due to commercial considerations.[167]

Mexico maintains the Pollutant Release and Transfer Register of specified substances releases and transfers, described above, and a national environmental reporting system for the purpose of registering, organizing, and disseminating up-to-date information on national environmental concerns. However, the right of private individuals to environmental information is not absolute.

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[158] Stakeholder Consultations, September 1, 2011.
[159] Article 32, General Law of Ecological Equilibrium and Environmental Protection.
[160] Stakeholder Consultations, August 31, 2011.
[161] Articles 37 and 39, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[162] Article 38, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[163] Article 40, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[164] Article 41, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[165] Article 43, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[166] Article, Regulations to the General Law of Ecology Equilibrium and Environmental Protection in matters Pertaining to Environmental Impact Evaluation.
[167] Articles 1, 13, 14 and 18, Federal Transparency and Access to Public Government Information Law.

Access to such information may be denied when such information is deemed by law to be classified or, because of the nature of the information, dissemination would constitute a breach of national security; when the information requested relates to issues that are the subject of a judicial proceeding or law enforcement matter; when the information has been provided by third parties who are under no legal obligation to provide it; and when information pertains to inventory or stocks and inputs and processing technology, including descriptions of industrial processes.[168]

The General Law for Prevention and Integral Waste Management is also contains provisions requiring the SEMARNAT to conduct public outreach and publish information concerning substances covered under the law. If CO_2 injections are regulated by this law, it would also likely trigger public reporting requirements for injection volumes but also possibly generation volumes.[169] The law provide the public and public interest organizations with the right to file complaints as defined in LGEEPA.[170]

3.10 Foreign Investment

Foreign persons (individuals or corporations) have certain right to acquire full title to real property in Mexico, although there are important qualifications of this right.[171] Foreign corporations may only acquire lands that are used in carrying out their corporate objectives. The Constitution restricts the ability of foreign nationals to acquire rights to natural resources. Only Mexicans by birth or naturalization and Mexican companies have the right to acquire ownership of lands, waters, and their appurtenances, or to obtain concessions for the exploitation of mines or of waters. The State may grant the same right to foreigners, provided they agree before the Ministry of Foreign Relations to consider themselves as nationals in respect to such property, and bind themselves not to invoke the protection of their governments in matters relating thereto; under penalty, in case of noncompliance with this agreement, of forfeiture of the property acquired to the Nation. Foreigners may not acquire direct ownership of lands or waters within a zone of one hundred kilometers along the frontiers and of fifty kilometers along the shores of the country.[172]

Investors from the U.S. and Canada enjoy protections under the North American Free Trade Agreement (NAFTA). NAFTA guarantees national treatment for investors from a NAFTA party,[173] and most-favored nation treatment to such investors.[174] It also provides protections for transfer of funds and protections against expropriation.[175]

Pursuant to the Mexican Foreign Investment Law, certain activities are reserved for the state and others are subject to varying limits on foreign investment ranging from 10% to 49%. Oil is a strategic area reserved exclusively to the state. The marketing of gasoline and commercialization of liquefied petroleum gas are reserved exclusively to Mexican companies without foreign investment. Foreign investment may participate in up to 49 percent (or more with a favorable opinion by the National Foreign Investment Commission) of Mexican

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[168] Articles 159 Bis 3 and 159 Bis 4, General Law of Ecology Equilibrium and Environmental Protection.
[169] Articles 35-39, General Law for Prevention and Integral Waste Management.
[170] Article 125, General Law for Prevention and Integral Waste Management.
[171] Article 27, Constitution of Mexico.
[172] Article 27, Constitution of Mexico.
[173] Article 1102, North American Free Trade Agreement.
[174] Article 1103, North American Free Trade Agreement.
[175] Articles 1109 and 1110, North American Free Trade Agreement.

companies whose corporate purpose is to build oil pipelines and drill oil wells as subcontractors of PEMEX. Otherwise, there are no specific restrictions for foreign investment participation in companies that render services contracted by PEMEX.[176]

3.11 Financial Incentives and Support

The General Law of Ecological Equilibrium and Environmental Protection promotes the use of tax incentives that "induce the fulfillment of the objectives of the environmental policy" as well as financial instruments such as credits, bonds, civil liability insurance, and funds. These financial instruments could involve market-based emissions permit schemes. It specifically identifies financing of programs, projects, studies and scientific and technological investigation as areas for support.[177]

Regulation to the LEEGPA in Matters Pertaining to Prevention and Control of Atmospheric Pollution states that "Activities in connection with the preservation and restoration of ecological equilibrium and environmental protection are considered to have priority in the granting of tax incentives."[178]

The Law for the Development of Renewable Energy and Energy Transition Financing established two funds that could potentially provide financial support for CCS. The Energy Transition Fund supports research and development projects that promote energy diversification.

The Sustainability Fund supports environmental research and development projects in specific clean energy technologies, renewable energy, energy efficiency and energy diversification project. The Sustainability Fund has indicated that it could support CCS applications. The Sustainability Fund does not support equipment purchase, however leasing of equipment could potentially be permitted.[179]

Both funds are governed by an inter-ministerial committee chaired by SENER,[180]and are supported by a percentage of PEMEX sales under the Federal Royalties Law.[181]

The Federal Royalties Law created the Hydrocarbon Fund. The Hydrocarbon Fund is intended to support optimization of hydrocarbon infrastructure and resources. The fund is supported by a percentage of PEMEX's sales.[182] The project selection criteria are in a process of revision.[183]

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[176] Oil Regulation in 29 Jurisdictions Worldwide, *Getting the Deal Through*, 2010.
[177] Article 22, General Law of Ecological Equilibrium and Environmental Protection.
[178] Article 12, Regulation to the LEEGPA in Matters Pertaining to Prevention and Control of Atmospheric Pollution, Nov. 1988.
[179] Stakeholder Consultations, August 31, 2011.
[180] Article 27, Law for the Development of Renewable Energy and Energy Transition Financing.
[181] Article 254bis, Federal Royalties Law.
[182] Article 254bis, Federal Royalties Law.
[183] Stakeholder Consultations, August 31, 2011.

CHINESE TAIPEI REGULATORY ASSESSMENT

1. POLITICAL AND LEGAL SYSTEM

Chinese Taipei's government is divided into central, provincial and municipal, as well as county and city levels. The central government comprises the Office of the President and five branches (or "Yuan") – the Executive Yuan, the Legislative Yuan, the Judicial Yuan, the Examination Yuan and the Control Yuan. The President and the Vice President are elected on the same ticket by receiving a plurality of the popular vote for a four-year term and may be re-elected for a second term.[1] The President is the head of state, command in chief and responsible for foreign affairs. Unlike the Premier, the President is not accountable to the Legislative Yuan. The Chinese Taipei is sometimes described as having a semi-presidential system because the president does not exercise direct administrative authority over the executive branch. Nevertheless, the president exerts considerable influence over the operations of the various branches of the central government through the power to appoint the Premier and other top officials.[2]

The Executive Yuan is the executive branch of the central government, headed by the Premier. The Premier is the head of the Executive Yuan and is accountable to the Legislative Yuan. For laws to take effect after enactment by the Legislature, they must be promulgated by the President and countersigned by the Premier. Pursuant to the restructuring of the central government to be completed in 2012, the number of Cabinet-level organizations will be reduced from 37 to 29 (14 ministries, eight councils, three independent agencies and four additional organizations).[3] Among the 14 ministries, six ministries for labor, agriculture, health and welfare, the environment, culture, and science and technology will be newly created.

The Legislative Yuan is the central government's sole law-making body, which comprises 113 legislators, one per electoral district, who serve four-year terms and are eligible to stand for re-election indefinitely.

The Judicial Yuan's central function is to oversee the operations of the nation's court systems, comprising district courts, high courts and a Supreme Court. Issues of fact are adjudged by district courts and high courts, while the Supreme Court considers only issues of law. At the apex of the judicial system is the Constitutional Court. The Court's 15 justices review the constitutionality of laws, legal procedures and government actions; make

[1] Website of the Government Information Office of Taiwan at www.gio.gov.tw/taiwan-website/5-gp/glance/ch4.htm (accessed July 2, 2011).
[2] Web Site of the Taiwanese Government available at www.taiwan.gov.tw (accessed July 2, 2011).
[3] Website of the Government Information Office of Taiwan at www.gio.gov.tw/taiwan-website/5-gp/glance/ch4.htm (accessed July 2, 2011), and Web Site of the Taiwanese Government available at www.taiwan.gov.tw (accessed July 2, 2011).

recommendations concerning rectification of inconsistencies between different laws and regulations; and preside over impeachment trials of the nation's President or Vice President if the Legislature passes an impeachment resolution.[4]

The Examination Yuan is responsible for administering the nation's civil service system.

The Control Yuan is an independent oversight body comprising 29 members and the Ministry of Audit. It is empowered to impeach and censure officials and audit government agencies.[5]

Local Government comprises three levels: special municipalities (5), counties and provincial municipalities (23), and townships and county municipalities. The Local Government Act of 2009 provides a legal basis for cities and counties to merge or upgrade to special municipalities.[6] Provincial and Municipal Governments are under the control of the Executive Yuan; they are not self-governing bodies.

Certain key government ministries would play a significant role in the development of CCS regulation and the approval of a CCS project in the country. They include:

<u>The Executive Yuan</u>

- **Environmental Protection Administration** (EPA) governs seven sectors: comprehensive planning, air quality protection and noise control, water quality protection, waste management, environmental sanitation and toxic substance management, supervision evaluation and dispute resolution, environmental monitoring and information management.[7] Each city and county government has its own local level Environmental Protection Bureau (EPB). The EPA normally consults county and city EPBs on the details of developing and enforcing new regulations.

  Environmental Impact Assessment (EIA) Review Committees have been established within the EPA at the central government, special municipality and county or city levels, pursuant to the Environmental Impact Assessment Act.

- **Ministry of Economic Affairs (MOEA)** is responsible for almost all energy related issues mainly by its subordinate unit, the Bureau of Energy. MOEA also has authority for energy and industrial pipelines. Only nuclear power is under the authority of the Atomic Energy Council (AEC).

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[4] Web Site of the Taiwanese Government available at www.taiwan.gov.tw (accessed July 2, 2011).
[5] Web Site of the Taiwanese Government available at www.taiwan.gov.tw (accessed July 2, 2011), and Website of the Government Information Office of Taiwan at www.gio.gov.tw/taiwan-website/5-gp/glance/ch4.htm (accessed July 2, 2011)
[6] Website of the Government Information Office of Taiwan at www.gio.gov.tw/taiwan-website/5-gp/glance/ch4.htm (accessed July 2, 2011).
[7] Website of the Environmental Protection Administration, R.O.C. (Taiwan) at www.epa.gov.tw (accessed July 2, 2011).

- **Bureau of Energy (BOE)**'s functions include formulating energy policy and regulation; permitting energy exploration, production, transport, storage, transformation, distribution, marketing, and utilization activities; reviewing natural gas and electricity prices; promoting research and development of new and renewable energy technology; and promoting international energy cooperation.[8]

- **Bureau of Mines** manages mineral resources, promotes sustainable development of mining industry. Its responsibilities include mine administration and technical assistance and regulating safety management and hazard prevention.[9]

- **Central Geological Survey (CGS)** is responsible for the geological survey and geosciences research.[10]

- **Water Resources Agency** is the public water utility serving residential, industrial, agricultural, and environmental water needs. It also is the water regulator.

- **Investment Commission** is responsible for screening applications for inward or outward investment and technical cooperation.

- **Taiwan Power Company (Taipower)** is the state-owned power company under the MOEA. It is the sole integrated power company in Chinese Taipei, and provides service to 12.58 million customers on the island of Taiwan and Kinmen and Matsu islets.[11] It is heavily dependent upon coal and is the single larger emitter of greenhouse gases, accounting for 39% of Chinese Taipei CO_2 emissions.[12]

- **China Petroleum Company (CPC) Taiwan** is the state-owned petroleum company responsible for the development and supply of petroleum and natural gas, and is the core of the country's petrochemical industry. Although it has limited production activities domestically, it possesses CCS-relevant expertise through exploration and production operations internationally,

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[8] Website of the Bureau of Energy, MOEA at http://www.moeaboe.gov.tw (accessed July 2, 2011).
[9] Website of the Bureau of Mines, MOEA at http://www.mine.gov.tw/en/ (accessed July 2, 2011).
[10] Website of the Central Geological Survey, MOEA at http://www.moeacgs.gov.tw/english/index.jsp (accessed July 2, 2011).
[11] Website of Taiwan Power Company at www.taipower.com.tw (accessed July 2, 2011).
[12] Yu-huay Sun, Taipower Plans Carbon-Capture Program at Coal-Fired Plant, Bloomberg, http://www.businessweek.com/news/2010-11-09/taipower-plans-trial-carbon-capture-program-at-coal-fired-plant.html (accessed October 1, 2011).

possesses depleted oil and gas fields and stores imported natural gas in geologic formations.

- **State-owned Enterprise Commission** supervises and sets policy for enterprises on such matters as product pricing for state-owned enterprises including Taipower and CPC.

- **Industrial Development Bureau** promotes investment, the development of new industries and the transformation of existing industries. This bureau also controls land in industrial parks.[13]

- **Ministry of the Interior (MOI)** is responsible for issues relating to people's rights and social welfare, including population, territory, construction, local governance, alternative service, security, immigration, etc.[14]

- **Ministry of Finance** serves as the national treasury. It is responsible for tax policy and collection, customs, and management of national property including national lands.[15]

- **Ministry of Transportation and Communications (MOTC)**'s duties include, among others, promoting sustainable green transport and tourism and strengthening energy-conserving and carbon-reducing efforts; and transportation systems and safety. MOTC would have authority over substances transported by truck or ship.

- **National Science Council (NSC)** is responsible for promoting the development of science and technology, and reviews and approves related programs and demonstration projects.[16] The NSC is primarily responsible for the development of energy technologies. NSC is playing a leadership role in promoting the developing of CCS.

- **Council for Economic Planning and Development (CEPD)** advises the Executive Yuan and is responsible for drafting plans for national economic development; evaluating development projects, proposals and programs; coordinating the economic policymaking activities of ministries and agencies; and monitoring the implementation of development projects, measures, and programs.[17]

- **Local governments** issue permits for the operation of power general and industrial facilities. Local government would therefore play a key role in the success of a project.

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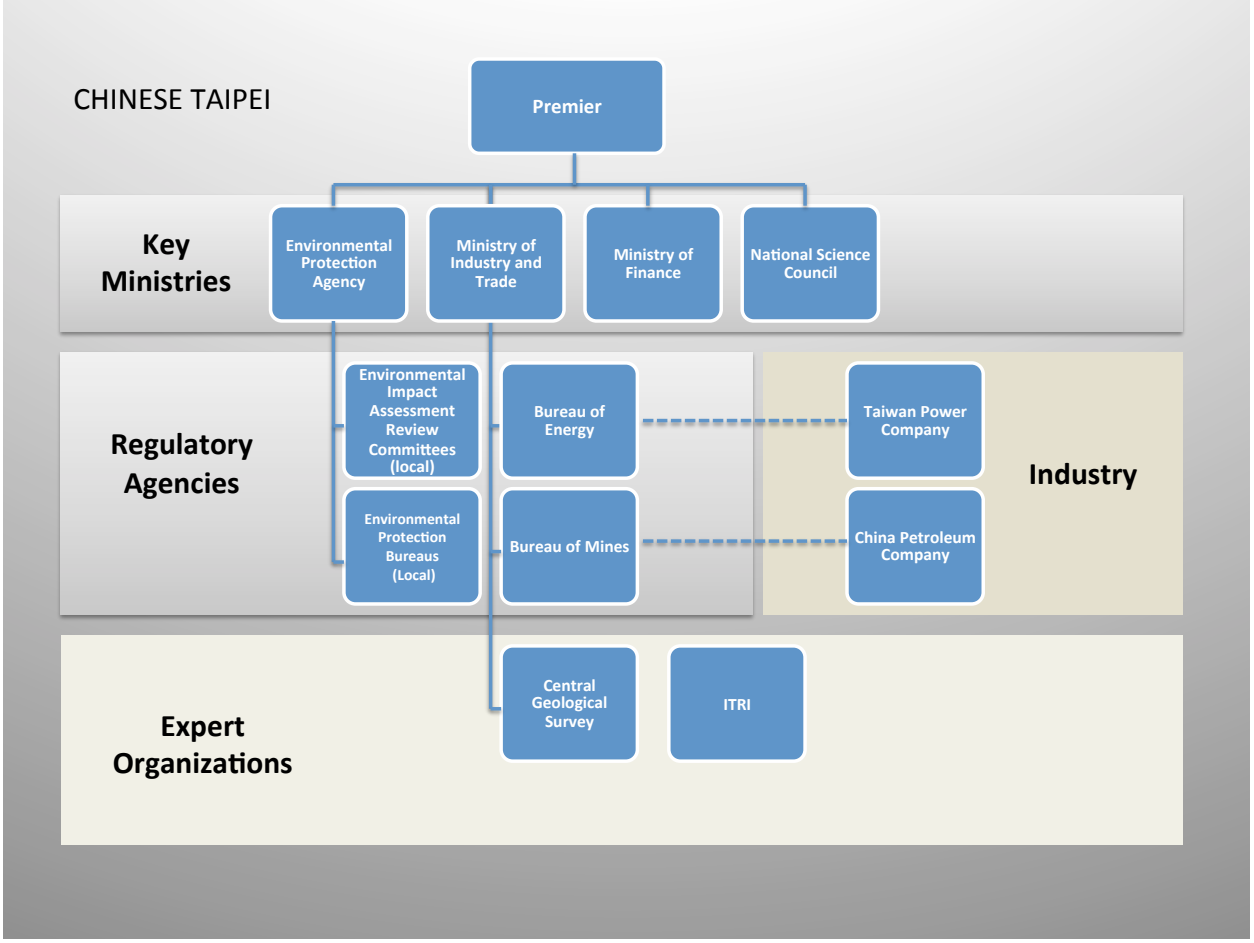
[13] Website of the Industrial Development Bureau, available at http://www.moeaidb.gov.tw/2009/ctlr?lang=1&PRO=index (accessed August 22, 2011).
[14] Website of the Ministry of the Interior, available at www.moi.gov.tw (accessed August 22, 2011).
[15] Website of the Ministry of Finance, available at www.mof.gov.tw (accessed August 22, 2011).
[16] Website of the EPA Taiwan at www.epa.gov.tw (accessed August 22, 2011).
[17] CEPD Website at www.cepd.gov.tw (accessed August 22, 2011).

The EPA and the MOEA have each appointed committees to examine the potential for CCS. The EPA committee known as the CCS Strategic Alliance concentrates on developing regulations for CCS. Members of the CCS Strategic Alliance include Taiwan Power Company, China Petroleum Company, China Steel Company and several government agencies under the EPA. The MOEA's CCS R&D Alliance includes Taiwan Power Company, China Petroleum Company, Industrial Technology Research Institute and China Steel Company. The National Science Council leads the Clean Coal Master Project under the National Energy Project and is funding CCS R&D projects, including a pilot test injection project conducted by Taiwan Power Company to inject 10,000 tons of CO_2.[18]

The diagram below shows selected central government entities and stakeholders that would be involved in regulating or undertaking a CCS project. Regional or local government entities are not shown on the diagram.



[18] Meg Chang, "EPA Unveils Carbon Capture, Storage Alliance for Taiwan," *Taiwan Today* available at www.taiwantoday.tw, July 2, 2011 (Accessed October 1, 2011).

2. CLIMATE CHANGE LAW AND POLICY

Chinese Taipei is not a member of the United Nations, and thus is not a signatory to the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Although Chinese Taipei has no international obligation to control its greenhouse gas emissions, it has officially adopted a policy of "voluntary compliance" to international environmental agreements and some cities have pledged emissions reductions targets.[19] The government announced its target of stabilizing Chinese Taipei's emissions at 2008 levels by 2020. The EPA later expanded this to a three-step target to reduce emissions to 2008 levels by 2020; to 2000 levels by 2025; and to half of 2000 levels by 2050.[20] Although it is not a signatory to the UNFCCC, Chinese Taipei made a further commitment to reduce greenhouse gas emissions by 30% of business as usual by 2020 in response to the Conference of the Parties held in Copenhagen in December 2009.[21]

The government implemented its "Frameworks for Sustainable Energy Policy – An Energy-Saving and Carbon-Reduction Action Plan"[22] in June 2008. The laws and policies to carry out this plan have either been implemented or are scheduled for legislative review.[23] These laws and policies include (dates refer to promulgation except where noted):

- *Greenhouse Gas Reduction Act (draft)* (2004)
- Greenhouse Gas Inventory and Registration Guidelines (issued July 2007)
- Framework for Sustainable Energy Policy (approved June 2008)
- 167 Energy Saving and Carbon Reduction Action Plans (approved September 2008)
- Renewable Energy Act (enacted June 2009)
- Energy Management Law (amended July 2009)
- Statute for Renewable Energy Development (July 2009)
- Working Principles for Managing Greenhouse Gas Inspection Organizations (November 2009)
- Principles for Promoting Greenhouse Gas Pilot and Offset Projects (September 2010)

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[19] "MOFA: Taiwan Must Not Be Excluded from Climate Change Efforts," *The China Post* available at www.chinapost.com.tw/taiwan/2008/03/02/145228/MOFA%3A-Taiwan.htm, Mar. 2, 2008; and Lila Buckley, "Taiwan: A Microcosm for Climate Change," *The Globalist* available at www.theglobalist.com/storyid.aspx?/StoryId=7676, Apr. 18, 2009 (accessed October 1, 2011).

[20] National Science and Technology Development Plan (2009-2012), National Science Council, Executive Yuan, July 2, 2009; and "Taiwan Raises bar on Tackling Greenhouse Gas Emissions," Ed Zacapa, *Taiwan Today* available at www.taiwantoday.tw/ct.asp?xItem=168972&ctNode=426, June 24, 2011 (accessed October 1, 2011).

[21] EPA, Taiwan Initiates Nationally Appropriate Mitigation Actions available at http://unfccc.epa.gov.tw/unfccc/english/_uploads/20100901/B5-NAMAs_en.pdf (accessed October 1, 2011).

[22] See www.go-moea.tw/en/download/June_2009.pdf (accessed October 1, 2011).

[23] Jenn Jiang Hwang and Wei Ru Chang, "Policy Progress in Mitigation of Climate Change in Taiwan," *Energy Policy, Volume 39, Issue 3,* March 2011.

- Greenhouse Gas Inventory and Registration Management Principles (September 2010)
- Greenhouse Gas Reduction Credit Account Management Guidelines (April 2011)

The Greenhouse Gas Reduction Act (draft), which was approved by the Executive Yuan in September 2006 and is pending final approval from the Legislative Yuan, would implement a cap and trade system among its measures.[24] The EPA is developing a voluntary prototype carbon emissions trading program until the law is enacted. The government is also promoting renewable energy, the development of nuclear energy, low-carbon architecture and green transportation.[25] Chinese Taipei's special municipalities lead regional efforts to reduce emissions through implementing international standards in Kaohsiung, New Taipei, Taichung, Taipei, and Tainan cities.

In 2009, the central government announced plans to impose a carbon tax, however no timeline has been set for its adoption.[26]

CCS technology has been recognized by the Chinese Taipei's government as one of the possible means to reduce national emissions to reach greenhouse gas reduction targets. The Framework of Taiwan's Sustainable Energy Policy identifies "CCS technology through international cooperation to reduce the CO_2 emission of power generating system" as a means to achieve the 2020 and 2025 greenhouse gas emissions reduction goals.[27] The MOEA has proposed a CCS roadmap that includes timelines for CCS R&D projects as part of the national energy plan.[28] The roadmap contemplates development of post-combustion, IGCC, oxyfuel and other supporting technologies. The roadmap calls for small-scale demonstration projects of under 3 MW in the near term to up to 30 MW by 2016, and readiness for commercialization by 2025.

3. LAWS AND REGULATION APPLICABLE TO CCS

Chinese Taipei currently has no laws that specifically govern CCS-related, however various existing laws would be relevant to CCS-related projects.

3.1 Classification of CO_2

The **Basic Environment Act** seeks to restrict CO_2 emissions. It states "Government entities at all levels shall actively adopt measures to control carbon dioxide emissions and establish

[24] Taichung Government Website, available at www.epb.taichung.gov.tw (accessed July 8, 2011).
[25] Stakeholder consultations, September 29, 2011. See also "Taiwan Raises Bar on Tackling Greenhouse Gas Emissions," Ed Zacapa, *Taiwan Today* available at www.taiwantoday.tw/ct.asp?xItem=168972&ctNode=426, June 24, 2011 (accessed October 1, 2011).
[26] Yvonne Chan, "Taiwan Plans Taxes for Energy and CO2 Emissions by 2011," *BusinessGreen Sustainable Thinking,* available at www.businessgreen.com/bg/news/1800579/taiwan-plans-taxes-energy-co2-emissions-2011, Oct. 20, 2009 (accessed October 1, 2011).
[27] Framework of Taiwan's Sustainable Energy Policy, *Ministry of Economic Affairs,* June 5, 2008.
[28] Bureau of Energy, Ministry of Economic Affairs, 2010 Energy Industrial Technology White Paper.

related plans to mitigate the greenhouse effect."[29] It does not, however, specifically identify CO_2 as a pollutant or waste and does not contain definitions for these concepts. Instead, these concepts are defined in laws governing soil and groundwater, waste disposal, toxic substances and the marine environment.

Under the ***Soil and Groundwater Pollution Remediation Act,*** soil or groundwater pollution means the introduction into soil or groundwater of substances, biological organisms or forms of energy that alter soil quality, impact the normal use of the soil or endanger public health and the living environment.[30]

The **Waste Disposal Act** divides waste into two categories: general waste (e.g., household waste) and industrial waste, of which there are two types of industrial waste. CO_2 could potentially be categorized under the broad definitions of industrial waste. "Hazardous industrial waste" is "waste produced by industry that is toxic or dangerous and the concentration or volume of which is sufficient to influence human health or pollute the environment." "General industrial waste" is "waste produced by industry that is not hazardous industrial waste."[31]

The **Toxic Chemical Material Control Act** defines chemical material is defined as "chemical materials produced intentionally by human being or derived unintentionally from production process, whose toxicity was identified by the central administrative entity [EPA of the Executive Yuan] . . .."[32] The Act provides four categories to controlled substance, the third and fourth being substance that exposure immediately endangers human life or could pose risk to human health, respectively. The Toxic Chemical Material Control Act states that the EPA may "refer" to the United States Clean Air Act classification of air pollutants in classifying substances under its own law.[33] It is not clear if CO_2 would be categorized as a toxic chemical material under the Act, however, according to a report sponsored by the National Science Council studying possible CCS regulations, CO_2 could possibly come within the definition of toxic chemical materials.[34]

If CO_2 is sequestered offshore, the **Ocean Pollution Control Act** would apply, which defines "harmful material" as "the designated materials according to International Maritime Dangerous Goods Code."[35] The International Maritime Dangerous Goods Code covers CO_2.[36] In the Act, "polluting conduct" means "the conducts that carry matters or energy into ocean environment

[29] Article 21, Basic Environment Act.
[30] Article 2, Soil and Groundwater Pollution Remediation Act.
[31] Article 2, Waste Disposal Act.
[32] Article 3, Toxic Chemical Material Control Act.
[33] Ordinance No. 0990006296, Special Guideline on the Designation of Toxic Chemical Substances of the Environmental Protection Agency, January 18, 2010.
[34] National Tsinghua University and National Chung Cheng University, The Development of Legal Framework to CCS in Taiwan, in Taiwan Institute of Economic Research and Sinotech Consultants, Inc., Mid-Term Report of the Studies on Regulatory Framework of CO_2 Sequestration, June 2011.
[35] Article 3, Ocean Pollution Control Act.
[36] Class 2.2 Non-Flammable Non-Toxic Gases, International Maritime Dangerous Goods Code.

directly or indirectly which cause harm to human body, property, natural resources or natural ecology."[37]

3.2 Surface Rights and Subsurface Rights

The **Land Act** contemplates real property is owned by the State on behalf of all citizens except for private property which may be created or extinguished from time to time. According to the Land Act, "All land lying within the territorial limits of the Republic of China shall belong to the Chinese people as a whole." Any part of the land whereof the ownership is lawfully acquired by an individual Chinese shall be private land. Any land whereof private ownership is extinguished shall be owned by the State."[38]

The Land Act defines "land" to mean "dry land, bodies of water, and natural sources of wealth."[39] The Land Act defines four types of land, of which type II is lands used for direct production including "lands with mineral deposits, . . . sources of water".[40] Although the Land Act does not refer to the subsurface, the reference to "natural sources of wealth" and "lands with mineral deposits" clearly encompass subsurface rights.

The Land Act further states, "Minerals attached to any land shall not become private property, even if private ownership of the said land has been duly acquired. The mineral referred to in the preceding paragraph shall be limited to those which are specified in the Mining Industry Act."[41] Further, the Land Act prohibits the transfer or lease of certain types of lands to aliens, including lands with mineral deposits, subject to an exception for aliens whose governments have established diplomat relations with the Republic of China.[42]

The Land Act limits leases of public lands under the jurisdiction of municipal or county (city) government to no more than ten years without consent of the local assembly and approval of the Executive Yuan.[43]

The Land Act provides for eminent domain rights known as "compulsory purchase" in favor of the central government, which requires the payment of compensation for land acquired by the State from third parties for certain specified undertaking including the "public interest" and "the implementation of national economic policies".[44]

The **National Property Act** governs the granting of rights to use national property for public and private purposes.[45] The grant of public lands to be used for a CCS project would be subject to

[37] Article 3, Ocean Pollution Control Act.
[38] Article 10, Land Act.
[39] Article 1, Land Act.
[40] Article 2, Land Act.
[41] Article 15, Land Act.
[42] Articles 17 and 18, Land Act.
[43] Article 25, Land Act.
[44] Articles 208 and 209, Land Act.
[45] Chapter 4, National Property Act.

the provisions of this law, a well as special property rights regimes for power and petroleum activities.

According to the Mining Act, "all mineral ownerships within the territory, exclusive economic marine zone and continental shelf of the Republic of China are owned by the state and shall not be exploited unless a mineral right thereof has been acquired pursuit to this Act."[46] Petroleum, oil shale and natural gas are specifically included within the definition of minerals.[47] The Mining Act provides for exploitation permits for up to 20 years that can be extended in 20-year intervals.[48]

The **Civil Code** clarifies that ownership of land extends to the subsurface to some extent based on what appears to be a use concept, although it does not define the precise boundary of subsurface rights. According to the Civil Code, "Unless otherwise restricted by the Acts and regulations, ownership of land extends to such height and depth above and below the surface of the land within the range advantageous to the exercise of such ownership. Interference from others shall not be excluded if it does not obstruct the exercise of the ownership."[49]

3.3 Long-Term Stewardship and Liability for Stored CO_2

The **Basic Environment Act** imposes liability for pollution and environmental harm. It states: "Those who pollute or destroy the environment shall be responsible for the environmental harm or risk they create."[50]

The **Civil Code** imposes requires one party compensate another under general tort theories of intentionally or negligently causing injury. According to the Civil Code, "A person who, intentionally or negligently, has wrongfully damaged the rights of another is bound to compensate him for any injury arising therefrom. The same rule shall be applied when the injury is done intentionally in a manner against the rules of morals."[51] Further, The Civil Code contemplates liability in the absence of negligence for violation of a statutory provision to protect others: "A person, who violates a statutory provision enacted for the protection of others and therefore prejudice to others, is bound to compensate for the injury, except no negligence in his act can be proved."[52] Where a defendant has not satisfied its duty to exercise reasonable care to prevent injury, an injured party may seek compensation caused by works on private land[53] or operation of a business on the theory that the business owner created the risk and should

[46] Article 2, Mineral Rights Act.
[47] Article 3, Mineral Rights Act.
[48] Article 12, Mineral Rights Act.
[49] Article 773, Civil Code.
[50] Article 4, Basic Environment Act.
[51] Article 184, Civil Code.
[52] Article 184, Civil Code.
[53] Article 191, Civil Code.

therefore be liable.[54] Damages may be pursued for wrongful death,[55] injury[56] and property damage.[57]

The Civil Code also establishes a number of rights relating to the quiet enjoyment of real property, principally the right to exclude others[58]and right to use property without interference,[59] as well as obligations that protect others in their use of property, including a duty to prevent injury to adjacent properties,[60] and prohibitions on trespass.[61] The Civil Code also prohibits the discharge of gases affecting others real property rights.[62]

Under the **Mining Act**, which governs oil and gas operations as well as other mining activities, exploitation permits may be granted for up to 20 years that can be extended for 20-year intervals.[63] The mineral rights holder is required to remediate land and would be liable to compensate others affected by their operations. [64] However, beyond these basic requirements, there is no provision for the setting aside of funds or other means to care for post-operation site care expenses.

If CO_2 is sequestered offshore, the **Ocean Pollution Control Act** would impose financial assurance requirements. Operators would be required to submit a proposal for emergency response and a letter of financial guarantee or liability insurance policy for compensating pollution damage in order to prevent or treat ocean pollution.[65]

Public employees may also be liable for damages under tort theories. Pursuant to the **Civil Code**, "A public employee shall be liable for compensation of a third party's loss caused by her intentional breach o f her duty. However, if the public employee has only acted negligently, she shall only be liable for compensation if the sufferer is not able to receive compensation through other means."[66]

3.4 Environmental Protection

Basic Environment Act. The Basic Environment Act provides the basic framework for regulating environmental issues in Chinese Taipei. As a framework, the Basic Environment relies on other environmental laws to implement environmental regulation in specific areas.

[54] Article 191-3, Civil Code.
[55] Article 192, Civil Code.
[56] Article 193, Civil Code.
[57] Article 196, Civil Code.
[58] Article 765, Civil Code.
[59] Article 767, Civil Code.
[60] Article 774, Civil Code.
[61] Article 790, Civil Code.
[62] Article 793, Civil Code.
[63] Article 12, Mineral Rights Act.
[64] Articles 48 and 49, Mineral Rights Act.
[65] Article 13, Ocean Pollution Control Act.
[66] Article 186(1), Civil Code.

The Basic Environment Act would apply to CCS activities undertaken in Chinese Taipei, both supporting and regulating CCS. As noted above, the Act requires government entities at all levels to take measures to reduce CO_2 emissions.[67] It adheres to the polluter pays principle, imposing liability for anyone who causes "environmental harm or risk."[68] According to the Act, those who pollute or destroy environmental resources are subject to pay pollution control or environmental restoration fees.[69] Under the Act, enterprises are required to establish dedicated units or personnel to support environmental protection and to draft and implement environmental protection plans.[70]

The central government is required by the Act to create "environmental funds" to cover costs associated with environmental cleanup, restoration and to track and investigate pollution sources.[71]

The Basic Environment Act requires government entities at all levels to adopt "preferential treatment and incentive measures" to guide the development of environmental protection enterprises and private environmental protection groups, as well as "encourage private investment in the environmental protection industry."[72] These incentives are to include "provision of land or other resources to be used to protect the environment."[73]

Further, the central government is specifically required to promote high technology and to achieve environmental goals. It requires the central government to provide incentives for academic and research organizations involved in environmental protection to upgrade facilities, recruit and train personnel "introduce advanced technologies, and integrate research resources, hastening the development of demonstration projects and research on environmental protection technology."[74]

The **Air Pollution Control Act** governs the air quality and regulates polluted air emission including from industries and transportation. The Air Pollution Control Act is administered at the central level by the EPA and at the provincial and city level by municipal authorities. Currently, CO_2 is not deemed as air pollutant under the Act.[75] The Act defines "air pollutant" as "matter in the air in amounts that can be harmful to citizens' health or living environment directly or indirectly," and "polluting origin" as "emitting air pollutant of physical or chemical operational elements."[76] According to the Act, the EPA, based on the geological and climate conditions, may designate a control regions of one or more cities and require plans to improve air quality in

[67] Article 21, Basic Environment Act.
[68] Article 4, Basic Environment Act.
[69] Article 28, Basic Environment Act.
[70] Article 13, Basic Environment Act.
[71] Article 31, Basic Environment Act.
[72] Article 36, Basic Environment Act.
[73] Article 37, Basic Environment Act.
[74] Article 35, Basic Environment Act.
[75] Article 2, Implementation Ordinance of the Air Pollution Control Act.
[76] Article 2, Air Pollution Control Act.

the designated.[77] The Act imposes an "air pollution control fee" to be collected from polluters,[78] and financial penalties for those who violate the Act.[79] The Act requires a prompt response for accidental pollution discharges including prompt notice to the regulator, immediate corrective measures, and a report to regulators within a certain period of time.[80] The Act also authorizes financial rewards and access to R&D funds for projects that improve air pollution and promote clean energy.[81]

Soil and Groundwater Pollution Remediation Act regulates the discharge or disposal of pollutants into the soil and groundwater. Under the Act, soil or groundwater pollution means the "introduction into soil or groundwater of substances, biological organisms or forms of energy that alter soil quality, impact the normal use of the soil or endanger public health and the living environment."[82] It establishes a Soil and Groundwater Remediation Fund, funded by various sources including revenues from fees collected for remediation, payments from polluters, land developers and funds appropriated through the budget process.[83] Private facilities designated by the central government must install pollution control equipment.[84] The Act grants local government jurisdiction to monitor compliance, enforce the law, and report results to the central government's EPA.[85] Victims of water pollution may seek enforcement of the Act and government authorities can remediate sites and seek compensation in the event polluters fail to comply with enforcement actions.[86] Under the Act if government authorities fail to enforce the law, public interest organizations can directly file a suit against the polluter in administrative court.[87]

The following regulations and standards have been adopted under the Soil and Groundwater Remediation Act:

- Groundwater Pollution Control Standards
- Groundwater Pollution Monitoring Standards
- Regulations Governing Collection of Soil and Groundwater Pollution Remediation Fees
- Regulations Governing the Preliminary Assessment of Soil and Groundwater Pollution Control Sites
- Remediation Site Scope of Pollution Survey, Environmental Impact Assessment, and Cleanup Priority Ranking Regulations
- Soil Pollution and Groundwater Pollution Remediation Fund Revenues and Expenditures, Safekeeping, and Utilization Regulations

[77] Article 8, Air Pollution Control Act.
[78] Article 16-18, Air Pollution Control Act.
[79] Chapter 4, Air Pollution Control Act.
[80] Article 77, Air Pollution Control Act.
[81] Article 18, Air Pollution Control Act.
[82] Article 2, Soil and Groundwater Pollution Remediation Act.
[83] Article 23, Soil and Groundwater Pollution Remediation Act.
[84] Article 33, Soil and Groundwater Pollution Remediation Act.
[85] Article 5, Soil and Groundwater Pollution Remediation Act.
[86] Articles 70 and 71, Soil and Groundwater Pollution Remediation Act.
[87] Article 72, Soil and Groundwater Pollution Remediation Act.

- Soil Pollution and Groundwater Pollution Remediation Act Enforcement Rules

Pursuant to the Soil and Groundwater Pollution Remediation Act, the EPA adopted Groundwater Pollution Control Standards (enacted in 2001 and revised in 2009), which specify pollutant control values for groundwater.[88] Under the Groundwater *Soil Pollution and Groundwater Pollution Remediation Act Enforcement Rules, where* a land development plan and soil and groundwater pollution remediation plan are required to be submitted simultaneously, the industry competent authority in charge of land development and the EPA "shall perform review and approval in accordance with relevant laws and regulations in mutual consultation."[89]

Under the Regulations Governing Collection of Soil and Groundwater Pollution Remediation Fees, "fee payers" (the chemical substance manufacturers and importers designated and officially announced by the central competent authority) to pay soil and groundwater pollution remediation fees. Fee payers that have purchased environmental damage liability insurance or other insurance may apply for a refund of a portion of remediation fees.

Drinking Water Management Act prohibits polluting areas within a certain distance of a drinking water sources. Under the Act, "dumping, release or discarding of garbage, ash, …, or other articles sufficient to cause the pollution of water sources" is prohibited.[90]

The Waste Disposal Act governs the disposal of "waste" in any media. It provides for two categories of waste: general waste (e.g., household waste) and industrial waste, of which there are two types of industrial waste. CO_2 could potentially be categorized under the broad definitions of industrial waste. "Hazardous industrial waste" is "waste produced by industry that is toxic or dangerous and the concentration or volume of which is sufficient to influence human health or pollute the environment." "General industrial waste" is "waste produced by industry that is not hazardous industrial waste."[91] Industrial wastes include wastes from industrial and mining plants and sites and other enterprises designated by the central competent authority.[92] Enterprises discharging industrial waste are required to obtain a permit and maintain records and make reports.[93] Enterprises of a certain scale may be designated by the central EPA to submit an industrial waste disposal plan to the local EPA or the organization commissioned by the central EPA for review and approval.[94] Failure to comply with the Waste Disposal Act can result in governmental action to remediate pollution, and seek compensation from the polluter.[95] If government authorities fail to enforce the law, public interest organizations can directly file a suit against the polluter in administrative court.[96]

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[88] Groundwater Pollution Control Standards, Nov. 2001 amended in 2009.
[89] Article 29, Soil Pollution and Groundwater Pollution Remediation Act Enforcement Rules.
[90] Article 5, Drinking Water Management Act.
[91] Article 2, Waste Disposal Act.
[92] Article 2, Waste Disposal Act.
[93] Article 30, Waste Disposal Act.
[94] Article 31, Waste Disposal Act.
[95] Article 71, Waste Disposal Act.
[96] Article 72, Waste Disposal Act.

Pursuant to the Waste Disposal Act, the Methods and Facilities Standards for the Storage, Clearance and Disposal of Industrial Waste contains measures to prevent waste liquids, waste gases or noxious odors, etc. from polluting surface water bodies, groundwater bodies, air or soil.[97]

The **Water Pollution Control Act** governs the surface water quality as well as the disposal of industrial wastewater and domestic sewage. The EPA administers the Act at the central level, and local governments administer it at the provincial and city levels. The Act defines "pollutant" as "any materials, living beings and energy that can result to water pollution."[98] It requires a water pollution control fee to be collected from industries, sewage systems as well as individual families that dispose wastewater or sewage into ground water body.[99] Industrial facilities disposing of wastewater or sewage are required to obtain a permit.[100] Violators of the Act are subject to financial fines or prison terms depending on the degrees of the violation.[101]

The **Ocean Pollution Control Act** defines "harmful material" as "the designated materials according to International Maritime Dangerous Goods Code."[102] The International Maritime Dangerous Goods Code covers CO_2.[103] In the Act, "polluting conduct" relating to the activities "in the ocean environment that directly or indirectly causes harm to human health, property, natural resources or natural ecology."[104] The MOEA designates entities subject to the Act. Currently, only the hydrocarbon industry has been designated as subject to the Act. According to the Act, actors engaged in oil transportation, sea engineering, ocean dumping, marine incineration and other polluters in public sites designated by the central administrative entity are subject to submit a proposal for emergency response and a letter of financial guarantee or liability insurance policy for compensating pollution damage in order to prevent or treat ocean pollution.[105] The content and format of the proposal for emergency response is determined by the Environmental Protection Agency of the Executive Yuan, as is the guarantee amount, in consultation with the Ministry of Finance.

Environmental Impact Assessment (EIA) Act requires an EIA Review Committee to be established at the central government, municipal, and county or city levels. The Committees are responsible for reviewing EIA reports. Membership is limited to 2-year terms and the composition of the committees must be no less than two-thirds experts and academics.[106] Under the law, EIAs shall be conducted for development activities for which there is concern of adverse impact on the environment, and the scope of "development activities" includes its

[97] Article 12, Methods and Facilities Standards for the Storage, Clearance and Disposal of Industrial Waste, Dec. 2006.
[98] Article 2, Water Pollution Control Act.
[99] Article 11, Water Pollution Control Act.
[100] Article 32, Water Pollution Control Act.
[101] Chapter 4, Waster Pollution Control Act.
[102] Article 3, Ocean Pollution Control Act.
[103] Class 2.2 Non-Flammable Non-Toxic Gases, International Maritime Dangerous Goods Code.
[104] Article 3, Ocean Pollution Control Act.
[105] Article 13, Ocean Pollution Control Act.
[106] Article 3, Environmental Impact Assessment Act.

planning, implementation and post-completion use.[107] A wide range of projects are required to prepare EIAs including environmental protection projects.[108] The law provides for Phase I (initial) and Phase II (comprehensive) EIAs, as well as review and follow-up evaluation.[109] The law requires extensive public disclosure and participation in review of plants, which are further described below in the section on public participation.

Regulations related to the Environmental Impact Assessment Act include:

- *EIA Act Enforcement Rules*
- *Regulations Governing Government Policies on EIA*
- *Standards for Determining Specific Items and Scope of EIAs for Development Activities*
- *Specific Policy Items Requiring the Conduct of an EIA*

3.5 CO_2 Transportation

The **Petroleum Administration Act** authorizes the use of land for oil and gas pipelines and provides a general framework for regulating the operation and access to pipelines. It states that "where necessary, oil refinery operators or importers may lay pipelines using rivers, irrigation canals and ditches, coastal areas, bridges, dikes, ports and harbors, roads, forest land, green land, parks, and other public lands."[110] Approval for siting pipelines is necessary from the MOEA and the agency in charge of the land.[111] A pipelines operator must compensate third parties for any damage caused to third parties in connection with the operation of the pipeline.[112] The Act also requires refinery operators or importers who operate oil pipelines to accept request from other businesses to transmit oil through those pipelines."[113]

CPC operates two LNG receiving terminals in Yongan Township in Kaohsiung and Taichung and operates a network of natural gas pipelines. In the south, the company laid a 36-inch diameter, 238 km long-distance undersea pipeline from Yongan to Tongxiao in 2002. In the north, CPC operates a 135-kilometer, 36-inch sea/land long-distance transportation pipeline from Taichung Harbor through the Tongxiao distribution station to the Datan measuring station, along with related facilities. In western area of Chinese Taipei, CPC constructed a transmission and distribution system, which includes 1,757 kilometers of truck pipelines, 36 distribution stations, and 1,471 kilometers of regional loop transmission networks belonging to eight supply centers.

MOTC would have authority over CO_2 transported by truck or ship. The **Ocean Pollution Control** Act would govern offshore pipelines.

[107] Article 5, Environmental Impact Assessment Act.
[108] Article 5, Environmental Impact Assessment Act.
[109] Article 4, Environmental Impact Assessment Act.
[110] Article 31, Petroleum Administration Act.
[111] Article 31, Petroleum Administration Act.
[112] Article 31, Petroleum Administration Act.
[113] Article 31, Petroleum Administration Act.

3.6 Health and Safety

The Council of Labor Affairs (CLA) through the Department of Labor Safety and Health is responsible for administering the **Labor Safety and Health Act**. The Labor Safety and Health Act governs workplace safety. The current law covered specified industries designated by the government but is currently under review to be expanded to cover all workers in the country except government employees.[114] The Act contains provisions concerning risk reduction associated with machine, including provisions relating to gases.[115] It requires monitoring workplace exposure to substances and adoption of an emergency response plan.[116]

The CLA maintains an occupational health safety system that focuses on risk mitigation. Construction and machinery operation have been identified as priority areas.[117] The current law already covers the electricity and fuel gas industries, which would be involved in CCS activities.[118] It specifically requires employers to provide take safety measures in accordance with established standards for risks of injury pose by high-pressure gas and from gas, liquid or solid wastes.[119]

3.7 Power Sector Laws

Taipower, the state-owned electric power, accounts for about three quarters of power generation and maintains a monopoly in transmission and distribution activities. Independent power producers own roughly one quarter of Chinese Taipei's generating capacity, although independent power producers are required to sign power purchase agreements with Taipower as the sole buyer of wholesale electricity.[120] The central government has been planning to carry out a full or partial privatization of Taipower's generation assets, splitting the company into several firms, however Taipower would retain a monopoly on transmission and distribution networks.[121]

The Bureau of Energy under the MOEA regulates Taipower and the electricity sector. Its functions include reviewing electricity prices; energy supply and demand planning; and granting

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[114] China Post, http://www.chinapost.com.tw/taiwan/national/national-news/2011/04/27/300160/CLA-to.htm (accessed on August 19, 2011).
[115] Articles 5.6, 5.7 and 5.10, Labor Safety and Health Act.
[116] Articles 7 and 10, Labor Safety and Health Act.
[117] Council of Labor Affairs website, http://www.cla.gov.tw/cgi-bin/siteMaker/SM_theme?page=48f2b97a (accessed on August 19, 2011).
[118] Article 4, Labor Safety and Health Law, as amended.
[119] Article 5, Labor Safety and Health Law, as amended.
[120] *The Encyclopedia of Earth* available at www.eoearth.org/article/energy_profile-of-Taiwan (accessed July 6, 2011).
[121] Tony Allison, "Taiwan: More than Just a Nuclear Controversy," *Asia Times Online* at www.atimes.com/reports/BK01Ai01.html, Nov. 1, 2000 (accessed October 1, 2011).

permission for energy-related production, distribution, marketing and utilization.[122] Electricity pricing is based on cost plus a "reasonable profit" formula.[123]

Taipower mainly decides Chinese Taipei's wholesale and consumer electricity prices. Fuel prices are set by the CPC. However, both are monitored by the Oil and Electricity Price Commission. Oil and electricity prices in Chinese Taipei are lower relative to world prices partially due to the government's pricing policy in oil and power sector. Since May 2008, President Ma's government has adopted a floating price formula for oil and partial adjustment for electricity prices to promote energy conservation and carbon emissions reductions.

3.8 Oil, Gas and Mining Laws

Mining Act governs the rights to, and exploitation of, mineral resources. It is designed to cover a broad range of mining activities and is general in nature. According to the Mining Act, "all mineral ownerships within the territory, exclusive economic marine zone and continental shelf of the Republic of China are owned by the state and shall not be exploited unless a mineral right thereof has been acquired pursuit to this Act."[124] Petroleum, oil shale and natural gas are specifically included within the definition of minerals.[125] The Mining Act provides for an exploration permit of up to 2 years and an exploitation permit for up to 20 years that can be extended in 20-year intervals.[126] The right holder is required to submit "construction plans, together with drawings" to the MOEA and to consult other agencies responsible for land administration, environmental protection and soil and water conservation.[127] After approval of the land use, the right holder is required to "consult with the landowner and interested party to secure the right to use the land. If an agreement cannot be reached, either party may request the governing agency for settlement."[128] The mineral rights holder is required to remediate land and would be liable to compensate others affected by their operations.[129]

Petroleum Administration Act regulates refining and downstream oil and gas operations. Its also provides for oil and gas pipeline siting requirements which are described in the section on transportation. In addition to the pipeline provisions, several provisions could provide a model for CCS regulation. The Act requires oil- and gasoline-related businesses to obtain public liability insurance coverage and accidental contamination liability insurance. The Bureau of Energy, MOEA determines how much insurance coverage each business must obtain after conferring with the Ministry of Finance.[130] The Petroleum Administration Act creates the

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[122] Article 59, Electricity Act; see also website of the Ministry of Economic Affairs, Bureau of Energy, http://www.moeaboe.gov.tw/English/About/EnAbMain.aspx?Pageid=Functions (accessed September 30, 2011).
[123] Articles 60 and 79, Electricity Act.
[124] Article 2, Mineral Rights Act.
[125] Article 3, Mineral Rights Act.
[126] Article 12, Mineral Rights Act.
[127] Article 43, Mineral Rights Act.
[128] Article 46, Mineral Rights Act.
[129] Articles 48 and 49, Mineral Rights Act.
[130] Article 22, Petroleum Administration Act.

Petroleum Fund, which is used for various objectives including to support energy security and to develop new technologies, funded based on fees collected from oil importers, oil exploration fees and chemical processing and refinery operations.[131]

3.9 Public Participation

The Basic Environmental Act states the principle that citizens, enterprises and government entities at all levels jointly share the duties and responsibilities of protecting the environment.[132] Under the Waste Disposal Act, if government authorities fail to enforce the law, public interest organizations can directly file a suit against the polluter in administrative court.[133] A similar provision enables public interest groups to directly enforce the Soil and Groundwater Pollution Remediation Act.[134]

The Environmental Impact Assessment Act requires extensive public disclosure and participation in the review of Phase II (comprehensive) EIAs. EIA Review Committees are required to be established at the central government, municipal, county and city levels. Under the law, the developer is required to make the initial EIA available at or near the development site for a period of 30 days, publish specified information in the newspaper concerning the development, and hold a public explanation meeting.[135] Members of the public including local residents, public interest groups and academics are to be invited to provide written opinions and the developer must take these opinions into consideration in drafting the Phase II EIA.[136] The government authority responsible for the project will then convent a meeting of the Committee together with local residents and other stakeholder to conduct on-site inspections and a public hearing within 30 days of the receipt of the draft EIA and thereafter prepare an evaluation of the EIA.[137]

Pursuant to the Local Government Act, provinces, municipalities, cities and towns have local government and consultative councils, which are administrative and legislative bodies.[138] Provincial governments are part of the Executive Yuan, and the President appoints their leadership.[139] Local governments are self-governing bodies and their officials are elected locally.[140] Local government has authority to regulate certain matters specified in the law including public safety, watersheds, environment and environmental protection and certain land

[131] Articles 35 and 36, Petroleum Administration Act.
[132] Article 4, Basic Environment Act.
[133] Article 72, Waste Disposal Act.
[134] Article 72, Soil and Groundwater Pollution Remediation Act.
[135] Article 8, *Environmental Impact Assessment Act.*
[136] Article 11, *Environmental Impact Assessment Act.*
[137] Articles 12 and 13, *Environmental Impact Assessment Act.*
[138] Article 5, Local Government Act.
[139] Article 7-1, Local Government Act.
[140] Articles 14 and 16, Local Government Act.

issues.[141] Local governments, however, remain subject to regulation by the Executive Yuan and any act in violation of central government regulation is subject to revocation.[142]

In 2005, the government enacted the Freedom of Government Information Law, which requires the government to make information available to the public in a pro-active and timely manner, or upon request of any citizen or groups established by citizens or foreigners.[143] Generally, the government is required to make determinations pursuant to requests within 30 days[144]and fees can be waived for requests made for academic or public interest use. [145] The Act provides for broad release of information, subject to a number of exceptions including national security and confidentiality reasons, or because the document is a draft or for internal use before a government agency decision has been rendered.[146]

3.10 Foreign Investment

The primary law regulating foreign investment is the ***Statute for Investment by Foreign Nationals***. Under the ***Statute for Investment by Foreign Nationals,*** MOEA approval is required for reinvestment if a foreign investor holds, in an aggregate, more than one third of the total shares issued by an enterprise in which he/she invests, or if a foreign investor contributes, in an aggregate, more than one third of the total capital amount of an enterprise.[147]

Foreigners are prohibited from investing in industries that may negatively affect national security, public order, good customs and practices, or national health; and those that are otherwise prohibited by the law.[148] After Chinese Taipei joined the WTO in 2001-2002, foreign investors could be permitted to own up to 100% of independent power producers.

In the area of foreign investment, the government is promoting the "Global Net Project" to establish the cross-strait industrial cooperation platform in order to attract foreign investors to participate in cross-strait projects.[149]

In order to encourage industries to use international resources, the **Statute of Industrial Innovation** allows the MOEA provide appropriate assistance and guidance with respect to

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[141] Articles 18-20, Local Government Act.
[142] Article 75, Local Government Act.
[143] Articles 5, 6 and 9, Freedom of Government Information Law.
[144] Article 12, Freedom of Government Information Law.
[145] Article 22, Freedom of Government Information Law.
[146] Article 18, Freedom of Government Information Law.
[147] *Statute for Investment by Foreign Nationals*, MOEA, Investment Commission, MOEA, amended in November 1997.
[148] Article 7, Statute for Investment by Foreign Nationals.
[149] Laws and Regulations, Invest in Taiwan, available at www.investtaiwan.nat.gov.tw/matter/show-eng.jsp?ID=8, (accessed August 24, 2011).

overseas investment or international technology collaboration.[150] In addition, according to the Statute, in order to attract funds back for investment, the MOEA may introduce measures to assist in the obtaining of land for industrial use as an incentive for investment.[151] Under the Statute, companies wishing to undertake overseas investment are subject to obtain an approval from the MOEA; and overseas investment of NT$1.5 billion or less are subject to be reported to the MOEA after the investment has been implemented.[152]

3.11 Financial Incentives

As described above, the Basic Environment Act requires government entities at all levels to adopt "preferential treatment and incentive measures" to guide the development of environmental protection enterprises and private environmental protection groups, as well as "encourage private investment in the environmental protection industry."[153] The central government is specifically required to provide incentives for academic and research organizations involved in environmental protection to upgrade facilities, recruit and train personnel "introduce advanced technologies, and integrate research resources, hastening the development of demonstration projects and research on environmental protection technology."[154]

The government has adopted several incentives for renewable and clean energy. These generally apply to solar thermal and photovoltaic, geothermal and other renewable energy. The incentives include government subsidies for purchase of equipment, power purchase requirements with additional tariff amounts. The Draft Renewable Energy development Law will establish a feed-in-tariff.

Tax incentives include tax credits of up to 11% of equipment cost, income tax credits from 10% to 20% of investment, accelerated depreciation, and low interest loans. In addition, the government grants exemptions from customs duties for imported equipment that cannot be manufactured domestically.[155]

The **Statute of Industrial Innovation,** enacted in May 2010 to promote industrial innovation and improvement of the industrial environment, instructs the MOEA to provide grants or guidance to industry and local governments to promote innovative activities including R&D, upgrade of industrial technology, and collaboration between industries, academic institutions, and research institutions.[156] It specifically authorizes MOEA to provide enterprises with grants or guidance to promote the development and application of technology relating to greenhouse

[150] Article 21, Statute of Industrial Innovation.
[151] Article 23, Statute of Industrial Innovation.
[152] Article 22, Statute of Industrial Innovation.
[153] Article 36, Basic Environment Act.
[154] Article 35, Basic Environment Act.
[155] Industrial Technology Research Institute website, http://re.org.tw/Re2/Eng/promotion.aspx (accessed August 19, 2011).
[156] Articles 5 and 9, Statute of Industrial Innovation.

gas reduction and pollution prevention.[157] The MOEA prescribes the criteria governing the selection and terms of these grants. Under the statute, the MOEA may provide grants to small- and medium-size enterprises that create job opportunities for citizens. The statute also provides firms with tax credits of up to 15% of its total expenditure on R&D against business income tax.[158]

[157] Article 26, Statute of Industrial Innovation.
[158] Articles 10 and 11, Statute of Industrial Innovation.