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1.1 Introduction

The number and scope of carbon capture and storage (CCS) projects worldwide are expanding at a rapid rate. Of concern, however, is the lack of a clear, defined legal and regulatory framework in which to operate. In particular, work is needed in the areas of the definition/classification of carbon dioxide (CO_2), access and property rights, intellectual property rights (IPR), monitoring and verification requirements, and liability. Several initiatives have been undertaken to address deficiencies through regulatory working groups and by incorporating a regulatory component within current and planned CCS projects.

To assist in the development of a regulatory framework for CCS projects, an understanding of current practices is important. This paper therefore examines regulatory developments of major CCS projects to determine actual progress in regulating such projects. In particular, we look at five case studies of CCS projects that range from enhanced resource recovery to direct storage and which have been developed for a mix of purposes, such as commercial, research and development, and pilot demonstrations. These case studies indicate that regulatory progress varies greatly among projects, and differs depending on the size, scope, and the location of the projects. The focus of this report is the legal and regulatory context for international projects, but it should be recognized that CCS field projects in the United States are also addressing many of the regulatory issues related to CCS.[1]

The first part of this paper (Section 1) highlights the major unresolved legal and regulatory issues related to CCS and summarizes international efforts to address these. Section 2 describes each of the case studies, Gorgon in Australia, In Salah in Algeria, Sleipner in Norway, RECOPOL in Poland, and CO_2SINK in Germany, and highlights how each of the case studies have or intend to address regulatory issues related to CCS. Section 3 concludes with a summary of major trends in addressing such regulatory issues at existing CCS projects worldwide and provides recommendations for further analysis and research. The findings presented in this paper can be used to support on-going and future research and technology transfer activities undertaken by international programs to promote the adoption of CCS, such as the Carbon Sequestration Leadership Forum (CSLF) and the Asia-Pacific Partnership on Clean Development and Climate (AP6).

1.2 Legal and Regulatory Issues for Carbon Capture and Storage

Interest in CCS has increased rapidly in the past few years as governments and businesses increasingly see the benefit of using technology to address climate change and enhance energy security. However, it is generally acknowledged that the use of CCS technology will only go so far without an effective framework that includes legal and regulatory templates and guidelines, particularly related to the long-term storage of injected carbon dioxide (CO_2). Currently, there are no uniform guidelines regulating CCS projects nationally or internationally. If regulatory issues are addressed in CCS projects, they are mostly dealt with on a case-by-case basis in contracts for a particular project.

Because these contracts typically only address topics that are necessary to meet existing regulatory requirements, they may not cover issues that have yet to be fully resolved, such as liability and safety requirements for long-term storage. This creates uncertainty and confusion about long-term property rights and liability, particularly in the post-injection phases of the project. It also raises concerns about the long-term environmental integrity of the projects.

The development of a more consistent regulatory framework would help alleviate some of this confusion. According to the CSLF, a group of nations led by the United States Department of Energy and that has formed a partnership to develop cost-effective CCS technologies, such a framework would help ensure short- and long-term public and environmental safety, provide stakeholder confidence and investment incentives, establish a common ground for all nations to undertake CCS, and create trust within and between nations.[2] Developing and enclosing recent international legislation related to CCS activities into national legislation may also prevent contradictory and overlapping rulings across national borders. Finally, a more consistent legal framework that also includes clear financial incentives for project activities would overcome some of the hesitancy of major industry players to expand investment in new CCS projects.

Additionally, collaborative projects such as AP6 could contribute to the development of regulations. AP6 was founded in 2005 by a partnership of six countries, the United States, Australia, China, India, Japan, and the Republic of Korea, and its focus is the development and transfer of technology to reduce greenhouse gas emissions. CCS is one of the potential technologies that may be supported by the Partnership. Future meetings of AP6 could address regulatory issues of deploying CCS technologies, and because of the unique nature of the Partnership and its members, the developed countries in the group could provide legal assistance to the developed countries in the Partnership with setting up regulations for CCS.

Several unresolved legal and regulatory issues have been identified as being critical to the future success of CCS technology development and deployment. As described in Table 1, most of these relate to the injection and storage of CO_2 and the long-term stewardship of the storage site (Table 1). In the area of CO_2 injection and storage, the paper will focus on storage, property rights, and intellectual property rights while the discussion of long-term stewardship will focus on monitoring and verification requirements and liability. Each of these issues is outlined further below.

Table 1. Legal and Regulatory Issues for CCS

CCS Project Phase	Major Legal and Regulatory Issues
CO_2 Injection and Storage	• Storage (definition and well design) • Property rights • Intellectual property rights
Long-term Stewardship	• Monitoring and verification • Liability

Accounting for CCS in national greenhouse gas inventories is a separate but related regulatory issue, which has received significant attention over the past couple of years. It is being addressed in the draft Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Inventories and is therefore not addressed further in this paper.[3]

1.2.1 Storage

Two main legal and regulatory issues relating to the storage of CO_2 include: 1) how the CO_2 itself is defined or classified, which determines its legality and treatment under existing international treaties and national laws, and 2) whether and how standards should be developed for well design at the storage site.

1.2.1.1 Definition of CO_2

The definition of CO_2 and the process by which it is stored is crucial for determining the type and jurisdiction of the regulations covering CCS activities. In general, the stored CO_2 can either be classified as an industrial product or as a waste product. This distinction is important because industrial projects typically are subject to less stringent environmental regulations than waste disposal projects. However, existing industrial and waste product classifications have typically been designed for other commodities and substances and therefore their regulation may not be relevant for CO_2. Industry groups engaged in enhanced oil recovery (EOR) activities tend to advocate the classification of CO_2 as an industrial product while regulators concerned with long-term environmental and health impacts of CO_2 lean toward defining it as a waste product. This is particularly the case for CCS projects developed solely for the purpose of CO_2 storage.

If CO_2 is used for enhanced resource recovery, the resulting CO_2 storage is generally considered an industrial use because the CO_2 is used to extract oil, gas, or methane for further use. This is the case for most EOR projects in the United States.[4] However, carbon storage projects that do not have an industrial, or resource recovery, component are in a legal grey area as the delineations between industrial and non-industrial are vague. Text Box 1 gives two examples of cases settled by the European Court of Justice that reflect the confusion of this issue. There is some controversy over the distinction between the purpose of the industrial process and waste, and whether the classification of CO_2 can change from industrial to waste if the operations shift from EOR to long-term storage. Such a shift could cause complications during the permitting of projects, because project developers essentially would be required to obtain permits for two different kinds of project categories.

How CO_2 is classified also determines its legality and treatment under international treaties and national laws and regulations. There are currently several regional and global treaties that could apply to international CO_2 storage projects, especially offshore. Current projects are allowed as industrial storage or enhanced resource recovery projects under the marine treaties, i.e., the London Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matters (London Convention) and the Protocol to the London Convention (London Protocol), the United Nations Convention on the Law of the Sea (UNCLOS), and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR). This is because the purpose of the storage is not considered disposal, but rather a part of an industrial process. Even though it has been determined that these conventions allow for enhanced resource recovery, it still remains uncertain whether these treaties actually

Text Box 1. European Court of Justice Decisions on Waste Recovery and Disposal

In 2003, the European Court of Justice issued two decisions regarding the definition of waste as recovery or disposal.

- In one case, the ECJ decided that the use of waste as fuel in cement kilns was waste recovery; and
- In the other case, the ECJ decided that the export of municipal waste for incineration was waste disposal, despite the fact that it involved energy recovery.

While neither of these decisions is directly related to CCS, they concern the definition of a waste product as dependent on its use for producing energy. As waste disposal and waste used in recovery operations come under different regulations (stricter environmental laws apply to the former), environmentalist worry that projects that should really be classified as waste disposal will be covered under recovery and thus be subject to less stringent laws. Because the deliberations came to different conclusions based on the intricacies of each case, some industry representatives are concerned that similarly contradictory decisions related to CO_2 injection and storage could slow down the permitting of enhanced resource recovery projects if unclear distinctions are used.

Sources: Institute for European Environment Policy, "European Forum on Integrated Environmental Assessment Workshop on Improving Waste Policy Through Integrated Environmental Assessment," Workshop Proceedings, Brussels, 6-7 December 2004, http://www.ieep.org/uk/pdfs/2004/efieaproceedings.pdf; Geir Vollsaeter, AK Norske Shell, "Legal Aspects of Storing Carbon Dioxide," Presentation for the IEA/CSLF on International Frameworks, Paris, 19 July 2004, http://www.iea.org/Textbase/work/2004/storing_carbon/vollsaeter.pdf

regulate or constrain any offshore CCS projects. The treaties were established before the emergence of CCS as a major option for reducing CO_2 emissions, and so a new framework may be needed to deal specifically with CCS projects, including those offshore projects, such as Sleipner, that do not include enhanced resource recovery. Efforts to clarify the treatment of CCS under relevant international treaties are described in Sections 1.3.3.2 and 1.3.3.3.

The issue of classifying CO_2 becomes more confusing once it relates to onshore projects where international and national jurisdictions may overlap. The most relevant international treaty that could regulate trans-border aspects of onshore projects is the United Nations Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention). However, the issue of whether this treaty applies to CCS is less clear because there is no consensus on the definition of CO_2 for the purpose of CCS. To solve this problem, the international community would either have to amend the Basel Convention to clarify its position on whether CCS should be included or establish a separate international regulatory approach for the transboundary effects of CCS. It may also be determined that enhanced resource recovery projects do not fit under the Basel Convention, as they do not produce hazardous waste, but that other CCS projects do fit under its jurisdiction. If enhanced resource recovery is not included in the Basel Convention, some other international framework would have to be established to cover this type of CCS projects. For example, the United States and Canada have dealt with this issue bilaterally in the Weyburn project.

1.2.1.2 Storage Well Design

Another issue for the regulation of storage is setting standards for well design. Consistent standards are needed to ensure the highest level of prevention of leakage into the ground, water, and air systems over the long term. Any regulation of well design should include operational practices, materials used, number and age of wells, potential geophysical changes, pathways in the event of leakage, and duration of storage.[6]

Outside of the United States, Canada, and the North Sea, there is limited historical experience with well designs in a high CO_2 environment. However, the oil and gas industry uses highly sophisticated well technologies that allow the drilling and completion of vertical and horizontal wells in deep formations and are able to handle corrosive fluids. Using the experience of the oil and gas industry, CCS projects have adapted well technologies for use in current CO_2 storage projects.[7]

The long-term interaction between CO_2 and the wells is an important issue which warrants further research. The greatest technical risk to long term storage integrity is considered by many to be the potential failure of a well due to the corrosive effects of CO_2. While current oil and gas well design standards are well-tested, some CCS-specific standards may be appropriate.

1.2.2 Access and Property Rights

Access to and property rights for the area in which a CCS project is undertaken must be defined in order to encourage investment and properly regulate the storage site. Property rights often determine who has or will have access to a project site and are therefore a crucial aspect of any CCS project. The three main areas of property rights are surface (injection of the CO_2), sub-surface (reservoir), and the CO_2 itself. Because the definition of property rights also influences liability, they must be clearly defined. It is also critical to determine if, when, and how private liability is transferred to the public sector, establish who determines to whom property rights are granted, public and private methods of acquiring the rights, and how to manage the title of the actual CO_2.[8]

Most of the unresolved issues related to access and property rights apply to onshore projects. Many offshore projects are under the purview of international treaties, where regulatory frameworks are already in the process of being developed (see Section 1.3). Because very little case law exists for property rights for onshore CCS projects, access and property rights have typically been determined on a case-by-case basis.

There are generally two schools of thought regarding the granting of property rights: rights that include ownership of the commodity (in this case, the CO_2), which entails greater liability on the property right holder; and rights according to a service provided, meaning that the access and property rights follow the steps in the disposal process. An example of a service-type property right is the Superfund in the United States, which imposes liability on parties responsible for the presence of a hazardous material at a facility or site. In this case the rights are granted in association with the service provided, such as owners and operators of facilities and generators that arranged for the disposal of the hazardous waste. In this case, the liability is much broader and can affect a wider range of participants and for extensive periods of time.[9] (See Text Box 2 for greater detail about Superfund liability.)

In most cases, property rights issues are addressed by specific contracts at the start of the development of each project, and the contracting parties determine which laws apply and how.[10] However, property rights for CCS are still a new issue, and standards for addressing this issue are not clearly defined, making it difficult to determine property rights in the long term. Clear titles and transferable rights would ensure a regularized operating environment and establish the chain of liability and responsibility in the event of CO_2 leakage, migration, or other problems.

1.2.3 Intellectual Property Rights

IPR issues are a sticking point between developed and developing countries when it comes to the transfer of technology. It is also the only specific regulatory issue that is expressly laid out in the CSLF Founding Charter as an issue to be addressed as part of its functions. A robust IPR regime in developing countries is crucial for encouraging developed countries to invest in CCS technologies for transfer and deployment in developing countries. The capture portion of the CCS process is the predominant cost driver and new technologies are being developed to reduce these costs. It is these new technologies that have the greatest exposure to IPR issues. Because CCS is such a technology-intensive process, and many of the existing, and possibly future, technologies will be protected, it is unclear whether the owners of the IPR for these technologies will be willing to license them, especially in the absence of a stringent regulatory framework.[11]

At this time, there is no CCS-specific IPR legal regime in development. IPR for CCS is considered a very long-term issue by many industry observers and, therefore, it is not given urgent attention. This is because CCS projects typically are managed by governments and/or private entities in developed countries even when they are located in developing countries. The technologies used for the CCS projects are therefore not yet being transferred to entities and/or countries where the protection if IPR is weak.

The international community is aware of IPR issues in general and has made attempts to address these for many years. This includes the World Trade Organization's Trade-related Aspects of Intellectual Property Rights (TRIPS) agreements. However, until the TRIPS regulations are put into place in national legislations (developing countries were given an extension), and there is effective enforcement, entities in developed countries will likely still be hesitant to transfer or license their technologies to developing countries.

1.2.4 Monitoring and Verification

Standards for the measurement, monitoring, and verification (MMV) of injected CO_2 are crucial to any regulatory or legal framework for CCS because they provide for the collection of vital data on containment, reactivity of CO_2 with surrounding well materials, seismic activity, leakage, and long-term storage, which are necessary for establishing who is liable in the event of leakage or disruption. For MMV in particular, existing and future CCS projects will provide the most concrete basis for a regulatory framework, especially when coupled with modeling in the research and development phases of a project. Because MMV is site-specific, it would be inappropriate to develop a single MMV framework with a uniform set of requirements. However, guidelines should be established to try to create consistency and uniformity where possible. One way to set up flexible but meaningful monitoring guidelines would be to rely on objectives and performance standards instead of specific measurement techniques.[12]

Guidelines currently used for MMV of CCS projects are often based on those used in natural gas storage and liquid and hazardous waste injection. Also, the U.S. Department of Energy's recently-released General Guidelines for the Voluntary Reporting of Greenhouse Gases (1605(b)) Program includes guidelines and an ordinal ranking of monitoring options applicable for CCS projects.[13] CCS-specific issues will ultimately need to be addressed in a more comprehensive CCS regulatory framework. In general, monitoring of stored CO_2 focuses on two dimensions: lateral migration of CO_2 and vertical leakage of CO_2 outside the storage area. A variety of MMV techniques are being applied and reviewed in active projects such as Weyburn and Sleipner to review lateral and vertical migration of the injected CO_2. The most often used techniques are time-lapse 3D seismic imaging (also called 4D seismic) and vertical seismic profiling (VSP) in wells, along with injection well pressure and rate monitoring, but a consensus of the most appropriate techniques to use has not been reached. Another area that could be included in a framework is the use of monitoring data to provide feedback into reservoir management practices during the injection phase of the project. Such a step could potentially be far more important than monitoring later in the project.[14]

There are few established guidelines for the specific kinds of monitoring that should be done for CCS in the short- and long-term, including who should be doing the monitoring, for how long a site should be monitored, and how to determine long-term MMV responsibilities in case of existing CO_2 compliance systems, such as the EU Emissions Trading Scheme (EU ETS), trans-border projects, or projects in international waters. As described further in Section 2, the Australian government recently developed principles for regulating CCS projects that also include general guidelines for when in the CCS process the MMV step should take place, and how it should be done. (See Text Box 4 for more details on the Australian Guiding Principles)

1.2.5 Liability

Liability is one of the most essential regulatory issues facing CCS projects. It will impact the costs of CCS projects and will be crucial in advancing public acceptance of the technologies and processes. As described in Table 2, liability issues can be divided into short- and long-term, with the preponderance of unresolved liability issues relating to long-term storage.

Table 2. Liability Timeframes and Issues

Timeframe	Liability
Short term • Generally considered to cover the timeframe of the project and any contractual time period covering post-injection	• Operational liability
Long term • Long-term timeframes are generally defined as 50-100 to thousands of years	• Environmental liability • *In situ* liability • Trans-border liability

1.2.5.1 Short-term Liability

A common liability issue raised in the connection with the short-term aspects of CCS projects is operational liability, which refers to the environmental, health, and safety risks associated with capture, transport, and injection of CO_2. Operational liability is similar to that already dealt with in the oil and gas industry and therefore few new issues should arise when applied to CCS.[15] Most short-term liability issues will probably be taken care of within the contract, but certain issues should be considered in a regulatory framework, including exemptions under special circumstances. Short-term liabilities will likely have a set timeframe. They are therefore easier to manage and plan for, and could be addressed in a regulatory framework relatively quickly. The more urgently needed regulations are for long-term liability.

1.2.5.2 Long-term Liability

There are three types of liability issues that are relevant for long-term CCS projects: environmental, *in situ*, and trans-national liability. Environmental liability is associated with any CO_2 leakage from the storage sites that may affect the global climate by contributing to CO_2 concentrations in the atmosphere. This is sometimes referred to as climate liability. In the event of any CO_2 leakage or migration to the atmosphere, responsibility must be assigned to address any harm caused to the global climate. Also, there could be an issue with assigned credits for greenhouse gas emissions reductions, i.e., national greenhouse gas accounting inventories would need to be corrected and liability might need to be re-assigned if credits were sold on the market.

In situ liability is associated with leakage or migration that could result in public health, environmental, or ecosystem damage. Like environmental leakage, this could stretch over thousands of years. *In situ* liabilities arise from several aspects of a CCS project. Sub-surface leakage could lead to damaged hydrocarbon resources, contaminated water supplies. Considerable risk lies in the potential for CO_2 migration over time that may cause damage to areas where it was not originally injected. Surface leakage could lead to health and environmental damage to the air, soil, water, and overall ecosystem.[16] Failure to properly address these issues could lead to negative public perceptions and an inability to procure appropriate sites for injection and storage. Some of these issues have been addressed by the oil and gas industry, and regulatory framers could reference that industry's experiences for commonalities.

Trans-border liability refers to any liability issues that may affect more than one country. This is important in instances of migration of CO_2 across national borders and/or damage to the global climate caused by CO_2 leakage in one individual country. These issues will have to be addressed by intergovernmental agreements and international treaties. The first area that should be addressed is how to determine where local/national liability and international liability differentiates. It is possible that CO_2 could leak far from its injection point and storage area, and if that leakage point is in another country or in international waters, a framework for determination of which party is liable for clean up, remediation, or loss of resources should be established.[17] These issues could be set up in an international framework, but specifics would probably be worked out on a case-by-case basis. In the case of CO_2 leaking into the atmosphere and causing "environmental liability," this is probably best addressed as part of a broad climate policy designed to control greenhouse gases.[18] Under that type of framework, it will be important to establish regulations about how emissions from CCS storage would be counted under existing protocols and conventions, and how to determine their effects in the future.[19] As described in Section 1.3, the Intergovernmental Panel on Climate Change (IPCC) has an ongoing effort in place to address such issues.

A major issue with long-term liability is simply the timeframe itself. Most CCS-related references determine "long-term" to be anywhere from 50 to 200 or more years. However, it is not completely clear when the shift from short- to long-term should occur. Considering that CCS projects are designed to last for centuries, it may be difficult to set up MMV for such long periods of time, but there should at least be parameters and guidelines laid down, and some sort of limitation or reference should be included to determine how long certain parties are liable and at what point the stored CO_2 becomes a public liability. Also, a basic compliance system should be established to assure accountability and proper enforcement in the event of leakage or other damage.

Generally, liability will rest with a particular industry, a specific firm, or the government (state or federal). However, regulations determining liability will probably take place on several levels; for example, federal statutes and industrial strategies could both be applied.[20] Depending on how the regulatory regime is set up, long-term risks could become a public liability after the contractual lifetime of a project. Having procedures or guidelines for determining the lifetime of a project is therefore of critical importance. Furthermore, deciding where any public liability should lie is essential because of issues of the longevity of public institutions, the transferability of institutional knowledge, and how any MMV of the storage site and payment for long-term public liability could be ensured.[21] Text Box 2 provides examples of how liability is handled in two U.S. cases.

Because of the longevity of CCS projects, assumptions about costs, discounting, rates of technological progress, and other related issues could lead to very different interpretations of liability and must be examined closely when establishing any sort of regulatory framework or regime.[22] Determining responsibility for cost coverage is crucial, and one option could be the establishment of special funds or insurance schemes to cover compensation or remediation in the case of any leakage or damage resulting from the process in the long term.[23] However, insurance schemes could be hampered by the ability to properly predict the costs of CCS liability and insurers' decisions not to insure could reduce the willingness of some to invest in CCS technologies or processes.[24]

Text Box 2. Liability for Superfund Sites and Surface Mining in the United States

The following describes how liability is handled by two U.S. industries. While these programs differ from CCS in that they are publicly-administered programs specifically designed to clean up environmentally dangerous sites or reclaim land used for mining, the broad and strict nature of Superfund liability and direct liability of surface mining could serve as examples of how to tie long-term liability to specific acts and responsible parties involved in CCS projects.

<u>Superfund</u>

The Superfund Program was established in 1980 to locate, investigate, and clean up the worst uncontrolled or abandoned hazardous waste sites in the United States. The Environmental Protection Agency administers the program in cooperation with individual states and tribal governments. The Superfund enabling legislation, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), imposes liability on parties wholly or partly responsible for the presence of hazardous waste at a Superfund site. Superfund liability is retroactive, so parties may be held accountable for acts that occurred before 1980 when the Fund was established.

Superfund liability is triggered if:

- Hazardous substances are present at a facility;
- There is a release or threat of release of these hazardous substances;
- Response costs have been or will be incurred; and
- The defendant is a liable party.

There are four types of Superfund liable parties:

- Current owners and operators of a facility;
- Past owners and operators of a facility at the time hazardous wastes were disposed;
- Generators and parties that arranged for the disposal or transport of the hazardous wastes; and
- Transporters of hazardous waste that selected the site where the hazardous wastes were brought.

Responsible parties could be liable for:

- The costs the government has occurred for cleanup;
- Damages to natural resources;
- The costs of certain health assessments; and
- Performing a cleanup where a site may present an imminent and substantial endangerment.

Source: U.S. Environmental Protection Agency, “About Superfund,” http://www.epa.gov/superfund/about.htm and “Superfund Liability,” http://www.epa.gov/compliance/cleanup/superfund/liability.html

<u>Surface Mining</u>

An operator of a surface mine must pay a performance bond to the appropriate state, Federal, or tribal regulatory authority in order to obtain a permit to mine the relevant land. The bond amount is set by the regulatory authority and must cover 100 percent of the anticipated cost of environmental degradation and reclamation in the event of forfeiture by the operator. The bond must be at least $10,000. Additional bonds may also be required to cover any increments of surface coal mining and reclamation operations beyond the original amount.

The liability period for the operator extends until all reclamation, restoration, and abatement work under the permit has been completed. If the operator walks away from the project, the operator forfeits the bond, which is then used by the regulatory authority to complete the reclamation or cleanup.

Source: Sec. 509 and 515, Surface Mining Control and Reclamation Act of 1977, http://www.osmre.gov/smcra.htm and Office of Surface Mining Regulations 30 CFR Part 800, http://www.osmre.gov/rules/subchapterj.htm#7

One way to deal with some of the liability and costs related to insurance is through something akin to the caps set by the Price-Anderson Act of 1957, which serves at the nuclear industry's limited liability policy in the United States. The Act required nuclear plants to acquire insurance of $200 million per plant, established a framework for plants to make payments to the public in the event of a nuclear accident, and required plant operators to contribute to an industry-wide fund. The federal government assumes liability above a certain threshold.[25] Although the provisions of the Act have been criticized for being a subsidy for the nuclear industry, the Energy Policy Act of 2005 extended its authority through 2025. However, even though industry might favor a liability cap for CCS projects, it could be detrimental for improving public perceptions of CCS, especially as statutory caps are generally reserved for extremely rare and catastrophic risks, such as those in the nuclear industry.[26] Furthermore, as no mechanism has yet been established to determine cost and risk of CCS in a regulatory framework, it is currently unclear whether insurance companies would be willing to take on the risk of CCS projects. While a framework can set the parameters, risk assessment will probably continue to need to be undertaken on a case-by-case basis.[27]

Text Box 3. IEA/CSLF Legal and Regulatory Issues Workshop

An International Energy Agency (IEA) and Carbon Sequestration Leadership Forum (CSLF) workshop was held in Paris in 2004 to address legal issues of CCS. The workshop was divided between national and international law and examined how current laws could be changed or improved to better apply to CCS projects.

The final report looked at:

- International frameworks; and
- National frameworks in the United States, United Kingdom, Japan, Canada, and Australia

It identified several priority issues for future work, including:

- Increasing the number of CCS demonstration projects;
- Focusing on long-term storage and monitoring;
- Encouraging governments to ensure there is an appropriate national legal and regulatory framework for demonstration projects in the short term;
- Recommending that parties to international marine treaties clarify the legal status of carbon storage in those treaties;
- Creating a level-playing field for CCS with other climate change mitigation technologies; and
- Increasing public awareness and improving public acceptance of CCS.

Sources: IEA/CSLF Joint Workshop on Legal Aspects of Storing Carbon Dioxide, http://www.iea.org/Textbase/work/workshopdetail.asp?WS_ID=183; IEA/OECD, "Legal Aspects of Storing CO_2," 2005, http://www.iea.org/textbase/nppdf/free/2005/co2_legal.pdf

1.3 Efforts to Address Legal and Regulatory Gaps

Interest in CCS has grown substantially in the past few years. Several efforts have been undertaken or are currently in process of addressing regulatory gaps that concern CCS projects. The following is a list of recent and current activities.

1.3.1 International Energy Agency/Carbon Sequestration Leadership Forum

In 2004, the International Energy Agency (IEA) and the Carbon Sequestration Leadership Forum (CSLF) held a joint workshop in Paris to address legal issues of CCS by sharing experiences between countries. The result was the 2005 publication of the report, "Legal Aspects of Storing CO_2," which is described in Text Box 3.

In June 2005, IEA formed the Legal Issues Subcommittee in order to work on legal issues of CCS. It works in close cooperation with the CSLF and members include Australia (Chair), the European Union, France, the Netherlands, Norway, the United Kingdom, and the United States. The subcommittee is currently developing papers on the priority issues from the report, with each country responsible for the following topics.

- IPR paper (the United States);
- Legal and regulatory frameworks (Australia);
- Level playing field. This paper will cover liability, tax incentives, market-based mechanisms, and emissions trading (United Kingdom);
- International environmental protection instruments (the Netherlands); and
- Public awareness (Norway).

As of June 2006, the papers were in draft form, and were expected to be discussed at the Subcommittee meeting in late June 2006 to prepare for their publication later in 2006. The next legal issues workshop will be held in October 2006 in Paris and a follow up report to the 2005 report will be released in 2007.[28]

At the G8 Summit at Gleneagles in 2005, G8 leaders asked IEA to be a partner in the Plan of Action for Climate Change, Clean Energy and Sustainable Development and to play a major role in delivering the Plan of Action. CCS is one of the six areas to be looked at under this process. A final report is due in 2008 at the G8 meeting in Japan.

1.3.2 Intergovernmental Panel on Climate Change/United Nations Framework Convention on Climate Change

In September 2005, the Intergovernmental Panel on Climate Change (IPCC) produced a Special Report on Carbon Dioxide Capture and Storage (IPCC Special Report), which summarizes the current status of research, technology development, and deployment of CCS. The Special Report was presented at a side event at the meetings of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) (COP 11) and the Parties to the Kyoto Protocol (COP/MOP 1) in Montreal in December 2005.

At the side event, the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) encouraged Parties to the UNFCCC and the private sector to support the acceleration of the research, development, and demonstration (RD&D) of CCS technologies. SBSTA Parties also decided that CCS project methodologies could be eligible for submission under the Clean Development Mechanism and as of June 23, 2006, three methodologies have been submitted to the CDM Executive Board.[29] Because CCS is not one of the project types originally included when the CDM was first established, the CDM Executive Board must review these methodologies and then submit recommendations to the COP/MOP regarding whether CCS should be included on the list of eligible project types under the CDM. There is great interest among industry participants in getting clarity on the eligibility of CCS projects under the CDM, and some companies, including BP, have indicated that they are reluctant to expand investment in this mitigation option until a legal framework with opportunities for financial incentives has been established.

SBSTA also requested that the Secretariat organize a working group at the 24th session of SBSTA (SB 24) (May 17-26, 2006) to study CCS and present a report for consideration at its 25th session (November 2006).[30] At SB 24, two in-session workshops and six side events related to CCS were organized.[31] One workshop was held with the objective of improving understanding of CCS through the IPCC Special Report and highlighting lessons learned. The SBSTA Chair announced that he would prepare a report based on the workshop for consideration at SB 25.[32] The other workshop was on CCS as a Clean Development Mechanism (CDM) activity, and was held with the purpose of opening the dialogue on CCS and focusing on project boundaries, leakage, and permanence.[33] Both workshops focused on information sharing and no decisions were taken related to CCS. While there was general support for using CCS as an emissions-reduction mechanism, environmental non-governmental organizations and some developing countries were concerned about liability and inadequate funding for other mitigation and adaptation measures. In particular, some developing countries raised concerns about using CCS in the CDM if the responsibility for long-term stewardship would be assigned to the host country governments instead of the project participants, as suggested by industry practitioners. They argued that it would be inappropriate to ask resource-constrained developing countries to cover the costs of monitoring and safeguarding CO_2 storage sites in the long term, since these countries would be the least capable of doing so in terms of funding and technological know-how.

If CCS becomes an approved type of project under the Kyoto Protocol or becomes something the SBSTA wants to encourage or pursue, it will necessarily require some regulatory parameters under the Protocol or the UNFCCC. No final or binding decisions were made at SB 24 regarding CCS under the CDM and the UNFCCC.

1.3.3 Activities in Europe

1.3.3.1 The Second European Climate Change Programme (ECCP II) Working Group III (WG III) (Carbon Capture and Geological Storage)

In February 2005, the European Commission released Communication COM(2005)35, which recommended that the next steps for the European Climate Change Programme should include a review of progress and exploration of "new actions to systematically exploit cost effective emission reduction options… Attention will be paid in particular to energy efficiency, renewable energy, the transport sector (including aviation and maritime transport), and carbon capture and storage."[34] To this end, the EU's Second European Climate Change Programme (ECCP II) Working Group III (WG III) has set as a primary objective the goal of "identifying regulatory needs and barriers and exploring the elements of an enabling regulatory framework for the development of environmentally sound CCS."[35] ECCP II held a stakeholder meeting in October 2005, followed by four WG III meetings, including one in April 2006 on a CCS regulatory framework and one in May 2006 to release a report on findings. A formal communication on CCS will be released at the end of 2006 or early 2007.[36]

1.3.3.2 North Sea Basin Task Force on Carbon Capture and Storage

In November 2005, Energy Ministers from the United Kingdom and Norway launched the North Sea Basin Task Force on Carbon Capture and Storage. The Task Force includes public and private organizations from the North Sea rim, and plans to work on issues related to the costs of and barriers to deploying CCS projects in the North Sea. The Task Force had its inaugural meeting in March 2006, and announced that its primary aim is to develop common principles on the regulation and management of CO_2 storage under the North Sea.[37]

In March of 2006, the British Treasury released a consultation report on the barriers to commercial deployment of CCS in the UK. The report notes that the North Sea Basin Task Force is addressing regulations to protect the environment and human health. The Treasury asked for comments to the report until May 11, 2006, and plans to use the comments for the wider energy policy review that is currently underway. Results of the consultation will be released in September 2006.[38]

1.3.4 The London Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matters (London Convention /London Protocol)

In March 2006, the London Protocol of 1996 entered into force, replacing the London Convention for those countries that have ratified the London Protocol.[39] The London Protocol strengthens international rules on dumping of waste at sea by:

- Prohibiting dumping except for materials on an approved list (the Convention permitted dumping except for materials on a banned list);
- Requiring preventative measures to protect the marine environment, including requiring the polluter to bear the cost of pollution; and
- Expanding geographical coverage, including the storage of wastes in the seabed and abandonment of offshore installations.[40]

In January 2006, Norway, the United States, the Netherlands, Australia, and the United Kingdom submitted CCS agenda items to the Meeting of the Consultative Meeting Inter-sessional Legal and Related Issues Working Group on CO_2 Sequestration. These agenda items were discussed at the Inter-sessional Meeting of the Working Group in April 2006, where the Working Group decided to submit amendment proposals for consideration at the next Meeting in October 2006. The agenda items submitted are described below, and will be considered further by member countries in advance of the October meeting.

- Norway asked that amendments be made to the London Protocol to better facilitate and regulate the deployment of CCS projects in sub-seabed geological structures.[41]
- The United States identified six issues that need to be addressed when considering options to facilitate and regulate CO_2 sequestration, including a basic approach to how CO_2 should be viewed and whether the approach should be done through an amendment or an interpretation.

- The Netherlands recommended an amendment to clarify whether sub-seabed CO_2 sequestration is compatible with the Convention and Protocol
- Australia recommended an amendment to remove any doubt that the Parties recognize the role of sub-seabed CO_2 sequestration as part of a climate change mitigation strategy, and submitted a draft proposal.
- The United Kingdom recommended that the Parties ensure that any amendment or clarification on sub-seabed CO_2 sequestration be formulated in a way that would not alter the legal position of any other issue.

1.3.5 Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR)

In March 2006, OSPAR released a report titled "Placement of CO_2 in Subsea Geological Structures," prepared by Norway and the UK. The report was prepared at the request of the OSPAR Commission and includes reviews of the risk characterization for potential site selection and of MMV for detecting leakage of CO_2 into the marine environment. The report concludes that guidelines or a framework for risk management should be established.[42] According to the OSPAR Commission, Norway will submit a proposal on this topic which will be considered at the annual meeting of the Commission at the end of June 2006.[43]

1.3.6 World Resources Institute

On February 28, 2006, the World Resources Institute (WRI) began a new project on CCS, which brings together business, governmental, and NGO partners to address regulatory and institutional gaps related to CCS. The goal of the project is to promote safe, transparent, and efficient practices that ensure public confidence in CCS.[44] The project will first work on establishing a framework for the United States, followed up by frameworks for developing countries.

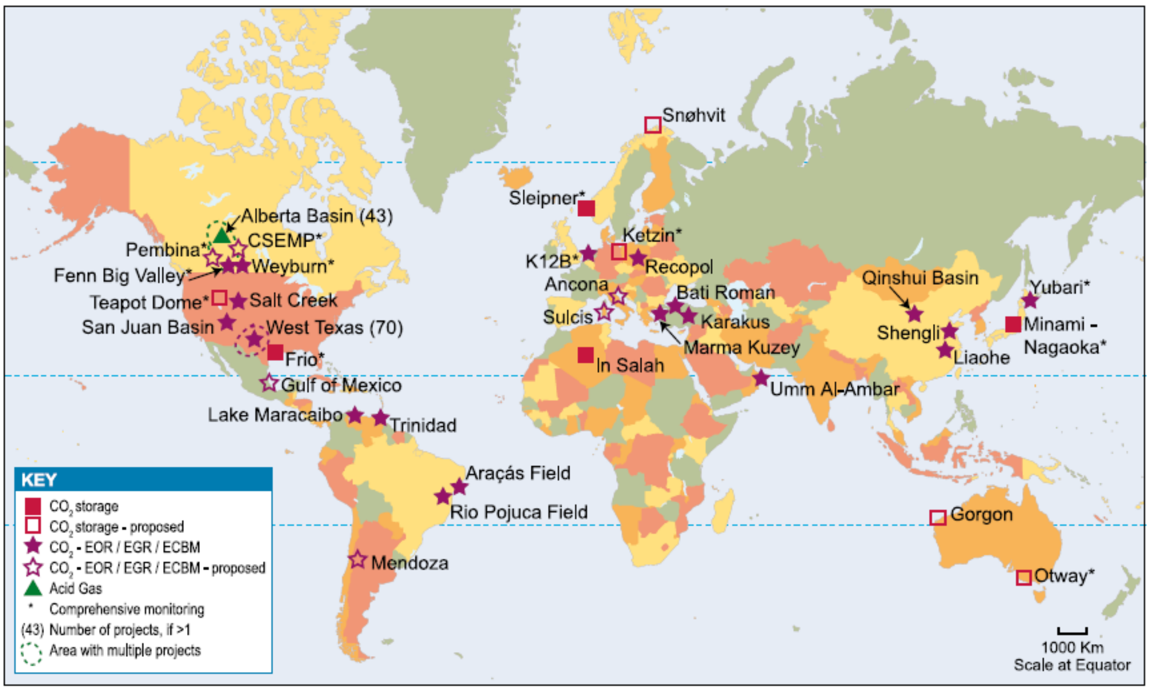
- On May 9, 2006 the Siting and MMW Working Group held a working dinner where it was decided that the Group would develop three project scenarios (a greenfield saline aquifer, an EOR opportunity, and a depleted gas reservoir) that will:[45]
    - Inform policymakers and regulators on how CCS projects might be sited and how MMV might be conducted;
    - Assist policymakers and regulators with the rule making process
    - Demonstrate potential paths to site certification
    - Show developers what steps are taken in the project creation process.
    - Build confidence among NGOs and the public that planning, oversight, and potential remediation are sufficient.

- On April 21, 2006, the Liability Working Group held a conference call that set May 15, 2006 as the deadline for an outline for a paper on understanding the basis of liability, and suggested that a future paper might cover models of public assumption of liability.[46] The types of liability being investigated by the Working Group include surface leakage, property, and groundwater liability.

2.1 Case Studies

Many countries and partnerships of countries and organizations are undertaking CCS pilot or commercial projects around the world. Most existing or planned commercial projects are related to major gas production facilities with gas streams of about 10-15 percent CO_2 by volume,[47] including the three commercial case studies examined in this paper: Gorgon, In Salah, and Sleipner. CCS commercial, demonstration, and research and development projects are being conducted on every continent except Antarctica. Figure 1 shows the geographical distribution of selected current or planned CCS projects.

Figure 1. Location of major current and planned CCS projects worldwide



Source: IPCC, Chapter 5.

Five case studies were chosen for this paper: CO_2SINK in Germany, Gorgon in Australia, In Salah in Algeria, RECOPOL in Poland, and Sleipner in the North Sea. The first two are planned projects, while the final three are current projects. CO_2SINK and RECOPOL are designed as a demonstration projects. The other three are private sector CCS projects intended to test commerciality of CCS as a project type. The projects inject or plan to inject CO_2 into a variety of formations, such as an aquifer, depleted hydrocarbon reservoirs, coal seams, and saline formations, using varying amounts of CO_2, from 760 tons in the RECOPOL project[48] to 20 million tons in the Sleipner project and potentially 120 million tons in the Gorgon project. All the projects involve long-term storage of CO_2 and no venting is expected after project completion. The case studies were chosen because they represent the range of planned and current projects with a variety of size and storage attributes.

In March 2006, the European Commission kicked off CO_2ReMoVe (CO_2 Research into Monitoring and Verification Technology), a consortium of researchers, geological surveys, universities, and industry, to establish a portfolio approach to providing a common basis for European guidelines for CCS projects, especially in anticipation of making CCS a more attractive option under the EU ETS. The consortium has five goals, which are to develop:

- Methods for baseline site evaluation;
- New tools for monitoring storage;
- New tools to predict and model long-term storage;
- Risk assessment methodologies for a variety of sites and timescales; and
- Best practices guidelines.[49]

CO_2ReMoVe is a five year project, and includes, as part of its monitoring portfolio, CO_2SINK, In Salah, RECOPOL, and Sleipner.

2.1.1 CO_2SINK

CO_2SINK is a research, development, and demonstration (RD&D) project located at Ketzin, Germany, near Berlin. It is being funded by the European Union's 6th Framework Programme for Research and Technological Development. The project, which is operated by Shell, began in 2004, and will inject and monitor CO_2 in a deep onshore saline aquifer.[50] Boreholes will be dug beginning in June 2006 and injection is slated to begin in October 2006.[51] The project developers plan to inject approximately 30,000 tons of CO_2 into the aquifer, which lies under a gas storage reservoir that is no longer in use.[52] CO_2SINK has three primary objectives for the project:

- To advance the understanding of science and technical processes of underground storage of CO_2;
- To build confidence towards future European CO_2 geological storage; and
- To provide real case experience for the development of regulatory frameworks for geological storage of CO_2.[53]

The following provides a summary of whether and how specific legal and regulatory issues were addressed by CO_2SINK.

2.1.1.1 Storage

Because CO_2SINK is such a small-scale project, it is exempt from Environmental Impact Statements or permits that apply to commercial projects in Germany. Thus, the project developers have not had to specify whether the injected CO_2 is an industrial commodity or a waste product. Owing to the size and location of the project in Germany it does not have an international dimension, and has only been subject to a few local regulations. For example, the project developers had to establish to the local mining authority that the project would cause no local harm.

2.1.1.2 Access and Property Rights

CO_2SINK is injecting CO_2 into a redundant gas storage site, and the rights to the site still belong to the operator of the site. The site operator has granted full access rights to the project operator (i.e., Shell).

2.1.1.3 Intellectual Property Rights

CO_2SINK does not have any intellectual property rights issues.

2.1.1.4 Monitoring and Verification

CO_2SINK is placing considerable emphasis on monitoring migration of the CO_2 after injection. It will evaluate migration through its standard monitoring practices, but also by including substantial seismic imaging and modeling. One of the major concerns for long-term liability issues is the migration of CO_2 and the gas' possible effects on seismic activity, so more knowledge in these areas will be valuable when setting up a regulatory framework. CO_2SINK is part of the CO_2ReMoVe monitoring and verification program. Table 3 provides a list of the monitoring techniques used in the CO_2SINK project.

Table 3. Monitoring Techniques for CO_2SINK

Monitoring technique	Performed at project?	Frequency
CO_2 injection rate, pressure	Yes	Continuously
CO_2 monitoring well pressure	Yes	Continuously
CO_2 injection profile survey	No	
Other surveys - tracer	Yes	Continuously
Formation geochemistry monitoring	Yes	Weekly
Seismic - 3D	Yes	Baseline completed
Seismic - 4D	Planned	
Seismic - VSP	Yes	Baseline, time lapse
Soil Gas monitoring	Yes	Continuously
Shallow groundwater monitoring	Yes	Weekly
CO_2 flux survey	Yes	Continuously
Other	Electric resistivity tomography; geomechanical and hydrodynamical	

Source: Günter Borm, CO_2SINK Project Coordinator, GeoForschungsZentrum Potsdam

2.1.1.5 Liability

CO_2SINK has established models to determine long-term CO_2 migration issues, but has not specifically addressed any long-term liability issues, such as assigning responsibility for any future CO_2 leakage.

2.1.2 Gorgon

Gorgon is a commercial project, which plans to begin injections into a saline formation underneath an island off the coast of Western Australia in 2011. Chevron is the lead organization within the Gorgon Joint Venture group, which also includes ExxonMobil and Shell. The CO_2 injection project is part of a large natural gas processing facility that is planned to be built on Barrow Island, off the coast of Western Australia. Once the injections begin, it will be the largest-scale CCS project in the world, with an intended injection rate of 10,000 tons of CO_2 per day.[54] The Gorgon Joint Ventures propose to inject CO_2 contained in the reservoir's natural gas and removed as a routine part of the project's gas processing. The project aims to inject approximately 2.7 million tons per year over a potential project lifetime of 40 years.[55]

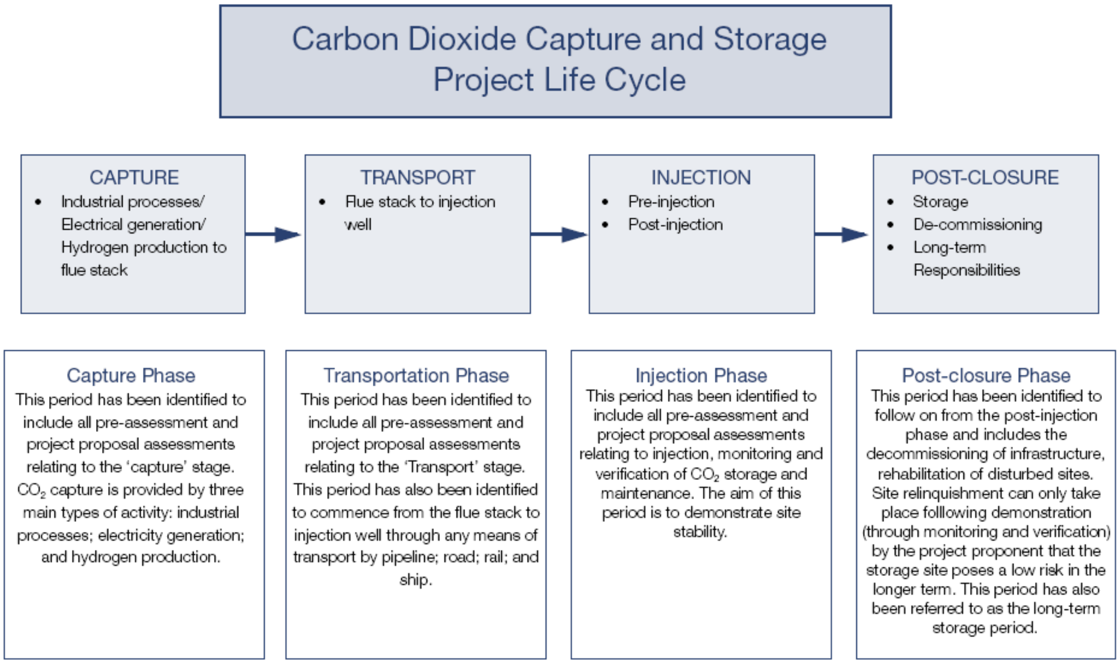
In anticipation of the Gorgon project, the Australian Ministerial Council on Mineral and Petroleum Resources has created Regulatory Guiding Principles for CCS projects. Although these guidelines were not created to target any specific project, the existence of the Gorgon project is acknowledged as having "accelerated the preparation" of them.[56] The project developers for the Gorgon project were among several stakeholders consulted in the development of the principles and it is generally accepted that Gorgon will provide a good test for their effectiveness and practicality. Many of the principles, including those relating to site closure and long-term responsibility, are very similar to the project position on these issues.

The Guiding Principles are intended to establish consistent regulations for CCS across state and federal jurisdictions, and addresses all stages of a project. Figure 2 shows the CCS project life cycle, according to the principles. Following are some of the important regulatory definitions established in the guidelines, including:

- Separation of CCS process into four distinct stages, including capture, transport, injection, and post-closure, with recommendations for regulatory steps for each distinct stage.
- Clear delineation between the injection and post-closure stages, with post-injection fitting into the "injection' category and de-commissioning and site rehabilitation falling under "post-closure." This distinction will be useful for determining the potential transition point between private and public liability.
- Pre-project assessment and demonstration of site stability are both categorized under the "injection" stage. A project cannot move to the "post-closure" phase until it has demonstrated site stability. This distinction is useful because it provides some flexibility in terms of defining the length of time that the project may use to move through each stage, yet provides a clear indicator for when the project could be covered by any potential "long-term" liability rules.

- Requirement that monitoring and verification must be undertaken during the injection stage to demonstrate site stability before the project can move to the post-closure stage. The monitoring and verification process must address a number of pre-specified issues, including level of accuracy, the quantity, composition and location of gas captured, transported, injected and stored, the net abatement of emissions, and an identification and accounting for potential leakage.

Figure 2. Carbon Capture and Storage Project Life Cycle



Source: Ministerial Council on Mineral and Petroleum Resources, "Carbon Dioxide Capture and Geological Storage: Australian Regulatory Guiding Principles," November 2005, http://www.industry.gov.au/assets/documents/itrinternet/Regulatory_Guiding_Principles_for_CCS20051124145652.pdf

The guidelines were released in November 2005, and in April 2006, a workshop was held to discuss the guidelines. An implementation strategy paper that will form the basis of any legislative amendments is anticipated to be presented to Ministers in October 2006, and the legislative process to accept any amendments will follow.[57] Text Box 4 describes the Regulatory Guiding Principles adopted in Australia.

In addition to the development of the general regulatory guidance for CCS projects in Australia, the Western Australian Government passed the *Barrow Island Act 2003*, which is specific to the Gorgon project and thus allows for the re-injection of CO_2 into the saline aquifer on Barrow Island.[58] The Act included a list of required information to be included in the Gorgon project's application for the disposal of CO_2 underground:

- The position, size, capacity and geological structure of the underground reservoir or subsurface formations;
- The rate of disposal and the volume of CO_2;
- The CO_2 composition and disposal duration;
- Injection and disposal methods;

- The capability of the reservoir to confine the CO_2; and
- Any other technical advice and data considered necessary.

Because the Act is specific to Gorgon, it is possible that different requirements could be requested of other CCS projects in Australia.

Text Box 4. Australian CCS Regulatory Guiding Principles

The Regulatory Guiding Principles for Carbon Dioxide and Geological Storage in Australia were released in November 2005. The principles are guidelines to help state and federal governments formulate consistent regulations for CCS projects in Australia. Stakeholders felt that environmental issues should be considered as an overarching theme and long-term liability required further consideration. The ultimate aim is to create a nationally consistent guiding framework for CCS, a process which has begun, but no timeframes have been decided. The guiding principles identify six key areas where regulation is needed for CCS, and examine these key areas against three options: status quo (applying current regulations to CCS activities), self-regulation (industry-formulated rules and codes of conduct), and amendments to existing regulations. After examining the options for each key area, the following recommendations were made:

Assessment and Approvals Process

- Assessment and approvals processes should be consistent with agreed national protocols and guidelines
- Existing legislation and regulations relating to CCS should be identified and modified and augmented where necessary

Access and Property Rights

- Surface and subsurface rights for CCS should provide certainty to rights-holders of their entitlements and obligations
- These rights should be based on established legislative and regulatory arrangements, custom and practice and accommodate the likely evolution of multi-user CCS infrastructure and facilities
- In granting rights to inject the CCS stream into subsurface formations, governments should give due consideration to land use planning issues that may arise as a consequence

Transportation Issues

- Regulation relating to the transport of a CCS stream should be considered where possible, using agreed national protocols and guidelines

Monitoring and Verification

- Regulation should provide for appropriate monitoring and verification requirements enable the generation of clear, comprehensive, timely, accurate and publicly accessible information that can be used to effectively and responsibly manage environmental, health, safety and economic risks
- Regulation should provide a framework to establish, to an appropriate level of accuracy, the quantity, composition and location of gas captured, transported, injected and stored and the net abatement of emissions. This should include identification and accounting of leakage

Liability and Post-closure Responsibilities

- Current regulatory principles and common law should continue to apply to liability issues for all stages of CCS projects
- Governments' overall consideration of post-closure storage of CCS streams must aim to minimize exposure to health, environmental and financial risks for project operators, governments and future generations

Financial Issues

- For all stages of a CCS project, wherever practical, established legislative, regulatory and accounting processes should be used in preference to introducing new regulations
- The income from, capital and operating costs associate with a CCS project should be treated in the same way as for any other business venture for taxation purposes
- Regulation should recognize the potential for post-closure liabilities for CCS activities and consider appropriate financial instruments to assist in the management of such risk

Source: Ministerial Council on Mineral and Petroleum Resources, "Carbon Dioxide Capture and Geological Storage: Australian Regulatory Guiding Principles," November 2005, http://www.industry.gov.au/assets/documents/itrinternet/Regulatory_Guiding_Principles_for_CCS20051124145652.pdf

2.1.2.1 Storage

CO_2 is not defined as a pollutant under Western Australian law.[59] The *Barrow Island Act of 2003* provides the legislative mechanism for the disposal of CO_2 by underground injection, including the approvals process for the Gorgon project.[60] The Act does not define how CO_2 should be classified, but the injected CO_2 is effectively considered a byproduct of gas processing operations under the Act.[61]

2.1.2.2 Access and Property Rights

The Gorgon project does not use the term storage, but rather refers to its injection of CO_2 as disposal.[62] The legislation for Gorgon clearly states that the project is disposing of the CO_2 rather than storing it. It can be inferred from this that the project developers own the CO_2 while it is in their facilities, but not once it has been disposed of. The *Barrow Island Act 2003* provides a mechanism that grants rights to the project developers to dispose of the CO_2 in the designated location.

The Gorgon project developers liken this regulatory scenario to the analogy of a smoke stack on a power station. In that case, the power station would have the right to emit CO_2 up the smoke stack, but would not own it once it has been emitted and there is no express statement in the permitting legislation that the government would take on ownership. Under this analogy, if the emitted CO_2 causes someone's vegetable patch downwind to die, the emitters would likely be held liable even though they do not "own" the CO_2. Thus, the emitters would have a responsibility for ensuring that by legally emitting the CO_2, they did not impose harm on the owners of the vegetable patch downwind. The *Barrow Island Act 2003* uses the same principle as described for the power station and simply turns the smoke stack upside down.[63]

2.1.2.3 Intellectual Property Rights

The legislation related to the Gorgon project does not provide any provisions relating to IPR, and any issues that arise must be dealt with by the project developers on a case-by-case basis.

2.1.2.4 Monitoring and Verification

According to the Environmental Impact Statement/Environmental Review and Management Programme for the Gorgon Development, the key objectives for MMV for the Gorgon project are:

- Generating clear, comprehensive, timely and accurate information that will be used to effectively and responsibly manage environmental, health, safety and economic risks and to ensure that set performance standards are being met;
- Determining, to an appropriate level of accuracy, the quality, composition and location of gas captured, injected and stored and the net abatement of emissions (including identification and accounting of fugitive emissions); and

- Demonstrating that the residual risk of leakage is acceptably low at the time of site closure.[64]

The Gorgon project partners have outlined a proposed monitoring program based on current available technologies, but anticipate that monitoring activities will likely evolve over the duration of the project.[65] A range of monitoring activities is under consideration to meet these requirements, including:

- Routine observation and recording of injection rates and surface pressures at the injection wells;
- Health, environment and safety-oriented surveillance to detect surface leaks; and
- Verification via repeat seismic surveys (4D) and/or observation wells of the CO_2 plume migration in the sub-surface.[66]

No timeframe for monitoring and verification has been set because the project has not yet begun and the project developers want to see how the project goes before setting deadlines and timeframes. The project developers will be responsible for monitoring and verification until the site closes.[67]

The project developers and the Western Australian Department of Industry and Resources have developed a set of site closure criteria that includes a requirement for the project developers to show to the satisfaction of the government that the site is safe. The developers must submit a detailed proposal (to the fullest extent practicable) to the Western Australian Government by December 31, 2008 regarding the closure plan. This must include a rehabilitation and long term management plan for the injected CO_2.

2.1.2.5 Liability

The project developers and governments (Western Australian and Federal) believe that existing statutory regulation and common law are appropriate for the management of long-term risks related to the Gorgon CO_2 project. Under current common law and statutory regulation, liability does not necessarily end at the point of site closure, and therefore, if injected CO_2 causes damage after site closure, the project managers could still be found liable.[68]

2.1.3 In Salah

In Salah is a private sector CCS project located in central Algeria and was designed to test the commerciality of CCS as a mitigation option. It is conducted by a joint venture between BP, the state energy company Sonatrach, and Statoil. The project is expected to last five years and is an industrial-scale demonstration.[69] Injection began in 2004, and the project includes a facility that removes CO_2 from the natural gas produced from the field followed by the planned re-injection of the CO_2 into the aquifer zone of one of the gas-producing reservoirs, with a planned total storage of 17 million tons of CO_2.[70] In Salah has three major objectives for the 2004-2009 timeframe:

- Provide assurance that secure geological storage of CO_2 can be cost-effectively verified and that long-term assurance can be provided by monitoring and modeling, including in the short term;
- Demonstrate to stakeholders that industrial-scale geological storage of CO_2 is a viable GHG mitigation option; and
- Set precedents for the regulation and verification of the geological storage of CO_2, allowing eligibility for GHG credits.[71]

2.1.3.1 Storage

The CO_2 is defined as industrial under the Algerian Hydrocarbon Law.[72]

2.1.3.2 Access and Property Rights

In Salah is a joint venture between BP, the Algerian state energy company Sonatrach, and Statoil. Access and property rights were granted by the Algerian government under BP's Contract of Association with Sonatrach.[73]

2.1.3.3 Intellectual Property Rights

The In Salah project does not have any IPR issues.

2.1.3.4 Monitoring and Verification

There is no legal requirement to monitor the storage site, but the project developers have implemented an extensive monitoring program, believing that In Salah could serve as an analog for projects in other countries, especially China and countries in North America and Europe.[74] In Salah is also instituting a suite of monitoring technologies on a trial basis.[75] Table 4 provides a list of the monitoring techniques used in the In Salah project.

Table 4. Monitoring Techniques for In Salah

Monitoring technique	Performed at project?	Frequency
CO_2 injection rate, pressure	Yes	Continuous
CO_2 monitoring well pressure	Yes	Continuous
CO_2 injection profile survey	Yes	Continuous
Other surveys - tracer	Yes	Once
Formation geochemistry monitoring	Yes	Probably annual
Seismic - 3D	Yes	Once
Seismic - 4D	Planned	Annual
Seismic - VSP	Planned	Annual
Soil Gas monitoring	Yes	Annual
Shallow groundwater monitoring	Yes	Annual
CO_2 flux survey	Planned	Continuous
Other	Microseismic, Well logging	

Source: Iain Wright, CO_2 Project Manager, BP Group Technology

In Salah is part of the CO_2ReMoVe monitoring and verification program, and under this program, the In Salah monitoring efforts are being used and supported for the purposes of gaining knowledge on long-term safety of the storage site.

2.1.3.5 Liability

Currently, In Salah does not have anything set up for long-term liability, but it is an issue that the project developers are concerned with and are attempting to address.

2.1.4 RECOPOL

RECOPOL (Reduction of CO_2 emission by means of CO_2 storage in coal seams in the Silesian Coal Basin of Poland) is a pilot R&D enhanced coalbed methane recovery (ECBM) project located in Poland. It is run by a consortium of industrial and academic organizations and IEA, with the Netherland Institute of Applied Geoscience (TNO-NITG) acting as the lead organization. It was the first demonstration project to investigate the economic and technical feasibility of permanently storing CO_2 in subsurface coal seams in Europe.[76] Because it was the first onshore CCS pilot project in Europe, RECOPOL project developers had to deal with the “soft” issues related to the project, such as permits, contracts, and opposition to the project and technologies.[77] The project started in 2001, injection began in 2003, and the last injection was in June 2005. The site continues to be monitored through the CO_2ReMoVe program.

2.1.4.1 Storage

The CO_2 is defined as industrial under the Polish Mining Law.[78]

2.1.4.2 Access and Property Rights

Access and property rights were granted to the project developers by the Polish government under the Polish Mining Law as a CBM concession.[79]

2.1.4.3 Intellectual Property Rights

All activities for the RECOPOL project were funded from research budgets from the European Union and project partners. As such, the rights of the results lie with the partners and the European Commission, as established in a consortium agreement, which gives much more freedom to disseminate the results. In September 2006, a detailed article will be released with the project results. IPR rights of the individual work of each partner stays with that partner.[80]

2.1.4.4 Monitoring and Verification

MMV is not required under the Polish Mining Law, but the project developers have set up an extensive monitoring program, which will be intensified during a follow-up project that starts in late 2006.[81] Monitoring for the RECOPOL project has three goals:

- To improve the understanding of CO_2 storage in coal layers, including coal reservoir behavior after injection;
- To verify that safety and environment are not threatened by potential leakage; and
- To determine that CO_2 is injected into the intended coal seams.[82]

RECOPOL is part of the CO_2ReMoVe monitoring and verification program. Table 5 provides a list of monitoring techniques used in the RECOPOL project.

Table 5. Monitoring Techniques for RECOPOL

Monitoring technique	Performed at project?	Frequency
CO_2 injection rate, pressure	Yes	Every 15 seconds
CO_2 monitoring well pressure	Yes	Every 15 seconds
CO_2 injection profile survey	No	
Other surveys - tracer	Yes	13C of (allochtonous) CO_2
Formation geochemistry monitoring	Yes	Monitoring of production water
Seismic - 3D	No	
Seismic - 4D	No	
Seismic - VSP	Yes	X-well tomography and VSP are tested
Soil Gas monitoring	Yes	Soil gas survey and stationary monitoring points (every 15 minutes)
Shallow groundwater monitoring	No	
CO_2 flux survey	Yes	Soil gas flux survey
Other	Production logging, tubing integrity, casing integrity logging	

Source: Frank van Bergen, NITG-TNO

2.1.4.5 Liability

Long-term liability was not considered an issue for the RECOPOL project developers because of the small amount of injected CO_2. However, the results from the project will likely be used to provide guidelines for future ECBM projects.[83]

2.1.4.5 Sleipner

Sleipner is a private sector demonstration project that injects and stores CO_2 from industrial sources into saline aquifers in the North Sea. The lead organizations running the project are Statoil and IEA. The project began injecting CO_2 in 1996, and plans to store a total of 20 million tons of CO_2.[84] Sleipner was the first industrial-scale storage project in the world, and the operators have established extensive monitoring models, including models to predict long-term movement of CO_2.[85] While the original project (Saline Aquifer CO_2 storage, or SACS) ended in 2002, project activities continued under the EU-funded CO_2STORE project (2003-2006), and CO_2ReMoVe (2006-).

2.1.5.1 Storage

The Sleipner project is the longest running private sector demonstration project and has therefore often been at the forefront of the debate over the definition of storage. Because the CO_2 extracted from the Sleipner field is the result of industrial activities, it has generally been accepted to be allowed under the international marine pollution treaties. The classification as an industrial activity means that the Sleipner project is exempt from any of the environmental regulations of the marine treaties. However, recently there has been some dispute whether the project actually qualifies for an exemption because of the long-term storage aspect of CO_2 injection. Particularly under the London Protocol, the definition is unclear. The London Protocol defines dumping as "any deliberate disposal into the sea of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea" and as "any storage of wastes or other matter in the seabed and the subsoil thereof from vessels, aircraft, platforms or other man-made structures at sea."[86]

Parties to the conventions differ on their interpretations of the legal status of CO_2 and whether it constitutes "industrial waste" under the London Protocol, especially because Sleipner's injection activities take place under the seabed. Several countries, including Norway and the United Kingdom, two of the major partners in the Sleipner project, are seeking clarification in order to better facilitate and regulate sub-seabed carbon sequestration. At the April 2006 Meeting of the Consultative Meeting Inter-sessional Legal and Related Issues Working Group on CO_2 Sequestration, the Working Group considered several agenda items requesting clarification and decided to collect and submit proposed amendments to the Meeting of Contracting Parties to the Protocol in October 2006 for a decision.

2.1.5.2 Access and Property Rights

The property rights to the Sleipner field have been granted to Statoil, the primary operator of the project, and its operational partners by the Norwegian government. CO_2 injection is part of the license. No special rules have been imposed by the Norwegian government, and Statoil operates according to the standard rule that "all operations should be done according to best industry practice."[87]

2.1.5.3 Intellectual Property Rights

IPR has been addressed through the Consortium Agreement made up between all partners of the Sleipner project. The European Commission, through its 6th Framework Program for Research and Development, has a set of rules to be followed, but the Sleipner partners have surpassed these rules in that they have granted themselves broad, worldwide, and irrevocable rights to use the results of the Sleipner project.[88]

2.1.5.4 Monitoring and Verification

Sleipner has employed monitoring throughout the project. Sleipner is part of the CO_2ReMoVe monitoring and verification program, and the objectives of CO_2ReMoVe are the same for any monitoring and verification at Sleipner. Thus, MMV for Sleipner includes developing and testing methods for baseline evaluation, developing new tools for monitoring storage and possible leakage, developing new tools to predict long-term behavior and risks, developing a generic risk assessment methodology for different sites and timeframes, and developing guidelines for best practice.[89] Table 6 provides a list of monitoring techniques used in the Sleipner project.

Table 6. Monitoring Techniques for Sleipner

Monitoring technique	Performed at project?	Frequency
CO_2 injection rate, pressure	N/A*	N/A
CO_2 monitoring well pressure	No	
CO_2 injection profile survey	N/A	N/A
Other surveys - tracer	N/A	N/A
Formation geochemistry monitoring	Yes	N/A
Seismic - 3D	Yes	1994, 1999, 2001, 2002, 2004
Seismic - 4D	Yes	N/A
Seismic - VSP	N/A	N/A
Soil Gas monitoring	No	
Shallow groundwater monitoring	No	
CO_2 flux survey	No	
Other	Microseismic, gravity survey	

* Not Available: No information from Sleipner project developer

2.1.5.5 Liability

The Sleipner project has not addressed long-term liability issues, primarily due to the fact that being the first major CCS project, they had little to refer to when setting up parameters for the project.[90]

3. Conclusions

The five case studies and the various international initiatives show that the development of national and international rules and regulations for CCS projects is still in the early stages. Except for the Gorgon project in Australia, none of the case studies have witnessed a consistent effort to address the major unresolved regulatory issues related specifically to CCS, such as long-term stewardship of the stored CO_2. In most cases, legal and regulatory issues are addressed on a case-by-case basis by applying existing laws and regulations. If no laws apply, the issue is typically not addressed. The following summarizes the general trends in regulatory and legal developments that can be drawn from the project case studies:

- Definition of CO_2 and Storage – In most cases, the case study projects have defined the injected CO_2 as "industrial" according to existing laws (In Salah, Sleipner, and RECOPOL). This is the case, even if the CO_2 was not expressly used for enhanced resource recovery such as in the case of In Salah and Sleipner. However, recently the Sleipner classification has come under scrutiny because of the long-term CO_2 storage objective of the project. CO_2SINK did not have to come up with a definition of the injected CO_2, due its small size that made it exempt from standard permitting procedures. Under the Gorgon project, the injected CO_2 is not considered a pollutant but rather a by-product of natural gas processing operations.
- Storage Well Design – None of the case studies report having had any issues related to well design. Most projects worldwide use the oil and gas industry standards and technologies that are already in existence, and have been adapted for use in CO_2 projects. The Gorgon project developers have noted that often oil and gas production environments are more corrosive than the CO_2 injection environment, and the established standards are sufficient.[91] Thus, the formulation and regulation of well standards may not be a high priority, although some effort may be needed in the future to create CCS-specific standards, most likely based on the oil and gas industry ones already in place.
- Access and Property Rights – In all cases, access and property rights to surface and sub-surface areas have been granted to the project operators during the injection and post-injection phases, but aside from the Gorgon project, it is uncertain who has responsibility in the long term after project completion. All five project operators have also assumed ownership of the injected CO_2 during project operation, but again, it is mostly unclear who owns the CO_2 after the site has been abandoned. Gorgon is the only project that specifies that the Joint Venture's ownership ends at the point of disposal (even though liability may not end).[92] However, this does not mean that the government takes on ownership at this time, and there is no statement to that effect in the *Barrow Island Act.*
- Intellectual Property Rights – Sleipner and RECOPOL are the only case studies that have addressed IPR in a broad sense, by establishing consortium agreements to determine how information will be shared. Project developers participating in Sleipner, in particular, have granted themselves broad rights to use the results of the project, although they do not report any particular issues related to the technologies deployed by the project. The other three projects do not address IPR issues.
- Monitoring and Verification – All case studies include a monitoring and verification component, and pay a great deal of attention to this issue. However, MMV is still handled on a case-by-case basis and none of the projects specify the length of time that monitoring will be required (which may mean that MMV will cease upon completion of the injection project) or who will be responsible for monitoring in the long-term. The Gorgon project is an exception in that the project developers and the Western Australian Department of Industry and Resources have developed a set of site closure criteria that include a requirement for the project developers to show that the site is safe. The unique part is that the project developers will have to demonstrate site safety *before* the government

takes over ownership of the storage site in the post-closure phase. By introducing this requirement, the government places the burden of proving long-term safety on the project developers and reduces some of the risk to the government of taking over long-term stewardship of the storage site and the injected CO_2. However, the Australian guiding principles have not yet developed guidelines for how the government should monitor and take care of the site in the long-term.

- Liability – Except for the Gorgon project, none of the case studies address long-term liability issues, regardless of whether these are environment, *in situ*, or trans-border. In the case of the Gorgon project, under existing statutory regulations and common law, the project developers may be found liable for any long-term environmental problems, even though ownership of the storage site will be transferred to the government in the post-closure phase. This assignment of liability may change in the future as part of the completion of the Regulatory Guiding Principles for CCS projects.

The Gorgon project and the newly released guiding principles in Australia provide the most promising examples of CCS regulations because they offer a general framework for organizing and classifying the various phases and activities involved in a CCS project. This again enables more consistency in defining regulations, including when and where to assign ownership and liability.

As outlined in the paper, several other national and international efforts are underway to address the priority issues of storage, property rights, MMV, and liability to assist international efforts to promote and adopt CCS technologies. Project developers for individual projects are also addressing the issues within the parameters of what they can do. Precedents from the oil and gas industry have helped lay the groundwork for a framework, but further work needs to be done to address CCS-specific issues, and especially long-term liability, which, if not addressed, could lead to a lack of public acceptance of CCS as a GHG emission mitigation option. Public awareness of the technologies and the role they could play in climate change mitigation is very low.

A first step should be a thorough examination of national and international laws to determine how they should be adjusted in countries of interest to clarify the definition of CO_2 and the status of CCS technologies and their use. Continued support for demonstration projects will help increase public awareness, advance the effectiveness of available technologies, lead to the development of more advanced technologies.

As the many efforts that are currently underway to address the need for a clearer legal and regulatory framework progress, governments and project developers could work in tandem with these efforts to amend laws and regulations to fit into the framework and make the laws and regulations under which the CCS projects operate more consistent across the board. Increased consistency will further encourage investors in participating and funding projects and growing the industry.

The case studies examined were intended to demonstrate CCS as a mitigation option and to test its commerciality and effectiveness. In the future, establishment of a regulatory framework that provides clear legal and financial incentives for CCS projects is necessary for more widespread use.

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