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**POTENTIAL REGULATORY SYSTEMS FOR
CARBON CAPTURE AND SEQUESTRATION (CCS)
: LEGAL ANALYSIS OF THE CURRENT AND FUTURE REGULATORY SYSTEMS
AND RECOMMENDATIONS FOR ACCEPTANCE IN SOUTH KOREA**

MoonSook Park

Submitted to the faculty of Indiana University Maurer School of Law

in partial fulfillment of the requirements

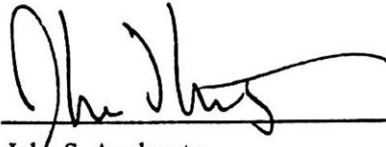
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Doctor of Juridical Science

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Accepted by the faculty, Indiana University Maurer School of Law, in partial fulfillment of the requirements for the degree of Doctor of Juridical Science.


Doctoral Committee



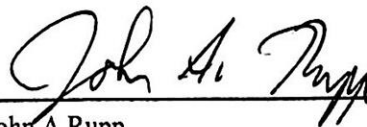
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ABSTRACT

The purpose of this dissertation is to create legal and regulatory systems for Carbon Capture and Sequestration (CCS), based on demonstrating rationales of this technology. This dissertation analyzes whether or not existing international and domestic (including the United States, Australia, China, and South Korea) laws could cover potential legal issues. After exploring desirable directions for addressing key legal issues regarding CCS, this dissertation ultimately aims to set up a legal and regulatory framework for CCS in South Korea.

Specifically, permits, environmental impact assessments, liability, and property rights issues are of common importance, which are priority areas to establish well. In resolving each of these issues, the precautionary principle and the polluter pays principle should be realized. Furthermore, a flexible approach to these principles' interpretation and application is also needed in order for the implementation of CCS to be carried out safely and smoothly through all the processes. The government plays a crucial role in many aspects, such as through regulatory surveillance, as well as facilitating CCS implementation and sharing liability associated with CCS.

From an international dimension, the incorporation of CCS into Clean Development Mechanism (CDM) would be efficient system, but clear standards for it are insufficient. Additionally, it is also important to establish international systems for CCS in order to cope with potential various scenarios associated with transboundary CCS projects and transboundary liability issues.

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I. Introduction

Climate change due to global warming is actually perceivable in the real world, and the predictions of scientific outcomes from global warming warn that in the near future countries will be at risk of irreversible disaster in the long term if they do not take aggressive and appropriate measures to reduce greenhouse gas emissions in addition to near term mitigation. Carbon dioxide is the most common cause of global warming and is produced most abundantly by power plants based on fossil fuels, accounting for about 70 percent of total emissions. Therefore, the technology of directly capturing and permanently isolating carbon dioxide from these emitting sources has attracted attention as a viable near term strategy to combat the problem of climate change. This crucial strategy in the fight against global warming is termed carbon capture and sequestration (CCS).

Of course, it is also necessary to improve energy efficiency and expand renewable energy, and these too are part of a desirable energy policy. However, there is a limit to achieving the amount of carbon dioxide reduction proposed, and when both developed and developing countries are faced with the stark reality that they will not give up their use of fossil fuels for the time being, CCS technology is expected to play an important role. On the other hand, there are opposing views on the grounds that such CCS technology poses the problems of scientific uncertainty, which is a potential risk, and economic barriers, in that it is a technology that requires excessively high costs.

This paper proposes to develop a thorough and well-designed legal and regulatory system in preparation for the introduction of CCS, which is considered to be

one of the key elements in any greenhouse gas reduction portfolio. Research and development on CCS technology has already achieved results, related CCS projects have been implemented (mainly in developed countries), and recent commercialization cases are emerging. Therefore, it is important to discuss how to make a legal and regulatory framework by reflecting these scientific and economic factors rather than whether CCS technology is scientifically and economically feasible and possible. Some developed countries that lead the technology of CCS have tried to fix the existing legal system and prepare a new legal system in preparation for CCS, but the problem is that it is not complete yet. Furthermore, legislative efforts are even less complete in developing countries. In other words, there are legislative gaps and disadvantages that do not fully take into account the specific nature of CCS technology, such as long-term storage, the organic connectivity of technologies and processes, and the complexity of the risks involved. Additionally even within a single country, the issue of legislative and regulatory discrepancies is also revealed. The lack and incompleteness of these legal and regulatory systems could lead to a delay in the implementation and commercialization of CCS due to the lack of certainty for CCS operators, and more importantly, the inability to cope with the potential risks of CCS, which may cause harm to humans and the environment.

In addition, this paper examines international legal issues proposed by CCS. In particular, various situations may arise from an international perspective, such as cooperative project opportunities between countries in a positive sense and environmental harm among countries in a negative sense. Given the natural proposition that the impact of environmental damages is not limited to one country and thus cannot be solved only by one country, and that the participation of both developed and developing countries in

resolving the current climate change crisis is a desirable and efficient measure, research on international legal systems for CCS is also necessary.¹ Currently, there is a lack of international analytical approach and legal disciplines in this respect. Therefore, it is necessary to review and create international legal and regulatory systems for CCS, which can ensure the international legal validity and viability of CCS and can contribute to the international implementation of CCS by reducing possible disputes between countries due to CCS which may be raised in the future.

With regard to the research methodology, this paper first analyzes existing legal systems and situations, and then provides a framework of the elements that should be more strongly emphasized and prioritized in future regulations. In analyzing current legislation, this paper seeks to examine as much of the domestic and international environmental norms as possible related to CCS, because CCS technology in nature can affect a considerable number of areas, such as atmospheric, soil, groundwater, marine, and so on. As a result, various environmental factors and related legal aspects need to be considered. In addition, in analyzing the existing domestic legal and regulatory situations, the four countries of the United States, Australia, China, and South Korea have been

¹ CCS technology needs to be implemented in developing countries as well, and it would be desirable that developed and developing countries are effectively cooperating and connected with the implementation of CCS. The Paris Agreement, which will be applied from 2021 as an agreement to replace the Kyoto Protocol, entered into force in November 2016. This agreement is meaningful in that all of the participating countries, not only developed countries, have agreed to fulfill their duties. Additionally, CCS could have a great significance in developing countries with high economic and industrial development needs and strong dependence on fossil fuel energy sources. See Global CCS Institute [GCCSI], *The Global Status of CCS: 100 days after the COP21 Paris Agreement* (Mar. 2016); MILAGROS MIRANDA, WORLD COAL ASSOCIATION [WCA], *THE NEW CLIMATE DEAL SHOWS THE IMPORTANCE OF CCS* (Feb. 2016).

selected as comparative legal analysis countries.² Additionally, this paper mainly addresses four legal issues that are fundamentally important to individual countries and should be addressed in any future systems: permit, environmental impact assessment, liability, property rights issues. The legal issues that CCS will bring are so wide and diverse that it would be more effective to identify key priority issues that need to be addressed first. It is also because these four issues are judged to be a suitable topic for comparing how the government should function efficiently in dealing with these main issues. In addressing a future CCS legal and regulatory framework on an international level, this paper has taken a scenario-based approach to analyze cases that have not yet been realized. Finally, this study aims to provide a roadmap for the legal and regulatory framework of CCS for South Korea. By applying these previous analyses to the situation in South Korea, this paper tries to show a more practical application from the results of this study.

Looking at its more specific configuration, this paper comprises a total of seven sections, including this Section I of Introduction and Section VII, which is a conclusion. Section II explains the concept, process, and characteristics of CCS, as well as its necessity. It also analyzes what concerns CCS raises, because these significant concerns need to be considered and resolved in order to establish the legal and regulatory framework of CCS. Section III deals with required factors that should be considered in making the structure for the implementation of CCS. The main focus of this paper is to

² The reason for this comparative approach is that it has the advantage of being able to understand the situations of both developed and developing countries and the possibility of analyzing the types of sequestration, both onshore and offshore.

provide a solid legal and regulatory system for CCS, which should be based on the analysis of economic, social, and technological factors. Therefore, this paper first reviews these relevant factors and emphasizes the legal and regulatory system which incorporates major environmental law principles. Section IV addresses the current domestic and international environmental norms regarding CCS. In the domestic analysis dimension, this section analyzes the extent to which CCS legislation is currently in effect in the four analyzed countries, and relevant environmental laws are reviewed. With regard to the international analysis, this paper examines treaties and norms that may be related to CCS and specifically looks into the legal meaning and problems regarding the incorporation of CCS within the CDM.³

More importantly, for the future domestic framework of CCS, Section V analyzes what the four priority legal issues are and how to approach them in order to resolve various legal problems associated with these legal issues. The issue of permits and environmental impact assessments can be raised throughout the entire process of capture, transportation, and sequestration, and liability issues include compensation for leakage accidents and monitoring obligations for long-term storage. Regarding the property rights issue, this paper analyzes the strengths and weakness of each option on the issue of who will “own” the vast pore space required for CCS implementation. In addition, there is the problem of transboundary CCS projects due to limitations of appropriate storage sites and

³ CDM has been functioning importantly as a measure complementing the developed and developing countries under the current Kyoto Protocol. The basic concept of this mechanism is expected to be maintained in a new system under the Paris Agreement. Article 6 of the Paris Agreement provides Sustainable Development Mechanism (SDM), which is very similar to the CDM. *See* ANDREI MARCU, CEPS SPECIAL REPORT NO. 128, CARBON MARKET PROVISIONS IN THE PARIS AGREEMENT (ARTICLE 6) 13 (2016).

potential transboundary CCS damages, which are not adequately covered under existing international law. This section also examines the necessity of preparing international norms and proposed contents to be included in these areas. Section VI addresses South Korea's CCS system construction. This section first describes the structure of South Korea's industrial, energy and legal systems as a basic background and then sets out the desirable directions for establishing South Korea's CCS legal and regulatory framework. Based on that, it will be suggested and recommended how South Korea should prepare for domestic and international legal issues and challenges associated with CCS.

The CCS legislation should take into account the objectives not only of a smooth implementation of CCS projects for the timely introduction of this technology, but also of the thorough preparation for the potential risks of CCS technology. Creating CCS legal and regulatory systems will be a difficult task because of the technology's unique features, such as interconnectedness between processes, technological complexity, long-term storage needs, and a wide range of impacts from the risk of leakage accidents. However, if this framework is well-established and CCS technology is implemented on that basis, CCS technology will be able to fulfill its role as a bridge technology in the transitional period between the fossil fuel and renewable energy eras.

II. What CCS is and why it is important

A. The concept and characteristics of CCS

Carbon Capture and Sequestration (CCS) is a technology comprised of a series of processes, in which CO₂ is captured from large-scale emitting sources, transported to a

determined storage site and then sequestered deep below the surface into pore space.⁴

The primary potential site where the capture of CO₂ might be carried out would be electric power plants, which are based on the use of fossil fuel energy sources.⁵ Installing capturing facilities to power plants could be considered both for new power plants and for existing power plants by retrofitting them.⁶ As for other emitting point sources of CO₂, there are oil refineries, manufacturing units (such as chemical plants cement manufacturers and steel works), and pulp mills.⁷ There are three main types of technologies which are available to capture carbon dioxide from emitting point sources:

⁴ See JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZIA, WORLD RESOURCE INSTITUTE [WRI] ISSUE BRIEF, BUILDING PUBLIC ACCEPTANCE FOR CARBON CAPTURE AND SEQUESTRATION 1 (2007); Stuart Haszeldine, *Geological Factors in Framing Legislation to Enable and Regulate Storage of Carbon Dioxide Deep in the Ground*, in THE CARBON CAPTURE AND STORAGE 7 (Ian Havercroft, Richard Macrory & Richard Stewart eds., 2011). Meanwhile, carbon sequestration could happen as a natural process. Forests, agricultural lands, and oceans exchange huge amounts of CO₂ and store it. However, the CCS that this dissertation covers is not this type of natural process but rather the artificial activity of carbon capture and sequestration as a new technology. See PETER FOLGER, CONGRESSIONAL RESEARCH SERVICE [CRS], CARBON CAPTURE AND SEQUESTRATION (CCS) 2 (Jan. 25, 2010); see also Elizabeth C. Brodeen, *Sequestration, Science, and the Law: An Analysis of the Sequestration Component of the California and Northeastern States' Plans to Curb Global Warming*, 37 ENVTL L. 1217, 1221 (2007). With regard to defining terms, both the terms “Carbon Capture and Storage” and “Carbon Capture and Sequestration” are used in legal and scientific literatures currently. This dissertation uses the term “Carbon Capture and Sequestration (CCS)” since it includes an emphasis on the long-term.

⁵ The amount of CO₂ emissions from electric power plants accounts for one-third of worldwide emissions and they are responsible for approximately 40 percent as the single largest contributor among anthropogenic CO₂ emissions in the United States. See Anand B. Rao, *Technologies: Separation and Capture*, in CARBON CAPTURE AND SEQUESTRATION – INTEGRATING TECHNOLOGY, MONITORING AND REGULATION 13 (Elizabeth J. Wilson & David Gerard eds., 2007). In order to generate power from fossil fuels, different types of power plants and combination of fuels could be used, such as pulverized coal-fired, natural gas combined, and integrated gasification combined cycles. The CCS technology could be utilized in all these power plants. See INT’L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, PUTTING CARBON BACK INTO THE GROUND 4 (2001).

⁶ See Anand B. Rao, *supra* note 5, at 13.

⁷ See *id.* at 13; INT’L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, *supra* note 5, at 4.

pre-combustion capture, post-combustion capture, and oxy-fuel with post-combustion capture technology.⁸

The CO₂ captured through these processes would be transported through pipelines or other transport methods such as trains, trucks, and ships.⁹ The state of CO₂ under this process of capture and transport is called “supercritical fluid,” which makes the movement of CO₂ in pipelines easy and enables the CO₂ to be stored efficiently in sequestration sites that are geologically stable.¹⁰ There are three types of reservoirs that are being considered as possible geological sequestration repositories: (1) saline aquifers, (2) depleted oil and gas reservoirs, and (3) unmineable coal seams.¹¹ These places will have CO₂ sequestered at least 1 kilometer below the surface because these three layers

⁸ First, the pre-combustion capture method converts fossil fuels into a mixture of hydrogen and carbon dioxide by combining the fuel with air. After the separation of hydrogen and carbon dioxide, the hydrogen can be burned and the carbon dioxide can be compressed, transported, and sequestered. This method has not been widely demonstrated due to the technological limitations. Second, the post-combustion capture method extracts carbon dioxide after the combustion of fossil fuels. This is a widely used method to capture carbon dioxide. Third, the oxy-fuel combustion capture method uses oxygen instead of air for the combustion of fossil fuels. This method produces a flu gas that is mainly water and carbon dioxide, after which the carbon dioxide can be compressed, transported, and sequestered. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], IPCC SPECIAL REPORT ON CARBON CAPTURE AND STORAGE 5 (2005), *also see* PETER FOLGER, *supra* note 4, at 10-11.

⁹ *See* Stuart Haszeldine, *supra* note 4, at 7; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 5.

¹⁰ *See CO2 transport for stroge: Regulatory regimes*, UCL CARBON CAPTURE LEGAL PROGRAMME; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 386. Precisely speaking, the supercritical fluid indicates that it exist above its critical temperature and pressure of 31.1 degree Celsius as an equilibrium between a gas, which is a general state of CO₂ under normal temperature and pressure, and liquid. *See* Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. ILL. L.REV. 363, 373 (2010).

¹¹ *See* Stuart Haszeldine, *supra* note 4, at 7; STEPHEN A. RACKLEY, CARBON CAPTURE AND STORAGE 24 (2010); INT’L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, *supra* note 5, at 15.

would be located deep below the ground.¹² Additionally, these available sequestration systems could exist below the seabed, below the surface of the ocean, as well as deep subsurface onshore. Therefore, there exist two kinds of sequestration methods of (1) onshore geological sequestration and (2) offshore geological sequestration.¹³ To summarize, CCS is a technology that captures and compresses the emitted carbon dioxide and turns it into a supercritical condition and then injects it after moving it to a deep underground space of the land or ocean (where the cover layer is), which seeks to safely isolate and permanently trap the carbon dioxide in that space.¹⁴

The distinctive characteristic that distinguishes CCS from other storage technologies is that it is designed to store CO₂ for a very long time, amounting to hundreds or thousands of years in the future.¹⁵ The technology of capture, transport, and storage of carbon dioxide has already been utilized by the oil and gas producing community in association with Enhanced Oil Recovery (EOR) technology and it has been implemented for more than 40 years.¹⁶ While the EOR technology utilizes temporary storage of CO₂ to increase oil production by injecting carbon dioxide into oil fields, CCS technology features a permanent sequestration and requires a more expansive pipeline

¹² See MIDWEST GEOLOGICAL SEQUESTRATION CONSORTIUM [MGSC], <http://www.sequestration.org/>

¹³ The offshore geological storage scheme sequesters CO₂ in an area at the bottom of the sea, such as a saline aquifer, not to dissolve into the seawater. The latter method of melting CO₂ into the ocean is strictly prohibited under international norms.

¹⁴ For a more explanation regarding technical and scientific process of CCS technology, *see infra* Section III. B. Technical and Scientific elements.

¹⁵ See Stuart Haszeldine, *supra* note 4, at 8.

¹⁶ See Arnold W. Reitze Jr., *Carbon Capture and storage (Sequestration)*, 43 ELR 10414, 10414 (2013).

system than that which serves the current EOR network.¹⁷ In addition, carbon sequestration in this paper needs to be distinguished from the concept of carbon mineralization, which makes carbon dioxide into a solid state.¹⁸

B. The important role of CCS

i. CCS technology responding to the climate change crisis

CCS is a form of novel and realistic technology that greatly contributes to overcoming the climate change crisis by significantly reducing carbon dioxide in the atmosphere.¹⁹ Current society is facing the challenges of climate change caused by global warming. Recently, global situations regarding climate change have become more serious, as shown by increases in the average temperature, melting polar ice, and

¹⁷ Current estimates state that about 3600 miles of pipeline to transport carbon dioxide exist for EOR. On the other hand, there is an analysis showing that around 300,000 miles pipeline network will be necessary for the commercialization of CCS, which is similar in scale to the natural gas pipeline network. *See* PETER FOLGER, *supra* note 4, at 13. For more analysis on CO₂ transportation infrastructure for EOR and CCS technology considering carbon price, *see* Matthew Tanner, *Projecting the scale of the pipeline network for CO₂-EOR and its implications for CCS infrastructure development*, U.S. ENERGY INFO. ADMIN. (Oct. 25, 2010), available at <http://www.eia.gov/workingpapers/co2pipeline.pdf>

¹⁸ Recently in Iceland, a new technique called carbon mineralization consisting of injecting carbon dioxide into basaltic rocks to convert gaseous carbon dioxide into rocks, has been researched and achieved positive outcomes. *See* Chris Mooney, *This Iceland plant just turned carbon dioxide into solid rock-and they did it super fast*, WASH. POST, June 9, 2016. It is noteworthy that the conversion of carbon dioxide into minerals takes place in a short period of time of about two years, thus drastically shortening the duration of monitoring for leak detection. Under the condition of solid rock, there is no possibility of carbon dioxide leakage, which is compatible with the concept of permanent sequestration. However, this carbon mineralization has been developed in a limited manner and there is also a restriction which requires a large amount of water. *See* Henry Fountain, *Iceland Carbon Dioxide Storage Project Locks Away Gas, and Fast*, N.Y. TIMES, June 9, 2016. In this new and advanced form regarding CCS technology, legal and regulatory systems need to be approached in a different way from the current CCS technology.

¹⁹ *See* SARAH M. FORBES & MICAH S. ZIEGLER, WORLD RESOURCES INSTITUTE [WRI] ISSUE BRIEF, CARBON DIOXIDE CAPTURE AND STORAGE AND THE UNFCCC: RECOMMENDATIONS FOR ADDRESSING TECHNICAL ISSUES 1 (2010).

warming oceans.²⁰ Scientific findings warn that the Earth might exceed the critical point and might not avoid the catastrophic impacts of climate change without additional action for mitigating climate change.²¹

Therefore, it is necessary to considerably reduce carbon dioxide emissions, as they represent greenhouse gases and the main cause of global warming. In this context, CCS will be a key technological option for dramatically reducing carbon dioxide emissions because CCS could capture up to 90 percent of the carbon dioxide emitted from point sources.²² Regarding the future of the CCS, the IEA estimates that CCS could account for around 20 percent of carbon dioxide emission reduction by 2050.²³ The recent report by IPCC also emphasized the important role of CCS as a major tool to

²⁰ JOHN THOMPSON, KURT WALTZER, MIKE FOWLER & JOE CHAISSON, CLEAN AIR TASK FORCE [CATF], THE CARBON CAPTURE AND STORAGE IMPERATIVE: RECOMMENDATIONS TO THE OBAMA ADMINISTRATION'S INTERAGENCY CARBON CAPTURE AND STORAGE TASK FORCE 12 (2010).

²¹ The 16th Conference of the Parties of the UNFCCC has regarded a 2 degree Celsius temperature increase compared to pre-industrial levels as a tipping point and suggested the aim of about 450-500 ppm CO₂ equivalents in 2100 in order to limit temperature changes within 2 degree Celsius. Additionally, recent scientific analysis shows that with the emission rate in 2014, the earth will be over the tipping point in a further 30 years. See P. Friedlingstein et al., *Persistent growth of CO₂ emissions and implications for reaching climate targets*, NATURE GEOSCIENCE, Sep.21, 2014, <http://www.nature.com/ngeo/journal/v7/n10/full/ngeo2248.html>; JOHN THOMPSON, KURT WALTZER, MIKE FOWLER & JOE CHAISSON, CLEAN AIR TASK FORCE [CATF], *supra* note 20, at 13; JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 1. IPCC's fifth report, issued in 2014, has analyzed whether the aim could be accomplished or not under various scenarios. See generally INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], IPCC WORKING GROUP III AR5, SUMMARY FOR POLICYMAKERS (2014).

²² See *What is CCS?*, Carbon Capture & Sequestration Association (CCSa), available at <http://www.ccsassociation.org/what-is-ccs/>

²³ See CARBON SEQUESTRATION LEADERSHIP FORUM [CSLF], 2013 TECHNOLOGY ROADMAP, 6 (2013).

achieve reduction targets and to overcome the climate change crisis.²⁴

Additionally, the deployment of CCS could help increase the authority of climate change relevant agreements by implementing obligations that are possible both internationally and domestically. The Kyoto protocol under the United Nations Framework Convention on Climate Change (UNFCCC) requires developed countries to meet certain greenhouse gas reduction aims on an international level, and each country suggests its own laws and policies to satisfy this obligation on a domestic level.²⁵ In spite of these agreements and provisions, however, there exists doubt and criticism that each country would not achieve this goal under current situations.²⁶ Without the help of CCS technology, it is very hard for each country to meet the obligations of reducing greenhouse gases under the currently existing international environmental law regimes, such as UNFCCC or Kyoto Protocol.²⁷ If the commitments under the international and domestic norms are not fulfilled, the authority of the current climate change relevant

²⁴ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 21. IPCC was established in 1988 by WMO and UNEP and has 195 member states currently. With the participation from around the world, the IPCC has issued reports five times since 1990 (1990, 1995, 2001, 2007, and 2014). Those reports include cause investigation, effect assessment, and strategy analysis with regard to climate change. Those results have been utilized as materials for climate change negotiation between countries, http://www.ipcc.ch/organization/organization_history.shtml

²⁵ See DONOLD M. GOLDBERG ET AL., BUILDING A COMPLIANCE REGIME UNDER THE KYOTO PROTOCOL, THE CENTER FOR INT'L ENVTL LAW [CIEL] & EURONATURA, <http://ciel.org/Publications/buildingacomplianceregimeunderKP.pdf>, also see *Kyoto Protocol*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], http://unfccc.int/kyoto_protocol/items/2830.php

²⁶ See Panilina Poplawski-Stephens, *What would be the consequences of not meeting Kyoto carbon targets?* THE INST. OF ENVTL. SCI. Feb. 2014, available at <https://www.the-ies.org/analysis/what-would-be-consequences-not>

²⁷ See Anders Hansson & Marten Bryngelsson, *Expert opinions on carbon dioxide capture and storage – A framing of uncertainties and possibilities*, 37-6 ENERGY POL'Y, 2273 (2009).

agreements are weakened and become incredible. This would make future negotiations difficult when new obligations are constructed.

Therefore, the commercialization of CCS could help countries to achieve their own CO₂ emission reduction targets and ensure the authority of the relevant climate change treaties by providing countries with this new mitigation technology.

ii. The role of CCS as a bridge technology

1. A bridge technology between fossil-fuel and renewable energy

When CCS technology is commercialized and stabilized in the near future, it will play an important role as a bridge technology between fossil fuels and renewable energy sources. Faced with the global warming crisis, current society has been trying to develop alternative energy sources, such as natural gas, shale gas, nuclear, and renewable energies instead of traditional fossil fuel energy sources like coal and oil.²⁸ However, natural gas also causes environmental problems by emitting carbon dioxide in the process of combustion, and shale gas has been in the very beginning stage of development until now. Nuclear energy has been drawing attention as a noteworthy energy source due to the merit of its environment-friendly method, however, several problems, such as nuclear waste and leakage accidents, have been exposed.²⁹

It is evident that renewable energy sources, such as solar, wind, and tidal power,

²⁸ For more information on world energy resources, see WORLD ENERGY RESOURCES: 2013 SURVEY, WORLD ENERGY COUNCIL [WEI], <http://www.worldenergy.org/publications/2013/world-energy-resources-2013-survey>

²⁹ Simon J. Lock, Melanie Smallman, Marie Lee & Yvonne Rydin, “Nuclear energy sounded wonderful 40 years ago”: UK citizen views on CCS, 66 ENERGY POL’Y 428, 434 (2014)

will be a future ideal energy source because they could realize zero-carbon emissions as well as serving as a safe resource. However, despite their merit as ideal energy sources and the huge investments into renewable energy sources, they have limitations in the aspects of cost-effectiveness and they do not form a large part of all energy resources. On the other hand, on a global level, there exists a high dependency on coal.³⁰ It is not just that developing countries heavily rely on fossil fuel energy sources³¹, but developed countries rely on fossil fuel energy sources as well. The United States, European Union, and Australia, to name a few, still depend on fossil fuel energy while being obligated to reduce carbon dioxide emissions.³² This current situation implies that it is difficult for the dependence on fossil fuel energy sources to be fully replaced for renewable energy sources in a short time.³³ Therefore, from a broad perspective, CCS technology is able to function as a bridge technology in the variable spectrum: fossil fuel power plants, fossil fuel power plant with CCS, and the phasing out of fossil fuel power plants, and the

³⁰ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 3; MATTHIAS FINKENRATH, JULIAN SMITH & DENNIS VOLK, INT'L ENERGY AGENCY [IEA] CCS RETROFIT: ANALYSIS OF THE GLOBALLY INSTALLED COAL-FIRED POWER PLANT FLEET 7 (2012).

³¹ See JOHN THOMPSON, KURT WALTZER, MIKE FOWLER & JOE CHAISSON, CLEAN AIR TASK FORCE [CATF], *supra* note 20, at 12; FRANCISCO ALMENDRA, LOGAN WEST, LI ZHENG & SARAH FORBES, WORLD RESOURCES INSTITUTE [WRI] WORKING PAPER, CCS DEMONSTRATION IN DEVELOPING COUNTRIES: PRIORITIES FOR A FINANCING MECHANISM FOR CARBON DIOXIDE CAPTURE AND STORAGE 1 (2011).

³² See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *Reconciling King Coal and Climate Change: A Regulatory Framework for Carbon Capture and Storage*, 11 VT. J. ENVTL. L. 7, 7 (2009). See also WORLD PETROLEUM CONGRESS, BP STATISTIC REVIEW, ENERGY IN 2013: TAKING STOCK (16 June, 2014); <http://www.eia.gov/totalenergy/>

³³ See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 42.

advent of the renewable energy era.³⁴

Meanwhile, CCS opponents argue that the adoption of CCS technology, which acknowledges the dependence on fossil fuel energy sources, is not suited for the ideal goal for the development of renewable energy.³⁵ They are concerned that CCS technology might be a barrier to the development of renewable energy.³⁶ However, what is significant is that CCS technology should not be used as a reason to justify the continuous use of fossil fuel energy sources.³⁷ In other words, CCS technology has to be deployed along with renewable energy development, and play an important role as a temporary solution connecting fossil fuel and renewable energy for the time being (likely the next few decades).³⁸ Additionally, in this context of the role of CCS as a bridge

³⁴ See Olaf Corry and Hauke Riesch, Beyond 'For or Against' – Environmental NGO-evaluations of CCS as a climate change solution, in *THE SOCIAL DYNAMICS OF CARBON CAPTURE AND STORAGE – UNDERSTANDING CCS REPRESENTATIONS, GOVERNANCE AND INNOVATION* 106 (Nils Markusson, Simon Shackley & Benjamin Eva eds., 2012); Bobby Magill, *Carbon Capture Faces Hurdles of Will, Not Technology*, CLIMATE CENTRAL (Apr. 23, 2014).

³⁵ See Mark A. Latham, *The BP Deepwater Horizon: A Cautionary Tale for CCS, Hydrofracking, Geoengineering and Other Emerging Technologies with Environmental and Human Health Risks*, 36 WM. & MARY ENVTL. L. & POL'Y REV. 31, 47 (2011).

³⁶ See GREENPEACE, FALSE HOPE: WHY CARBON CAPTURE AND STORAGE WON'T SAVE THE CLIMATE, 37 (2008); *Carbon Dioxide Capture and Storage as a sequestration strategy*, GERMANWATCH, <http://germanwatch.org/rio/ccs04e.pdf>. See also Philip J. Vergragt, Nils Markusson & Hanrik Karlsson, *Carbon Capture and Storage, bio-energy with carbon capture and storage, and the escape from the fossil-fuel lock-in*, GLOBAL ENVTL. CHANGE 21(2) (2011).

³⁷ See JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 1.

³⁸ See David Hone, *A Clear Explanation of Why We Need Carbon Capture and Storage*, THE ENERGY COLLECTIVE, Sep. 24, 2013, available at <http://theenergycollective.com/davidhone/278546/clear-explanation-why-we-need-carbon-capture-and-storage>; Schalk Cloete, *Why we Need CCS – Part 5: Bridge to a Sustainable Energy Future*, THE ENERGY COLLECTIVE, July 22, 2014, available at <http://theenergycollective.com/schalk-cloete/437046/why-we-need-ccs-part-5-bridge-sustainable-energy-future>

technology, it is encouraging that several methods that link CCS technology with bioenergy or renewable energy are considered and researched in addition to the CCS technology improvement.³⁹ For example, there are bioenergy with CCS (BECCS) and CCS conversion technology.⁴⁰

In conclusion, CCS will be a necessary technology for the urgent need to reduce carbon dioxide emissions, acting as a bridge technology that considers both the current dependence on fossil fuel energy sources and future goals for renewable energy sources.⁴¹ For this function of CCS, a legal and regulatory system for CCS needs to be developed, along with some technical improvements to CCS. Additionally, the establishment of CCS legal and regulatory system should not be delayed due to the urgency of the need for a foundational bridge. In other words, late adoption and deployment of CCS and untimely establishment of CCS legal and regulatory systems may ultimately lead to the prevention of renewable energy development in the future. Thus, it is necessary for early stabilization of CCS and CCS facilitation.

2. A bridge technology between developing and developed countries

³⁹ See generally HENRIK KARLSSON & LENNART BYSTROM, GLOBAL CCS INSTITUTE [GCCSI] & BIORECRO, GLOBAL STATUS OF BECCS PROJECTS 2010 (2011).

⁴⁰ See CARBON SEQUESTRATION LEADERSHIP FORUM [CSLF], *supra* note 23, at 14; INT'L ENERGY AGENCY [IEA], COMBINING BIOENERGY WITH CCS – REPORTING AND ACCOUNTING FOR NEGATIVE EMISSIONS UNDER UNFCCC AND THE KYOTO PROTOCOL 6 (2011); HENRIK KARLSSON & LENNART BYSTROM, *supra* note 39, at 8.

⁴¹ See Maximilian Vibeisen, *CCS-Technology: Implications for New Power Plants under German and European Law*, 2011 CARBON & CLIMATE L. REV. 264, 264 (2011).

In addition to the role of the bridge toward the future renewable energy era, CCS could help mediate current conflicts between developed and developing countries. During climate change relevant negotiations, developed and developing countries have shown very different attitudes regarding the responsibility for the causes of the global warming.⁴²

However, climate change issues cannot be resolved substantially without the participation of the developing countries that focus on industrial development. In other words, developing countries' participation in the obligations of greenhouse gas reduction will be an inevitable task. For example, China, the top carbon dioxide emitting country, has increased large and young coal-fired power plants, and India also uses coal as a dominant energy source as a rising developing country.⁴³ Since activities by developing countries might make the global climate change crisis worse, developing countries' cooperation is imperative in reducing CO₂ emissions.⁴⁴

The adoption of CCS technology has a characteristic that is favorable to both developing and developed countries as CCS technology acknowledges the use of fossil

⁴² See Justin Gillis, *Climate Efforts Falling Short, U.N. Panel Says*, N.Y. TIMES, Apr. 13 2014, http://www.nytimes.com/2014/04/14/science/earth/un-climate-panel-warns-speedier-action-is-needed-to-avert-disaster.html?_r=0

⁴³ See MATTHIAS FINKENRATH, JULIAN SMITH & DENNIS VOLK, *supra* note 30, at 22; Malti Goel, *Carbon Capture and Storage, Energy Future and Sustainable Development: Indian Perspective*, in CARBON CAPTURE AND STORAGE –R&D TECHNOLOGIES FOR SUSTAINABLE ENERGY FUTURE 3 (Malti Goel, Baleshwar Kumar & S. Nirmal Charan eds., 2008).

⁴⁴ See Clarke Bruno et al, *Report of the Climate Change and Emissions Committee*, 30 ENERGY L. J. 563 (2009).

fuel energy sources for the time being.⁴⁵ Specifically, CCS could have an important role and be a persuasive method that involves developing countries in the climate change negotiation table, while still being able to rely on fossil fuels⁴⁶ and ensuring time for a gradual shift from fossil fuel to renewable energy sources.⁴⁷ Additionally, CCS R&D programs have been led by developed countries, and currently the United States, Australia, and European countries are conducting large-scale CCS projects. Developing countries could get an insight from developed countries through their approved project experiences with a lesser cost burden.⁴⁸ In this context, CCS could play an important role as a bridge between developed and developing countries.

Meanwhile, it is true that the economic and technical circumstances regarding CCS or renewable energy development are worse in developing countries.⁴⁹ For this reason, more efforts to link developed and developing countries and to mediate the current technical and economic gap will be needed in establishing a legal and regulatory system for CCS.

⁴⁵ See Stuart Haszeldine, *supra* note 4, at 8.

⁴⁶ See David Schwartz, *The Natural Gas Industry Lessons: for the Future of the Carbon Dioxide Capture and Storage Industry*, 19 STAN. L. & POL'Y REV. 550, 551 (2008).

⁴⁷ See FRANCISCO ALMENDRA, LOGAN WEST, LI ZHENG & SARAH FORBES, *supra* note 31, at 1.

⁴⁸ See *Id.* at 3. In recent years, developing countries in Asia and Middle East, such as India and the United Arab Emirates, are increasingly interested in CCS projects, and these countries also have the ability and affordability to implement CCS technology.

⁴⁹ See *Id.* at 2; *CCS in Developing Countries*, GLOBAL CCS INSTITUTE [GCCSI], <http://www.globalccsinstitute.com/sites/www.globalccsinstitute.com/files/content/page/92241/files/CCS%20in%20Developing%20Countries.pdf>

iii. Current status of CCS as an upcoming technology

CCS technology is a new and innovative concept for preventing a global environmental problem from becoming more serious. CCS technology also requires a variety of complicated implementation techniques. Therefore, CCS-relevant projects have been performed after significant extensive technical development and public financial support to demonstrate the feasibility of CCS over the last two decades. As a result, it has been shown that CCS technology is a viable, albeit very expensive, technology which potentially could be commercialized in developed countries within five years.

CCS history and project statistics make the argument that CCS technology is an upcoming technology reasonable and concrete. The concept of storing carbon dioxide in deep underground below the surface was a noble idea at the time when Marchetti first suggested it in 1977.⁵⁰ Initial studies regarding CCS started in the 1980s. In the 1990s, full-scale research was initiated and governments paid more attention to CCS technology in order to realize carbon dioxide emission abatement as greenhouse gas emissions were considered a serious environmental problem.⁵¹

The Sleipner Project, a CCS project to sequester carbon dioxide in a deep saline reservoir, was conducted in the North Sea in 1996.⁵² Additionally, in the early history of

⁵⁰ See Benjamin Evar, Chiara Armeni & Vivian Scott, *An Introduction to Key Developments and Concept in CCS*, in THE SOCIAL DYNAMICS OF CARBON CAPTURE AND STORAGE – UNDERSTANDING CCS REPRESENTATIONS, GOVERNANCE AND INNOVATION 20 (Nils Markusson, Simon Shackley & Benjamin Evar eds., 2012).

⁵¹ See *Id.*

⁵² PETER FOLGER, *supra* note 4, at 15.

CCS projects, there are other representative projects relevant to CCS technology, such as the Weyburn Project in Canada and the In Salah Project in Algeria.⁵³ Through continuous development, the number of project amounts to 13 large-scale CCS projects in operation and 9 large-scale CCS projects under construction as of 2014.⁵⁴ Additionally, it is analyzed that there exist about 55 large-scale CCS projects when including large-scale projects which are in advanced and early stages of planning.⁵⁵ Even though large-scale CCS projects in developing countries are much less numerous than in developed countries, some emerging economies, such as China, South Africa, and India, have already taken international RD&D collaborations and moved forward towards setting up a roadmap for CCS deployment.⁵⁶ On the other hand, some of the developed countries have been trying to verify the feasibility of CCS deployment through the enforcement of

⁵³ The Weyburn Project was initiated in 2000 and is a CCS project relevant to Enhanced Oil Recovery (EOR). Under this project, carbon dioxide, which is produced from a coal gasification plant in the state of North Dakota in the United States, is transported to the Weyburn oil fields in Canada to improve oil recovery rate. Meanwhile, under the In Salah Project, carbon dioxide is separated from a natural gas reservoir and then injected again into the same formation. The In Salah Project was initiated in 2004. *See id.* at 14.

⁵⁴ The term “large-scale CCS projects” here is used when it meets the following standards: capturing at least 800,000 tons of carbon dioxide annually for a coal-based power plant or at least 400,000 tons of carbon dioxide annually for other emission-intensive industrial facilities (such as natural gas-based power generation). *See Large-Scale CCS Projects – Definitions*, PROJECTS, GLOBAL CCS INSTITUTE [GCCSI], available at <http://www.globalccsinstitute.com/projects/large-scale-ccs-projects-definitions>

⁵⁵ For more detailed information on these 55 projects including location, lifecycle stage, capture type, capture capacity, transport type etc., *see* <http://www.globalccsinstitute.com/projects/large-scale-ccs-projects>. Furthermore, if including all CCS projects regardless of large-scale considerations, it is estimated that there are about 75 projects and that 17 projects among them are being performed in developing countries.

⁵⁶ *See* Benjamin Evar, Chiara Armeni & Vivian Scott, *supra* note 50, at 29.

large-scale CCS projects.⁵⁷

On a domestic level, the governments of developed countries have been working on CCS project development and have been actively investing in the CCS industry as the G8 leaders have agreed on the promotion of CCS commercialization.⁵⁸ For example, the U.S. Department of Energy (DOE) has initiated many CCS programs and projects including the FutureGen project.⁵⁹ These programs and projects are expected to be expanded and financially supported through some relevant laws, such as the *Energy Independence and Security Act* (EISA) of 2007 and the *American Recovery and Reinvestment Act* (ARRA) of 2009.⁶⁰ Also, the task force for CCS was organized by the instruction of President Obama in 2010. Likewise, in Australia, CCS projects, such as the Otway and Gorgon projects, have been developed and are currently funded. In addition to these efforts, many CCS relevant institutes or organizations have been established to strengthen the cooperation between countries at an international level. For example, the IEA Greenhouse Gas R&D Programme (IEA GHG), GCCSI (Global CCS Institute), and CSLF (Carbon Sequestration Leadership Forum) are representative institutions.

⁵⁷ See Saroja Asthana & Vilas Pharande, *Global Challenges and Strategies for Capture, Recovery and Utilization of CO₂ for Sustainable Development*, in CARBON CAPTURE AND STORAGE— R&D TECHNOLOGIES FOR SUSTAINABLE ENERGY FUTURE 215 (Malti Goel, Baleshwar Kumar & S. Nirmal Charan eds., 2008).

⁵⁸ See INT'L ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE - PROGRESS AND NEXT STEPS, IEA/CSLF REPORT TO THE MUSKOKA 2010 G8 SUMMIT (2010).

⁵⁹ See PETER FOLGER, *supra* note 4, at 4.

⁶⁰ See *Id.* at 4.

Additionally, according to the analysis by IEA, the future prospects regarding CCS are promising. The IEA has expected that globally 100 demonstration projects need to be implemented by 2020, and more than 3000 projects need to be deployed by 2050.⁶¹ In regards to future CCS prospects in developing countries, the IEA reports also say that it is reasonable that in 2050, 65 percent of capture and storage of CO₂ will be performed in developing countries.⁶²

As seen from this analysis of current CCS projects, future plans, and prospects, CCS is an upcoming technology in the near future, not a vague technology in the distant future, which has a potential in developing countries as well as developed countries. Therefore, by looking at the inevitable development and use of CCS technology, it is imperative to lay the foundation for a CCS legal and regulatory regime in preparation for adopting the approaching technology of CCS that will soon be commercialized.

C. Concerns on CCS technology and Rationale for CCS regulation

After dealing with the importance and necessity of CCS, the next step will be to review specific risks and concerns regarding CCS. It is significant to analyze CCS risks and concerns because they would be valuable sources in order to determine the content of any regulation contents and level of that regulation regarding CCS. Some valuable and reasonable analysis on possible concerns needs to be reflected if applicable in

⁶¹ See Benjamin Evar, Chiara Armeni & Vivian Scott, *supra* note 50, at 18.

⁶² See HyunJeong Noh et al, *Discussion and Challenges on Inclusion of Carbon Dioxide Capture and Geological Storage (CCS) as Clean Development Mechanism (CDM) Projects Activities*, JOURNAL OF THE KOREAN SOCIETY FOR MARINE ENVIRONMENTAL ENGINEERING Vol.15(3), 185 (2011).

establishing legal and regulatory system for CCS. In other words, in order to reduce, manage and resolve these concerns and risks, governance via regulatory oversight is needed, and such regulations should be grounded in laws. The concerns related to CCS are divided into three categories in this part. First, technical concern includes the possibility of physical leaks of carbon dioxide. Second, administrative concern means the potential problem that regulations could not be effective due to the difference in the level of regulations. Finally, the financial concern looks at the cost burdens that can be associated with CCS implementation from a variety of perspectives.

i. Technical leakage concern

In addition to the benefit of reducing the emissions of CO₂ into the atmosphere and mitigating climate change, the technology has associated technical risks. The technical risks include both engineered and geological risks. The primary risk is the loss of integrity in the system and leakage of CO₂ into the atmosphere, which was posed by CCS opponents, such as Greenpeace.⁶³ They say that this new technology will create many technical risks (e.g., low reservoir permeability that will require high pressure, leading to fracturing of the seal and leakage of carbon dioxide) both in the near future and in the long run.⁶⁴ They argue that CCS is a risky technology that could damage the environment and humans rather than protecting the global environment. As mentioned before, carbon dioxide under the CCS process is in a supercritical phase, a very dense

⁶³ See GREENPEACE, *supra* note 36, at 21.

⁶⁴ See David E. Adelman & Ian J. Duncan, *The limits of liability in Promoting Safe Geologic Sequestration of CO₂*, 43 ELR 10646 (2013).

condition. It means that unlike carbon dioxide's normal condition as a gas, chemically the supercritical phase of carbon dioxide could damage humans and the environment if leakage of carbon dioxide happens.⁶⁵

The leakage accidents could happen because of the erosion of pipelines or injection wells. The erosion could be the result of impurities mixed during the process of capturing carbon dioxide.⁶⁶ Additionally, there is a scientific concern that earthquakes might be a cause of carbon dioxide leakage by affecting possible sequestration sites, such as saline formations.⁶⁷ As for the method of leakage, two types of leakage are possible: abrupt leakage by sudden leakage accidents; and gradual leakage, which progresses little by little.⁶⁸

Regarding the issue of when carbon dioxide leakage happens, it might happen during any point of the CCS process.⁶⁹ This could happen in a variety of places within the constructed portion of the CCS system. It means that both above the surface and below the surface could be where the leakage takes place in the case of onshore

⁶⁵ See Mark A. Latham, *supra* note 35, at 45; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 12.

⁶⁶ JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 2.

⁶⁷ See Yvette Carr, *The International Legal Issues Relating to the Facilitation of Sub-Seabed CO₂ Sequestration Projects in Australia*, AUSTRALIAN INT'L L. J. 137, 139 (2007); See Mark A. Latham, *supra* note 35, at 46.

⁶⁸ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 13.

⁶⁹ See Mark A. Latham, *supra* note 35, at 44; INT'L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, *supra* note 5, at 12.

sequestration. When leakage accidents happen in offshore sequestration, the leakage place would be expanded to the ocean.⁷⁰ First, when a leakage accident happens above the surface, it could damage human beings directly. It is highly likely that the employees of the CCS relevant facilities or its neighborhood residents could be suffocated by leakage accidents.⁷¹ Moreover, carbon dioxide disposed above the surface could damage animals, plants, and the environment (through air pollution).⁷² Second, there are risks to the subsurface, including groundwater contamination,⁷³ sterilization of other subsurface mineral resources, and the triggering of earthquakes. Third, leakage in the ocean could change and destroy the ocean ecosystem by killing marine organisms and aggravating ocean acidification, a significant problem in ocean environmental pollution issues.⁷⁴

As shown in the discussion of the risks of carbon dioxide leakage, CCS technology has various possible leakage scenarios. However, the potential scenarios should not be a reason to oppose the adoption of CCS technology. Current scientific

⁷⁰ The leakage of carbon dioxide in a country or in a local area might influence other countries, a situation which is more likely in offshore sequestration which causes ocean pollution. Thus, in such a case, it could be said that there is a global leakage as well as a leakage in local areas. See JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 1-2.

⁷¹ See Christopher Bidlack, *Regulating the Inevitable: Understanding the Legal Consequences of and Providing for the Regulation of the Geologic Sequestration of Carbon Dioxide*, 30 J. LAND RESOURCES & ENVTL. L. 199, 209 (2010).

⁷² See *id.*; JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 2; David Schwartz, *supra* note 46, at 44.

⁷³ It could finally bring about a negative effect on human health due to the contamination of drinking water.

⁷⁴ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 14.

evidence indicates that the possibility of actual leakage accidents is very low.⁷⁵ Even though there is a small chance of leakage accidents, it is necessary for leakage accidents to be prevented during the whole process of CCS by preparing a legal and regulatory system in advance.⁷⁶ The legal and regulatory system to set up requirements and procedures can help to mitigate and manage risk occurrences. Meanwhile, there is a lack of analysis and evaluation on the possibility of leakage accidents regarding the long-term storage of carbon dioxide, a unique situation of CCS, which means that scientific certainty about CCS risks and probability of leakage accidents is not high.⁷⁷

Therefore, a future important task will be the establishment of a legal and regulatory system focused on preparing for the leakage accidents that might happen after long-term storage of carbon dioxide. In other words, the legal system needs to be analyzed and monitored for all the possible long-term risks as well as short-term risks. Additionally, since CCS technology is composed of a series of processes (including capture, transport, injection, and sequestration), occurrence of leakage accidents in one

⁷⁵ There are no carbon leakage accidents caused by the deployment of CCS under this time of developing commercialization of CCS technology. However, the accident that happened in 1986 in Cameroon, Africa, could be a good example for predicting future consequences that CCS leakage accidents might cause. In this accident, carbon dioxide in high concentrations was formed naturally in the lake Nyos, and the subsequent eruption of the carbon dioxide killed more than 1700 peoples and 3500 animals. *See* Mark A. Latham, *supra* note 35, at 45. After the accident, there exists a current system to warn residents near the lake Nyos of a carbon dioxide leakage accident.

⁷⁶ *See* JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 2, *see also* INT'L RISK GOVERNANCE COUNCIL [IRGC], REGULATION OF CARBON CAPTURE AND STORAGE 12 (2008).

⁷⁷ The fact that CCS requires long-term storage of carbon dioxide means that carbon dioxide leaks may occur not only abruptly after a long period of time but also gradually and slowly over a long period of time. The slow leakage can offset the benefits of sequestering carbon dioxide, so it also needs to be carefully observed.

process could affect other processes. It will ruin the whole process of CCS and lead to CCS failure. For this reason, it is necessary for a country to have a comprehensive system in creating a CCS legal and regulatory system.

ii. Administrative leakage concern

There is a concern that the CCS technology would not contribute to solving the climate change problem of global warming because of administrative leakage.⁷⁸ As shown in the physical leakage concern, the risk of leakage accidents could be reduced with a strict regulatory system. However, only the strong and comprehensive governance in some limited countries could create another problem of market leakage.⁷⁹

Market leakage describes a situation where corporations are likely to transfer their greenhouse gas emissions from one country with stringent environmental regulation (e.g., carbon dioxide emission control) to other countries with loose environmental regulation.⁸⁰ Consequently, due to the market leakage under the theory of market economies, there is no change in total emission on a global level and there is no

⁷⁸ The terms of market leakage and carbon leakage have been used to describe this concept. Since the term carbon leakage is thought to be confused with technical or physical leakage, this paper uses the terms administrative and market leakage.

⁷⁹ See generally, ANDREA PEART, CARBON LEAKAGE: WHAT IS IT? POLICY OPTIONS FOR PREVENTING IT, CANADIAN LABOUR CONGRESS (Aug. 2010).

⁸⁰ See Neil Peretz, *Carbon Leakage under the European Union Emissions Trading Scheme: Is it a Major Policy Concern?* 23 TUL. ENVTL. L.J. 57, 60 (2009).

environmental benefit in the end.⁸¹ However, the concerns of market leakage should not justify opposition to CCS technology. Rather, it is necessary to find a way to solve the market leakage problem. This market leakage problem would become worse when there is a huge difference on greenhouse gas reduction related policies.⁸² Therefore, as well as the establishment of domestic CCS systems, an international regulatory system for CCS is needed to somewhat unify each country's CCS legal and regulatory system. Meanwhile, if a leakage accident does happen, it is not just a local environmental problem. It could bring about risks and damages on a global level. This possibility proves the need for uniformed international standards for CCS.⁸³

In conclusion, international norms regulating CCS, suggesting some standards to countries, is needed. It would help to mitigate the market leakage problem and to solve climate change problems substantially and effectively.

iii. Financial concern

The third concern is about the cost relevant to CCS technology development and

⁸¹ INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 13; Mark A. Latham, *supra* note 35, at 46. It could be said that the market leakage problem points to an invisible structural problem while physical leakage of carbon dioxide notes a visible and explicit environmental problem.

⁸² See ANDREI MARCU, CHRISTIAN EGENHOFER, SUSANNA ROTH & WIJNAND STOEFS, CARBON LEAKAGE: AN OVERVIEW, CENTRE FOR EUROPEAN POLICY STUDIES [CEPS] 5 (Dec. 2013).

⁸³ See generally, Jonathan Baert Wiener, *Global Environmental Regulation: Instrument Choice in Legal Context*, 108 YALE L.J. 677 (1999).

deployment. Greenpeace argues that the cost which has to be paid for CCS is too high.⁸⁴ The U.S. DOE points out an increase in the cost of electricity due to the introduction of CCS and the need for an intensive CCS RD & D effort to reduce this cost increase.⁸⁵ However, whether or not the CCS technology is a cost-effective technology should not be determined with a simple standard on how much money should be invested for CCS development and deployment. It is reasonable to analyze CCS costs with various comparative analyses. For example, other evaluation criteria could be included, such as future environmental benefits from the adoption of CCS technology, the environmental and economic damages without CCS technology, and the economic profits in case of the adoption of the CCS technology.⁸⁶ This CCS cost estimation can be conducted through various criteria.⁸⁷ In addition, the results of cost estimation can vary depending on the situation in each country or the level of capture technology development.⁸⁸ Because of

⁸⁴ See GREENPEACE, *supra* note 36, at 27. Also, CCS opponents with skeptical views on the CCS costs also say that the CCS is an expensive technology when the cost includes social cost as well as economic cost. See Jennie C. Stephens, *Time to stop investing in carbon capture and storage*, RESILIENCE, <http://www.resilience.org/stories/2014-01-02/time-to-stop-investing-in-carbon-capture-and-storage>

⁸⁵ See DAVID BERNELL & CHRISTOPHER A. SIMON, *THE ENERGY SECURITY DILEMMA: US POLICY AND PRACTICE* (2016).

⁸⁶ The CCS technology might foster contingent advantages, such as job creation. Also, incorporating CCS within the CDM could be a way to make an economic profit through CCS, which will be explained more in Section IV.

⁸⁷ For example, the criteria for cost estimation may include capital cost, levelized electricity cost, and cost per tonne of carbon dioxide avoided. See GCCSI, *THE COSTS OF CCS AND OTHER LOW-CARBON TECHNOLOGIES IN THE UNITED STATES – 2015 UPDATE*, 1-6 (July 2015).

⁸⁸ For example, the results of the cost analysis conducted in China are evaluated to be lower than those of developed countries, which is a result of considering the lower construction and labor costs compared to developed countries. JiHyun Lee et al., *Development of Techno-Economic Evaluation Model for CCS (Carbon Capture & Sequestration)*, JOURNAL OF CLIMATE CHANGE RESEARCH VOL.7(2), 112 (2016). In this

this complexity of estimating costs, it is necessary to evaluate the economic status of CCS within the country in order for a more accurate estimation.⁸⁹ It is also important to analyze the competitiveness of CCS in terms of economic efficiency in comparison with other carbon dioxide reduction measures. According to a study on the cost of CCS in the United States, which is published by GCCSI, it has been analyzed as a competitive technology in economic efficiency compared to other options, such as nuclear, biomass, and solar thermal.⁹⁰ At an international level, there is an economic assessment granted by the IEA, which considers the expected economic damage that should be paid for curbing climate change in the future. This report states that the cost for mitigating climate change without CCS technology would actually increase by as much as 70 percent.⁹¹

However, it is true that an enormous cost factor is required to deploy CCS technology, even though CCS is analyzed as a cost-effective technology on the whole assessment.⁹² Therefore, the efforts, such as reducing the cost of CCS, allocating the cost

regard, there is a view that cost estimation that does not depend on developed countries' data needs to be carried out in South Korea. Specifically, in South Korea, cost-effective capture techniques are still being developed, so it is necessary to adjust the CCS cost to reflect these realities.

⁸⁹ Assessing cost in specific CCS projects is also important as well as overall CCS cost evaluation because the result of the cost evaluation can also affect the maintenance and cancellation of the project. For an example of cost estimates for individual projects, *see* IEAGHG (INTERNATIONAL ENERGY AGENCY GREENHOUSE GAS PROGRAMME), CCS COST NETWORK -2016 WORKSHOP, 4-7 (March, 2016).

⁹⁰ *See* GCCSI, *supra* note 87, at 8-11. As of 2014, the avoided cost per tonne of carbon dioxide for a plant in the United States was \$48-109 for coal with CCS and \$74-114 for natural gas with CCS. Nuclear and biomass were estimated at \$8-28 and \$54-70 respectively. On the other hand, solar thermal and solar PV (photovoltaics) are estimated to be more expensive than other options, ranging from \$108-191 for solar thermal and \$101-225 for solar PV.

⁹¹ *See* Benjamin Evar, Chiara Armeni & Vivian Scott, *supra* note 50, at 19.

⁹² The process of capturing carbon dioxide is the most costly process. *See* PETER FOLGER, *supra* note 4, at 21.

effectively, and allowing for financial support if necessary, are needed. Reducing CCS cost is especially important because too high of a cost might be a problem in the relationship of carbon price.⁹³ When considering the possible expansion of the carbon trading system in the future, the cost of CCS deployment needs to be formed at a reasonable level.⁹⁴ Therefore, the economic elements regarding CCS are significant and need to be reflected in setting up the legal and regulatory policies for CCS.

iv. Summary

The concerns pointed out by CCS opponents primarily deal with scientific uncertainty and economic efficiency. However, until now, there has been a lack of economic and scientific certainty on the concerns related to CCS according to both predictions and analyses. On the other hand, CCS technology is a necessary and upcoming technology, approaching commercialization as a bridge technology. Therefore, it would be unwise to abandon a necessary new technology due to unproven and unrealized risks. To ameliorate these concerns, a basic and important component of CCS deployment that needs to be established is the legal and regulatory framework. The legal and regulatory regime in preparation for the harms and risks of CCS technology could relieve the concerns that the opponents of CCS have. Also, the elements of economic and technical areas should be considered continuously to be efficient in all facets of CCS,

⁹³ See SBC ENERGY INSTITUTE, LEADING THE ENERGY TRANSITION: BRINGING CARBON CAPTURE & STORAGE TO MARKET 53 (2012).

⁹⁴ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 12.

since they are still important in creating a CCS legal and regulatory structure.

The legal system should be comprehensive and strict in order to prevent possible leakage risks during the whole process of capture, transportation, and sequestration.

Additionally, the legal system needs to consider CCS facilitation, as well as a strong and comprehensive CCS regulation. It is because the CCS technology functions as a bridge technology, which becomes insignificant as it is delayed. Furthermore, the international system that deals with CCS relevant issues with unified standards is necessary for effective problem solving of the climate change crisis.

III. Required elements for CCS structure

A. The economic and social elements of CCS

i. Economic elements of CCS

An analysis of the current economic feasibility regarding CCS technology is necessary for CCS implementation and facilitation, along with an effort to find a way to make CCS technology cost-effective. The legal and regulatory systems would become more sound and realistic if they reflect the results of economic analyses. Also, the research on the economics of CCS needs to include the issue of how CCS technology is related to other economic tools used to reduce carbon emissions (e.g., carbon price or emission trading systems) as well as the issue of how CCS could be sufficiently funded

with direct incentive programs.⁹⁵

As mentioned before, CCS technology itself is considered an effective mitigation option when considering the required reduction cost without CCS technology. However, the cost of CCS might be an economic barrier that prevents CCS-relevant operators from participating or investing in CCS technology when the cost is significantly larger than their economic ability.⁹⁶ Given this obstacle, the ways to fill the economic gap need to be considered.⁹⁷ To begin with, it is necessary to know which costs are required during the whole process of CCS and how much money are required for the expansion of CCS deployment. The main cost is the installation of infrastructure facilities for capture, transport, and sequestration. In addition, CCS deployment could include a variety of other costs, such as site exploration, geological research, risk assessment, and monitoring costs.⁹⁸

Among the three steps of capture, transport, and sequestration, the carbon dioxide capture process is the most costly, accounting for 70-80 percent of total costs.⁹⁹ When it

⁹⁵ See JUSTINE GARRETT & SEAN MCCOY, INT'L ENERGY AGENCY [IEA], 4TH IEA INTERNATIONAL CCS REGULATORY NETWORK MEETING 22 (2012).

⁹⁶ See GLOBAL CCS INSTITUTE [GCCSI], FUNDING CARBON CAPTURE AND STORAGE IN DEVELOPING COUNTRIES 8 (2012).

⁹⁷ *Id.* at 15.

⁹⁸ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 11.

⁹⁹ See SBC ENERGY INSTITUTE, CARBON CAPTURE AND STORAGE –BRINGING CARBON CAPTURE AND STORAGE TO MARKET (2013). According to the analysis by the IEA, the capture cost in the United States, European Union, and Canada amounts to 15-40 US\$/CO₂. Another research result predicts that capture cost will account for 15-70 US\$/CO₂ or 42-90t/CO₂. Additionally, the capture cost could vary, depending on the types of power plant and the kinds of capture technology. For example, capture cost could be lower

comes to installing capture facilities, retrofitting an existing power plant for the application of CCS technology is also expensive, as it is very costly to build a new capture facility.¹⁰⁰ Additionally, when repairing existing facilities (e.g., fossil-fuel power plants) to install CCS capture facilities, it will be necessary to consider how long the payback will be for that investment, considering the remaining service life of existing facilities.¹⁰¹ Meanwhile, it is estimated that the cost of offshore sequestration will be higher than onshore sequestration due to the cost of offshore drilling, platform installation, and operation.¹⁰² On the whole, the economic analysis for CCS commercialization shows that CCS technology requires a considerable amount of capital that could result in financial problems for CCS operators, even though CCS technology is a necessary and cost-effective mitigation option.

In order to overcome this financial problem and to ensure the economic feasibility of CCS, the need for financial support mechanisms, such as a trust fund

when utilizing IGCC (using oxy-fuel combustion capture technology) than NGCC (using post-combustion capture technology). *See* Global CCS Institute [GCCSI], *ECONOMIC ASSESSMENT OF CARBON CAPTURE AND STORAGE TECHNOLOGIES 5* (2011), *see also* PETER FOLGER, *supra* note 4, at 22. On the other hand, it is known that relatively lower costs are needed for CO₂ sequestration and monitoring. The cost of sequestration is typically estimated between 0.5-8US\$/CO₂ and monitoring cost will be between 0.1-0.3 US\$/CO₂. *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 36.

¹⁰⁰ *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 27.

¹⁰¹ *See* ECOFYS, *MAKING LARGE-SCALE CARBON CAPTURE AND STORAGE CCS IN THE NETHERLANDS WORK – AN AGENDA FOR 2007-2020 POLICY, TECHNOLOGY AND ORGANISATION*, 42 (May, 2007).

¹⁰² *See* GCCSI, *supra* note 99, at 48. The cost analysis for sequestering CO₂ shows a little difference, but it is common that offshore sequestration is more expensive than onshore sequestration. For example, in Australia, there is an evaluation that onshore sequestration cost will be 0.5 US\$/CO₂ and offshore cost will be 3.4 US\$/CO₂, predicting that overall sequestration cost accounts for within 5.1 US\$/CO₂. Also, an analysis from the European Union predicted the onshore sequestration cost as 2.8 US\$/CO₂ and offshore sequestration as 4.7-12 US\$/CO₂, stating that overall sequestration cost accounts for within 8 US\$/CO₂.

strategy, has emerged. Specifically, the governments of some developed countries have provided and enforced financial support programs.¹⁰³ The NER 300 in the European Union, and financial assistance or tax benefit bills for CCS in the United States are good examples.¹⁰⁴ A public funding trust is necessary and provides an advantage in that such a financial mechanism could encourage the development of a private sector CCS market. Additionally, it is important to think carefully about how to raise the fund and how to allocate it appropriately.¹⁰⁵ For example, one opinion recommends that the fund be preferentially provided for capturing processes, due to the high cost of capturing CO₂, or for geological exploration, given that CCS is very location-specific.¹⁰⁶ Furthermore, it is also necessary to have a careful attitude towards maintaining an appropriate amount of money for CCS funds. In other words, distribution of the fund needs to strike a balance between funds for CCS technology and funds for renewable energy technologies to ensure that CCS technology functions well as a bridge technology.¹⁰⁷

In addition, the economic feasibility study needs to include an analysis associated

¹⁰³ See INT'L ENERGY AGENCY [IEA], *supra* note 58, at 17.

¹⁰⁴ See generally, Jonas W. Myhre, *Financing of CCS Demonstration Projects – State Aid, EEPR and NER funding – an EU and EEA Perspective*, EUROPEAN BUSINESS LAW REVIEW (2011); MOHAMMED AL-JUAIED, ANALYSIS OF FINANCIAL INCENTIVES FOR EARLY CCS DEPLOYMENT, BELFER CENTER FOR SCIENCE AND INT'L AFFAIRS (2010).

¹⁰⁵ The CCS fund could be raised through both public budgets and private sector investments. See Michael I. Jeffery, *International Climate Change Mitigation and Adaptation Post-Copenhagen: Carbon Capture and Storage: Wishful Thinking or a Meaningful Part of the Climate Change Solution*, 27 PACE ENVTL. L. REV. 421, 470-471 (2010).

¹⁰⁶ See GCCSI, *supra* note 96, at 11.

¹⁰⁷ *Id.* at 10.

with liability issues resulting from possible leakage accidents. When compensation claims are raised with regard to massive carbon dioxide leakage accidents, the amount of damages might be far beyond CCS operators' financial capacity. In order to cope with this problem, the establishment of financial assurance or a limitation of liability needs to be considered. For example, two laws in the United States, the Surface Mining Control and Reclamation Act (SMCRA) and the Price-Anderson Act could be useful guides in creating a legal and regulatory system for CCS.¹⁰⁸ Creating a legal and regulatory system that integrates the economic feasibility of CCS, which includes not only funding CCS in its early stages but also covering liability issues, will help encourage private CCS operators to engage in the CCS market. Similarly, when dealing with CCS-specific legal issues, economic elements need to be included. For example, important property rights questions regarding who has pore space ownership need to be resolved considering the economic outcomes that the decision might bring, such as high transaction costs.¹⁰⁹

In order for CCS technology to be commercialized globally and to overcome the imbalance problem between countries, the economic feasibility of CCS needs to be guaranteed in developing countries in addition to developed countries.¹¹⁰ While developed countries have used many financial strategies to try and make CCS technology competitive, developing countries still face financial barriers for adopting and

¹⁰⁸ See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 37.

¹⁰⁹ See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *Pouring Out Our Soils: Facing the Challenge of Poorly Defined Property Rights in Subsurface Pore Space for Carbon Capture and Storage*, J. ENERGY & ENVTL. L. 33, 57 (2012).

¹¹⁰ See INT'L ENERGY AGENCY [IEA], A POLICY STRATEGY FOR CARBON CAPTURE AND STORAGE 34-35 (2012).

implementing CCS technology.¹¹¹ Recognizing the difficulty in assuming the heavy cost of CCS for developing countries, there is a discussion on the need for funding support from developed countries. It is expected that global funding could help start and advance many CCS projects in developing countries by lowering the CCS cost to a point where it is more economically feasible.¹¹² However, the issue of global funding for CCS could become complex, like the issue of climate change funding.¹¹³ In other words, developed and developing countries could show a different attitude on the global funding issue for CCS, and different opinions might exist even within developing countries (e.g., some developing countries might not want funding from developed countries due to the concern of developed countries' exercising influence over them). Additionally, conflicting views could exist in addressing the problem of how to raise the global fund realistically and which organization should govern the fund.¹¹⁴

Therefore, since it is hard to solve the imbalance problem between countries by relying solely on global funding, a market-based approach is a more desirable and realistic direction. This is shown in the Kyoto Protocol, which has adopted a market economy-based system, such as the Clean Development Mechanism (CDM) and

¹¹¹ See FRANCISCO ALMENDRA, LOGAN WEST, LI ZHENG & SARAH FORBES, *supra* note 31, at 12.

¹¹² See GCCSI, *supra* note 96, at 2.

¹¹³ See OHWADA TAKIYOSHI & OKAMURA TAKASHI, CHIKYU ONDANKA BUSINESS NO FRONTIER 93 (2013).

¹¹⁴ For example, developed countries prefer a management of the global CCS fund by the World Bank, a current predominant organization. On the other hand, developing countries show resistance to this idea.

Emission Trading System (ETS).¹¹⁵ Therefore, it is important to analyze how CCS implementation could interact with these current two mechanisms.

First, the CDM has an advantage that provides financial incentives within a market economy system and provides benefits to both developed and developing countries. This suggests that incorporation of CCS within the CDM could encourage and facilitate CCS technology implementation.¹¹⁶ Second, the ETS has been enforced in some countries and has a potential to be expanded in the future.¹¹⁷ In that context, it is necessary for a clear interpretation on how to address CCS under the credit allowances and accounting system.¹¹⁸ In addition, as mentioned before, setting a carbon price within an appropriate scope without market distortion in the carbon market is directly related to CCS commercialization and success.¹¹⁹ Despite the rationale of incorporating CCS into the CDM, there exists a concern from developing countries that it might cause a market

¹¹⁵ See INT'L ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE –MODEL REGULATORY FRAMEWORK 36 (2010); IEA, *supra* note 58, at 16.

¹¹⁶ Paying attention to the potential of CDM, this dissertation will address the function of CCS incorporation into the CDM and legal issues associated with that incorporation in Section IV.

¹¹⁷ Representatively, the European Union has enforced the E.U. ETS since 2005. As of January 2015, South Korea has initiated emission trading system with the law named the *Greenhouse Gas Emission Trading Act*.

¹¹⁸ See GOVERNMENT ACCOUNTABILITY OFFICE [GAO], FEDERAL ACTIONS WILL GREATLY AFFECT THE VIABILITY OF CARBON CAPTURE AND STORAGE AS A KEY MITIGATION OPTION 49 (2008).

¹¹⁹ See Jon Gibbins & Hannah Chalmers, *Fossil Power Generation with Carbon Capture and Storage (CCS): Policy Development for Technology Deployment*, in CARBON CAPTURE SEQUESTRATION AND STORAGE (R.E. Hester & R.M. Harrison eds., 2010), *see also* GCCSI, *supra* note 96, at 14. Currently, carbon is generally priced below \$25t/CO₂, typically ranging from \$13-18t/CO₂. If the CCS cost is much more expensive than the estimated market price of CO₂, it would affect CCS implementation negatively because it makes potential CCS operators reluctant to invest in CCS technology and instead inclined to just purchase allowances.

distortion by increasing Certified Emission Reductions (CERs) issues.¹²⁰ For this reason, it is important to establish thorough standards, requirements, and procedures for issuing CERs.

ii. Social elements of CCS

It has been shown that CCS technology is almost unknown to the general public.¹²¹ Also, there is a concern that public acceptance of CCS is likely to be low because CCS still has many uncertainties (e.g., scientific, economic, and social uncertainty) as a new technology.¹²² However, public acceptance of CCS is a fundamental element, since limited public awareness and support could create a large barrier to adoption and widespread implementation of CCS technology. For example, some CCS projects could be delayed or cancelled by neighboring citizens' objections.¹²³ For this reason, it is necessary to improve public acceptance of CCS.¹²⁴ In addition,

¹²⁰ The CERs are issued for emission reductions from CDM project activities.

¹²¹ See GCCSI, *THE GLOBAL STATUS OF CCS 2016, SUMMARY REPORT*, 23 (2016) (stating that “while global climate change and energy models continually emphasize the value and importance of CCS in meeting global emission reduction targets, the levels of public/political awareness of the technology remain persistently low. This disconnection between expert knowledge and public awareness is a challenging issue for CCS deployment.”).

¹²² See INT’L RISK GOVERNANCE COUNCIL [IRGC], *supra* note 76, at 24; Judith Bradbury et al., *The Role of Social Factors in Shaping Public Perceptions of CCS: Results of Multi-State Focus Group Interviews in the US*, ENERGY PROCEDIA 4665, 4670 (2009).

¹²³ See JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 2. As evidence for the importance of public acceptance, in Germany, a draft bill relevant to CCS was suggested in 2009. However, it was miscarried due to the objection by neighbors of possible storage sites.

¹²⁴ The objection to CCS can be based not only on the fear of damages but also on the concern that the

incorporating social elements effectively in the legal and regulatory framework for CCS is needed in order to facilitate CCS implementation.

Recently, surveys that evaluate public acceptance of CCS have been conducted in some developed countries, and the overall results reveal low public acceptance.¹²⁵ However, there is some meaningful information that can be gleaned from the studies. For example, when conducting surveys in the United States and United Kingdom, providing information on other mitigation options (such as renewable energy sources) had a negative impact on public acceptance of CCS. On the other hand, including explanations regarding the safety of CCS technology and the urgency of climate change improved public acceptance of CCS.¹²⁶ The surveys suggest that various and sufficient information relating to CCS technology needs to be known to the public for an objective evaluation.¹²⁷ Also, in order to promote CCS acceptance, it is necessary to start creating effective methods and strategies, such as education through websites, dialogues on the Internet, and media portrayal.¹²⁸ Meanwhile, there is a common result that the public is

CCS implementation may lead to the continuation or expansion of fossil fuel power plants. *See* Nils Markusson & Stuart Haszeldine, 'Capture readiness': lock-in problems for CCS governance, *ENERGY PROCEDIA* 1, 4625 (2009). Therefore, CCS policies to mitigate these social concerns are needed. *See* Philip J. Vergragt, Nils Markusson & Henrik Karlsson, *supra* note 36, at 282.

¹²⁵ In South Korea, a survey relevant to CCS technology showed that CCS technology is not yet known to the public and has low public acceptance.

¹²⁶ *See* KOREA CARBON CAPTURE & SEQUESTRATION R&D CENTER [KCRC], CARBON DIOXIDE CAPTURE, STORAGE AND CONVERSION TECHNOLOGY 484 (2013).

¹²⁷ *See* JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 4; *see also* Elizabeth L. Malone et al., *Keeping CCS Stakeholder Involvement in Perspective*, *ENERGY PROCEDIA*, 4789, 4793 (2009).

¹²⁸ *See* JEFFREY LOGAN, ANDREA DISCH, KATE LARSEN & JOHN VENEZZA, *supra* note 4, at 5.

less favorable to offshore sequestration than to onshore sequestration.¹²⁹ Therefore, some countries that are considering offshore sequestration, such as South Korea, need to make an effort to seek the public's understanding of why it is necessary.

Furthermore, beyond offering information and raising awareness of CCS technology, more of an effort to gather and include stakeholders' opinions is required.¹³⁰ For example, there is a continued need for open dialogue and a transparent feedback process between stakeholders and residents of the areas where transportation pipelines or storage sites are located.¹³¹ Specifically, residents' opinions and their interests could be reflected in the CCS legal and regulatory system through social assessment items under a risk assessment process.¹³² In the case of CDM, it is more meaningful to seek local residents' opinions because CDM includes the adoption of technology transfers from other countries. Therefore, it is necessary for governments to make an effort to interact with local residents and to explain how CDM benefits local developments.¹³³

¹²⁹ See KCRC, *supra* note 126, at 483.

¹³⁰ See Elizabeth L. Malone et al., *supra* note 127, at 4793; Judith Bradbury et al., *supra* note 122, at 4670.

¹³¹ There exists the classic concern of "not in my backyard" (NIMBY) in implementing CCS technology. See Arnold W. Reitze, Jr. *Legal Issues in the Control Technology of Geological Carbon Sequestration*, THE INSTITUTE FOR CLEAN AND SECURE ENERGY, <http://www.icse.utah.edu/leftnavid3subleftnavid10subpage60;jsessionid=FFAE32B2D78D70A804585FA3AD9CBC09>

¹³² See Sallie E. Greenberg et al., *A Multi-Level Approach to Outreach for Geologic Sequestration Projects*, ENERGY PROCEDIA 4707, 4713 (2009).

¹³³ See JeoungGil Seo et al., *A Study on Maximizing Achievements for the Clean Development Mechanism on Local Government – The Case Study of Daegu Metropolitan City*, 14-2 KOREAN JOURNAL OF LOCAL GOVERNMENT STUDIES 173 (2010).

B. The technical and scientific elements of CCS

CCS technology is a complex technology that consists of a series of processes (capture, transport, and sequestration) and also requires a variety of enabling techniques and knowledge from many fields, such as geology, chemistry, physics, and environmental science.¹³⁴ For the safe and successful implementation of CCS technology, the technical feasibility and accumulation of scientific research needs to be improved. The inclusion of the results from the technical and scientific elements is particularly important in creating a sound CCS legal and regulatory system.

First, suggesting CCS technology as a necessary option for greenhouse gas emission reduction is based on the concept that this technology could sequester a large amount of carbon dioxide securely and permanently. Carbon dioxide, under the state of supercritical fluid for CCS technology, moves slowly, responding to surrounding stratum and subsurface fluid, which is called a trapping mechanism.¹³⁵ This trapping mechanism decreases the mobility of carbon dioxide more and more and finally makes it become permanently contained. More specifically, this process happens through thermal-hydraulic-mechanical-chemical interactions, and there are three kinds of trapping: cap rock trapping (physical trapping), solubility trapping (chemical trapping), and mineral

¹³⁴ See Jon Gibbins & Hannah Chalmers, *Carbon Capture and Storage*, 36 ENERGY POLICY 4317, 4320 (2008).

¹³⁵ See LEONARDO CIPOLLA, CENTER SVILUPPO MAATERIALI [CSM], CARBON CAPTURE AND STORAGE AT POWER PLANTS – A PERSPECTIVE TOWARDS A SUCCESSFUL ZERO EMISSION STRATEGY 28 (2007). The reason why carbon dioxide is transported and sequestered in a supercritical state is because it is cost effective as well as technically safe.

trapping.¹³⁶ In the case of sequestration in deep saline aquifers, there is a concern that deep saline aquifers might be more vulnerable to this trapping mechanism and have a potential for carbon dioxide leakage as compared to depleted oil and gas reservoirs.¹³⁷

Therefore, it will be very important to explore geologically appropriate sites for sequestering carbon dioxide.¹³⁸ The storage sites need to ensure both enough cap rocks for secure confinement with sufficient reservoir rocks for adequate storage capacity. This will require establishing evaluation standards for site selection. In addition, since finding an appropriate storage site is fundamental for CCS implementation, a country that could not find an appropriate site will need to consider transport and storage to other sites, which may be in countries. Extensive geological data acquisition, along with national and international information sharing of that data, is therefore necessary.

Next, a detailed technical and scientific analysis on the specific risks of each step in the CCS process is necessary, because it could strongly affect the regulation level, and could generate different legal issues. In the *capturing stage*, three capturing techniques (pre-combustion, post-combustion, and oxy-fuel combustion) and methods within each

¹³⁶ Cap rock trapping, which is also called structural trapping, makes up the majority of trapping. Mineral trapping dramatically increases permanent safety sequestration. *See* Chen Zhu et al., *Benchmark modeling of the Sleipner CO₂ plume: Calibration to seismic data for the uppermost layer and model sensitivity analysis*, INT. J. GREENHOUSE GAS CONTROL (2015).

¹³⁷ *See* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 31. Further studies on the interface between aquifer and cap rock are needed. *See* Seyed M. Shariatipour et al., *The Effect of Aquifer/Caprock Interface on Geological Storage of CO₂*, 63 ENERGY PROCEDIA 5544 (2014).

¹³⁸ In the United States, in order to find suitable storage sites that consider the distance from emitting sources, research that utilizes geographic information system and economic analysis has been performed.

capturing technique have been developed.¹³⁹ Technical feasibility and safety studies have accumulated in developed countries. However, since the technical feasibility has been limited until now, the permit system or the mandatory establishment of capturing facilities needs to be addressed. In the *transport stage*, the methods of pipeline transport require more attention. Captured carbon dioxide includes other mixed substances that could pose a risk of eroding pipelines.¹⁴⁰ Therefore, there is a need for establishing acceptable criteria regarding carbon dioxide purity and impurity.¹⁴¹ The last *sequestration stage* has a potential risk of carbon dioxide leakage in each process of installing wells, injecting carbon dioxide, and closing wells. The potential risk of leakage is related to some elements called “parameter sensibility” (e.g., pressure, temperature, and permeability).¹⁴² Therefore, it is necessary to create legislative standards with regard to injection pressure and rate so that the cap rock is not adversely affected. Another potential cause of leakage is earthquake occurrences, and the activity of stratum depends on the pressure and rate with which carbon dioxide is injected.¹⁴³ This type of earthquake, which takes place because of human or anthropogenic activities, is called induced

¹³⁹ See generally CARBON SEQUESTRATION LEADERSHIP FORUM [CSLF], *supra* note 23.

¹⁴⁰ See IEA, *supra* note 115, at 52.

¹⁴¹ The purity of carbon dioxide is high in the case of EOR. However, carbon dioxide under the CCS technology includes a variety of impurities, which prevents the use of existing EOR pipelines. For this reason, safety review on the material quality of pipelines is necessary.

¹⁴² See LEONARDO CIPOLLA, *supra* note 135, at 28; Chen Zhu et al., *supra* note 136, at 1.

¹⁴³ See *Ethical Issues Entailed by Geologic Carbon Sequestration*, ROCK ETHINS INSTITUTE (June 23, 2008), <http://sites.psu.edu/rockblogs/2008/06/23/ethical-issues-entailed-by-geologic-carbon-sequestration/>.

seismicity or an induced earthquake.¹⁴⁴ Furthermore, thorough management of injection wells is also essential, even after the closure of injection wells. Neglect or carelessness in managing the closure of wells might cause an erosion of cement where an injection well plug is sealed.

Finally, scientific analysis of the impacts of all types leakage accidents in both onshore and offshore sequestration is necessary. For example, one scientific question would be how humans react to differing concentrations of the released carbon dioxide chemically.¹⁴⁵ Also, released carbon dioxide from a leakage accident on the ground will disperse into the atmosphere. Another question would be how the released carbon dioxide will be diluted in the atmosphere depending on the distance from the storage sites. These technical and scientific research topics will help establish contingency plans and response measures.¹⁴⁶ On the other hand, offshore sequestration has little potential harms on humans but has higher potential harms on the environment, such as ocean acidification and ocean ecosystem destruction.¹⁴⁷ Therefore, scientific research regarding marine microorganisms' distribution near possible sites needs to be conducted and reflected in

¹⁴⁴ See IEAGHG, INDUCED SEISMICITY AND ITS IMPLICATION FOR CO₂ STORAGE RISK 4 (2013).

¹⁴⁵ For example, if the concentration of carbon dioxide is greater than 7-10 percent in the air, it might be very dangerous and lead to death for humans. It is necessary to conduct a study on the effects from continuous exposure at a low concentration (e.g., 1 to 2 percent) in preparation for gradual leakage.

¹⁴⁶ See Klaus S. Lackner & Sarah Brennan, *Envisioning Carbon Capture and Storage: Expanded Possibilities Due to Air Capture, Leakage Insurance, and C-14 Monitoring*, CLIMATE CHANGE 357, 370-371 (2009); INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 35.

¹⁴⁷ See Joanna Wragg et al., *Potential Impact of CO₂ on Subsurface Microbial Ecosystems and Implications for the Performance of Storage Reservoirs*, ENERGY PROCEDIA 800 (2011).

site exploration and selection.¹⁴⁸ However, there exists a limitation on technical feasibility due to the characteristic of long-term sequestration beyond 100 years or 500 years. This barrier of scientific uncertainty could be overcome with continued risk assessments and monitoring systems.¹⁴⁹ In this context, the improvement of monitoring techniques is significant for CCS implementation, which will also lead to the enhancement of public acceptance.¹⁵⁰ As monitoring techniques are secured, it is also necessary to place monitoring obligations on CCS operators as well as to enforce these obligations.

As seen from the technical and scientific perspectives, CCS is a new technology that has a complex and highly integrated process, and requires numerous interdependent relevant techniques for implementation and commercialization. Therefore, scientific research in each phase and type of CCS technology is continuously needed, yielding scientific evidence with regard to geological potential and technical feasibility. This improvement will be helpful in finding efficient and safe legal standards for CCS technology. Moreover, this kind of criteria in the field of science has a strong need for unification. For this reason, a rationale could develop to create international criteria or guidelines regarding scientific standards for CCS.

¹⁴⁸ See JungSuk Lee et al., *An Ecological effects and guideline of CO2 exposure on environmental assessment for large-scale marind CCS*, KOREAN INSTITUTE OF OCEAN ENVIRONMENT & ENERGY (2014).

¹⁴⁹ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 35.

¹⁵⁰ As for the technical feasibility of monitoring, it is estimated that observation for offshore sequestration is easier than for onshore.

C. The legal and regulatory structure for CCS

i. Importance of the legal and regulatory system

As shown in Sections II and III, CCS technology is an appealing bridge technology for effectively reducing greenhouse gases, but at the same time there is economic, technical, and scientific uncertainty. To overcome the uncertainty, developed countries have focused on the technical improvement or economic investment aspects in order to vitalize the CCS industry. On the other hand, it is true that the current legal and regulatory framework is insufficient for adopting and regulating CCS technology.¹⁵¹ Therefore, it is time to create a legal and regulatory framework that reflects important economic and technical elements, which are in need of legislation, and incorporates new legal issues that CCS technology might entail.¹⁵² The establishment of a legal and regulatory infrastructure will be an important and imperative task to connect all the relevant elements, to facilitate CCS technology, and to ensure the safety of CCS technology.

Some countries have already initiated legislative efforts to modify existing laws relevant to CCS or have enacted a law that deals exclusively with CCS technology. For example, the European Union enacted Directive 2009/31/EC in 2009, which is called the CCS Directive.¹⁵³ As a representative incorporation of the CCS Directive, Germany

¹⁵¹ See MINISTRY OF KNOWLEDGE ECONOMY [MKE], STUDY ON LEGISLATIONS AND TECHNOLOGICAL STANDARDS OF CCS FOR ITS IMPLEMENTATION IN KOREA 12 (2011).

¹⁵² See INT'L RISK GOVERNANCE COUNCIL [IRGC], *supra* note 76, at 19.

¹⁵³ The CCS Directive provides a solid legal basis for companies as well as for the government in implementing CCS. For more information on the implementation of the CCS Directive, see *Climate Action*,

enacted a law that deals with the sequestration phase in 2012.¹⁵⁴ However, even in developed countries the improvements to existing legislation are insufficient, and new legislation also has shortcomings by not sufficiently covering all CCS-relevant issues.¹⁵⁵ For example, despite its importance, there is a lack of a thorough legal and regulatory framework in preparation for the long-term storage of carbon dioxide or the liability issues that might be caused from the long-term storage.¹⁵⁶ Additionally, the ownership of pore space is another important and unresolved property law issue, which could be raised by CCS implementation.¹⁵⁷ Similarly to the situation at a domestic level, there is a need for a legal and regulatory system for CCS from an international view. Current international environmental laws are not enough to cope with the new technology of CCS and there are many unresolved global issues regarding CCS implementation.¹⁵⁸

Therefore, there is an urgent need for a legal and regulatory system to overcome the insufficiency and gaps of current laws both domestically and internationally. The CCS legal system is necessary not only for CCS regulation but also for CCS facilitation.

EUROPEAN COMMISSION, http://ec.europa.eu/clima/policies/lowcarbon/ccs/implementation/index_en.htm.

¹⁵⁴ In Germany, two laws of CCS Act and CO₂ Storage Act became effective on 24 August 2012. *See German CCS legislation*, SOLUTIONS TO CLIMATE CHANGE, <http://decarboni.se/publications/dedicated-ccs-legislation-current-and-proposed/german-ccs-legislation>.

¹⁵⁵ *See generally*, GOVERNMENT ACCOUNTABILITY OFFICE [GAO], *supra* note 118.

¹⁵⁶ It is important to clearly stipulate who will assume the liability and how long the assumption of liability will last. It will be helpful for the operators' decision-making and improvement of public acceptance for CCS.

¹⁵⁷ *See* MINISTERIAL COUNCIL ON MINERAL AND PETROLEUM RESOURCES [MCMPR], CARBON DIOXIDE CAPTURE AND GEOLOGICAL STORAGE, AUSTRALIAN REGULATORY GUIDING PRINCIPLES 26 (2005).

¹⁵⁸ International environmental laws which could be relevant to CCS are weighed towards maritime laws.

Additionally, the legal system for CCS has an important meaning since it requires the formation of a coherent CCS policy, and the CCS policy is fundamentally related to an entire environmental policy that embraces main environmental principles.

ii. Directions and key elements

The CCS legal and regulatory system must be comprehensive over issues like the characteristics of this interconnected CCS technology, and it also needs to effectively and efficiently merge with other existing laws. As shown before, the possible risks of CCS implementation exist in many places throughout surface, subsurface, and the ocean, and affect many areas, such as freshwater, land, air, seawater, and ecosystems. For this reason, the legal and regulatory system for CCS needs to be comprehensive to cover all possible risk areas. A legal system for CCS will necessarily cover areas that are already being regulated under existing environmental laws.¹⁵⁹ Therefore, an initial task will be to review compatibility with existing laws.¹⁶⁰ To evaluate the compatibility (e.g., whether the relevant laws are appropriate for adopting CCS technology or whether there is a need of modifying them to sufficiently address possible risks), the domestic laws of the United States, Australia, China, and South Korea will be reviewed.¹⁶¹ Likewise, at an

¹⁵⁹ See MJ MACE, INTERNATIONAL INSTITUTE FOR ENVIRONMENT AND DEVELOPMENT [IIED], CARBON CAPTURE AND STORAGE: LEGAL ISSUES (2006), <http://pubs.iied.org/pdfs/11066IIED.pdf>.

¹⁶⁰ See generally, RAY PURDY & RICHARD MACRORY, TYNDALL CENTRE FOR CLIMATE CHANGE RESEARCH, GEOLOGICAL CARBON SEQUESTRATION: CRITICAL LEGAL ISSUES (2004).

¹⁶¹ The main purpose of this dissertation is to establish a CCS legal and regulatory system for South Korea. As for a target of legislative analysis, this dissertation focuses on domestic laws of three countries (the United States, Australia, and China), which are expected to offer many implications for South Korea.

international level, it is necessary for CCS technology to be compatible with existing environmental treaties and current international systems.¹⁶²

After reviewing current norms relevant to CCS, more specific and key issues on which the future legal system needs to focus will be addressed more thoroughly. The first key issue would be a permit system, which would set forth CCS operators' obligations and would include a permit for sequestration site exploration. Other key issues will include pore space ownership and risk assessment, which need to be resolved before the start and implementation of carbon dioxide sequestration.¹⁶³ Government will play an important role in addressing these issues.¹⁶⁴ Moreover, long-term sequestration of carbon dioxide is a unique and significant part of CCS implementation, which requires a legal and regulatory system in preparation for it.¹⁶⁵ Specifically, the government is expected to play a key role in the surveillance of monitoring by regulating to prevent leakage

Meanwhile, the European Union's or E.U. member countries' legislations are not the main focus of this dissertation. It is due to the fact that the acceptance of the E.U. CCS Directive in each member country is not obvious and that it is hard to choose some countries among current members. However, the main provisions that could give an insight will be addressed in relevant parts.

¹⁶² See IAN HAVERCROFT & RAY PURDY, CARBON CAPTURE AND STORAGE – A LEGAL PERSPECTIVE, CARBON CAPTURE AND STORAGE AND SUSTAINABLE DEVELOPMENT, UN DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS (2007), https://sustainabledevelopment.un.org/content/documents/1486havercroft_paper_legal.pdf.

¹⁶³ The issue of pore space ownership is a new legal issue that the adoption of CCS technology has brought. In resolving this issue, legislators and administrators will play an important role. It has been demonstrated that the exact definition and allocation of rights and liabilities under property law are very significant in resolving environmental issues in a country.

¹⁶⁴ See MINISTERIAL COUNCIL ON MINERAL AND PETROLEUM RESOURCES [MCMPR], *supra* note 157, at 42.

¹⁶⁵ See WORLD RESOURCES INSTITUTE [WRI], THE FUTURE OF COAL UNDER A CARBON CAP AND TRADE REGIME 7 (Sep. 2007); JUSTINE GARRETT & SEAN MCCOY, *supra* note 95, at 14.

accidents. In addition, the government could play a positive role in liability transfer by assuming liability regarding leakage accidents that happen after a long period of time.¹⁶⁶ The government includes both federal and state governments in a federal state, and the government's role needs to be extended to the provincial government's role in a non-federal state.¹⁶⁷

The main issues that need to be resolved from an international level will be transboundary movement of carbon dioxide and transboundary environmental liability caused by leakage accidents. There is a greater potential for future cooperative CCS projects between countries due to the geological, technical, and economic barriers.¹⁶⁸ Also, current international environmental problems generally occur beyond national boundaries, which is more likely to happen in offshore sequestration.¹⁶⁹ These situations increase the need for international regulation for CCS implementation. Global guidelines to make clear rights, obligations, and liabilities among countries are necessary for the global facilitation of CCS technology. Additionally, a discussion on procedural issues, such as which international organization will regulate and which type of international

¹⁶⁶ See Philip M. Marston & Patricia A. Moore, *From EOR to CCS: The Evolving Legal and Regulatory Framework for Carbon Capture and Storage*, 29 ENERGY L. J. 421, 487 (2008).

¹⁶⁷ See IEA, *supra* note 58, at 7. For example, the role of provincial governments is important in that environmental risk assessments could be regulated at a provincial government level and that stakeholders' opinions could be reflected in the central government's decision-making process through provincial governments.

¹⁶⁸ See Heleen de Coninck, *Global learning on Carbon Capture and storage: A Call for Strong International Cooperation on CCS Demonstration*, 37 ENERGY POLICY 2161 (2009).

¹⁶⁹ See KIHON HONG, A NEW INTERNATIONAL ASSISTANCE REGIME IN CASE OF ACCIDENTS IN HAZARDOUS INDUSTRIAL INSTALLATIONS TO PREVENT EXTRATERRITORIAL MARINE POLLUTION 164 (2012).

norm is appropriate, is needed in order to govern global CCS problems.

iii. The legal and regulatory framework, embracing environmental principles

Some important principles have been established in the field of international environmental laws, and they have been reflected in specific international environmental treaties. Examples of the principles under the Rio Declaration include the *common but differentiated responsibility principle*, *precautionary principle*, and *polluter pays principle*, as well as the concept of sustainable development. Naturally, these principles need to apply to creating a legal and regulatory system for CCS domestically and internationally.¹⁷⁰ In addition, if the CCS legal and regulatory framework were to do more than merely be compatible with these principles and rather contribute to consolidating and strengthening them, it would be a step in the right direction for enhancing the rationale of CCS technology as well.

First, sustainable development is a concept relating to the process of how to achieve and balance both environmental protection and economic development.¹⁷¹ The way in which countries have interpreted sustainable development, especially which of the two goals is emphasized, has been relatively flexible. Developing countries' understanding of sustainable development places priority on economic development,

¹⁷⁰ See FRIEDERIKE MARIE. LEHMANN, OFFSHORE CARBON DIOXIDE CAPTURE AND STORAGE – AN INTERNATIONAL ENVIRONMENTAL LAW PERSPECTIVE 297 (2013).

¹⁷¹ This concept of sustainable development was well established in the Brundtland report of Our Future, which was issued in 1987 by the World Commission on Environment and Development (WCED).

while developed countries focus more on environmental protection. However, as mentioned in Section II, CCS technology is an appealing technology for both developed and developing countries by allowing, for the time being, the use of fossil fuels.¹⁷² Therefore, CCS technology, as a bridge technology, enables both developed and developing countries to realize sustainable development.¹⁷³ Additionally, the CDM is consistent with the sustainable development concept.¹⁷⁴ The CDM is especially helpful for developing countries' sustainable development by contributing to environmental protection and transferring technical knowledge and economic activities to developing countries.¹⁷⁵

Meanwhile, there is a concern that CCS technology is not consistent with next-generation sustainable development.¹⁷⁶ The concern increases due to the characteristic of long-term sequestration that could affect future generations.¹⁷⁷ However, CCS technology is compatible with inter-generation sustainability because CCS technology contributes to

¹⁷² See SUSTAINABLE DEVELOPMENT AND CARBON CAPTURE AND STORAGE, GLOBAL CCS INSTITUTE [GCCSI], https://seors.unfccc.int/seors/attachments/get_attachment?code.

¹⁷³ See EXPERT GROUP MEETING ON CARBON CAPTURE AND STORAGE AND SUSTAINABLE DEVELOPMENT, UNITED NATIONS, <https://sustainabledevelopment.un.org/index.php?page=view&type=13&nr=360&menu=866>.

¹⁷⁴ See Emily Boyd et al., *Reforming the CDM for sustainable development: lessons learned and policy futures*, 12 ENVIRONMENTAL SCIENCE & POLICY 820, 822 (2009).

¹⁷⁵ *Id.*

¹⁷⁶ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 70; Kenshi Itaoka et al., *A study on roles of public survey and focus groups to assess public opinions for CCS implementation*, 4 ENERGY PROCEDIA 6330, 6337 (2011).

¹⁷⁷ See INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE [IPCC], *supra* note 8, at 70.

making future generations enjoy sustainable life by significantly reducing greenhouse gas emissions as this generation's urgent need for overcoming the climate change crisis.¹⁷⁸

The concern of passing on risk to the next generation will have to be mitigated with sound legal and regulatory standards for CCS technology.¹⁷⁹

Second, CCS is a necessary technology in realizing the *common but differentiated responsibility principle*. The *common but differentiated responsibility principle* holds that every country has a common responsibility for protecting the environment but developed countries have a more strengthened and intrinsic responsibility.¹⁸⁰ The provision of differentiated emission reduction responsibility under article 10 of the Kyoto Protocol reflects the concept of the *common but differentiated responsibility principle*.¹⁸¹ For developed countries with reduction obligations, such as Annex I countries, CCS could be

¹⁷⁸ See Paul E. Hardisty et al., *The Environmental and Economic Sustainability of Carbon Capture and Storage*, INT'L J ENVIRT. RES. 1461 (2011).

¹⁷⁹ For the discussion on intergenerational Equity, see EDITH BROWN WEISS, IN FAIRNESS TO FUTURE GENERATION: INTERNATIONAL LAW, COMMON PATRIMONY, AND INTERGENERATIONAL EQUITY 1-2, 45 (Richard Falk ed., 1989) (explaining the concept of intergenerational equity with planetary rights and obligations and stating that "Today we have the power to alter planet Earth irreversibly, on a global scale, in many different ways. While we may develop new technologies to forestall some environmental disasters, it is by no means certain technology will provide a sufficient response. For the first time, we must be concerned as members of the human species with the condition of the natural and cultural heritage that we will pass on to future generations and with our own rights of access to and enjoyment of the legacy we have received from past generations...The dual role of each generation as trustee of the planet for present and future generations and as beneficiary of the planetary legacy imposes certain obligations upon each generation and gives it certain rights.").

¹⁸⁰ Similar to the interpretation regarding sustainable development, developed and developing countries show different attitudes toward the concept, due to the lack of an exact definition on the level of responsibility.

¹⁸¹ See Shufan Sung, *Coal-fired China: Rethink the Precautionary Principle* (2011), http://digitalcommons.law.ggu.edu/cgi/viewcontent.cgi?article=1050&context=fulbright_symposium.

an effective tool to help meet current heavy reduction targets. Additionally, for developing countries with no current obligations, CCS technology gives an opportunity to be able to prepare for future potential obligations. This suggests that the adoption of CCS technology could play a role in implementing the *common but differentiated responsibility principle*.

Third, the *precautionary principle* will be an influential principle in creating a legal and regulatory framework for CCS technology, an emerging technology that has both necessity and uncertainty.¹⁸² The *precautionary principle* is a concept that suggests a desirable direction for policy makers, faced with the problem of how to deal with potential risks that have scientific uncertainty.¹⁸³ The *precautionary principle* supports actions to combat environmental problems against possible risks even when scientific evidence regarding the risks is lacking.¹⁸⁴ There is a strong need for the application of the *precautionary principle* to a CCS legal and regulatory system since CCS technology has not yet been commercialized and there is not enough scientific certainty about the

¹⁸² The precautionary principle is a key concept that needs to be applied in creating climate change policies. Anticipatory regulation systems are necessary to prevent any possible negative effects. See John S. Applegate, *Embracing a Precautionary Approach to Climate Change*, in ECONOMIC THOUGHT AND U.S. CLIMATE CHANGE POLICY 181 (David M. Driesen ed., 2010).

¹⁸³ See John S. Applegate, *The Taming of the Precautionary Principle*, 27 WM. & MARY ENVTL. & POL'Y REV. 13 (2002).

¹⁸⁴ There exists an argument that a shift of the burden of proof comes from the precautionary principle, which is called the strong precautionary principle. See Noah M. Sachs, *Rescuing the Strong Precautionary Principle from Its Critics*, 2011 U. ILL. L. REV. 1285, 1295 (2011). It might be possible to apply this strong precautionary principle to CCS implementation. See *supra* note 46, at 19. However, more court decisions and practices are needed for recognizing the burden of proof shift under the precautionary principle. See CAROLINE E. FOSTER, SCIENCE AND THE PRECAUTIONARY PRINCIPLE IN INTERNATIONAL COURTS AND TRIBUNALS – EXPERT EVIDENCE, BURDEN OF PROOF AND FINALITY 240 (2011).

long-term effects of carbon dioxide sequestration.¹⁸⁵ The application of the *precautionary principle* to CCS technology would make the legal and regulatory system for CCS more persuasive.¹⁸⁶

In addition, it could be argued that the *precautionary principle* is a concept that has a flexible, rather than static, characteristic, which could be applied differently depending on a number of factors, such as economic, technical, and scientific feasibility and improvement.¹⁸⁷ In other words, the precautionary principle does not justify excessive environmental regulatory actions.¹⁸⁸ In the same context, there exists a current opinion that suggests considering the application of the *precautionary principle* as a process for analyzing risk tradeoffs, which demonstrates the need for a flexible approach for this principle.¹⁸⁹ Therefore, the application of the *precautionary principle* to CCS will require a continued and varied risk analysis that includes economic, social, technical, and scientific factors. Also, the risk analysis needs to be comprehensive, including a comparative risk analysis with other technologies as well as the many processes within

¹⁸⁵ See Mark A. Latham, *supra* note 35, at 70-73; Julia M. West et al., *Issue Profile: Environmental Issues and the Geological Storage of CO₂*, 15 EUROPEAN ENVTL. 250 (2005).

¹⁸⁶ Particularly, detailed and strict standards regarding environmental risk assessment will consolidate the application of the precautionary principle to a CCS legal and regulatory system. See Nicola Durrant, *Carbon Capture and Storage Laws in Australia: project facilitation or a precautionary approach?*, 18 ENVTL. LIAB. J. 148 (2010).

¹⁸⁷ See John S. Applegate, *supra* note 183, at 19-21.

¹⁸⁸ As mentioned before, the reasonable CCS legal and regulatory system that this dissertation aims for considers facilitating and regulating CCS together.

¹⁸⁹ The concept of risk-risk tradeoffs emphasizes an analysis that considers various policy consequences, such as countervailing risks and ancillary benefits. See Jonathan B. Wiener, *The Real Pattern of Precaution*, in THE REALITY OF PRECAUTION (Jonathan B. Wiener eds., 2011).

CCS technology. By doing this, a CCS legal and regulatory system will be gradually able to fully integrate the *precautionary principle*.

Finally, the *polluter pays principle* needs to be newly reviewed in the context of its application and interpretation to CCS technology.¹⁹⁰ The polluter pays principle is a central concept related to environmental liability and will be an important issue with regard to the liability transfer to the government from CCS operators.¹⁹¹ Currently, liability transfer to the government does not yet hold a strong legal basis. However, a logical foundation has been laid out. Specifically, considering the technical uniqueness of long-term sequestration and actual necessity for facilitating the technology, the transfer of liability to the government after a period of time is necessary. Therefore, the flexible interpretation regarding the *polluter pays principle* needs to be demonstrated in its application to the CCS legal and regulatory system.

iv. Summary

CCS technology is a technology that has the benefit of mitigating climate change, but at the same time has the disadvantage or potential risk of environmental pollution if leakage accidents occur. Additionally, there exist limitations on other factors associated

¹⁹⁰ See Sven Bode & Lars Dietrich, *Regulating Carbon Capture and Storage in the European Union: An Economic and Legal Analysis*, 2008 CARBON & CLIMATE L. REV. 197, 198 (2008).

¹⁹¹ See Paul Bailey, Elizabeth McCullough & Sonya Suter, *Can Governments Ensure Adherence to the Polluter Pays Principle in the Long-term CCS Liability Context?*, 12 SUSTAINABLE DEV. L. & POL'Y 46, 48 (2012).

with CCS that need to be improved continuously, such as economic, social, technical and scientific factors. Specifically, these factors need to be resolved and discussed early on before commercialization, as they can have a significant impact on successful CCS implementation, and CCS legislation will be designed based on these various factors through a manifold approach. Moreover, the risks that CCS technology can bring are not limited to simple areas, and there are various potential risks regarding CCS. In addition, since CCS is intended for permanent sequestration, these uncertainties may increase and the area of liability also may be increasingly unclear. Therefore, in light of these circumstances, the analysis of these risks and a serious comparison among the risks is more important in setting up the legal and regulatory system of CCS. Additionally, it needs to be noted that the principles of existing environmental laws should be kept in mind and appropriately interpreted and applied to CCS implementation in a legal and regulatory way.

IV. Current domestic and international legal framework regarding CCS

A. Domestic level analysis for CCS

i. The United States

1. Current status of CCS technology and projects in the US

As a leading country, the United States has developed CCS technology and invested in CCS projects. It is analyzed that the United States has geologically sufficient sequestration sites onshore, and current CCS projects in progress are proposed to be

commercialized around 2020. The U.S. projects have drawn attention to the CCS technology. The reason why CCS technology is recognized as an important technology comes from a couple of factors. There is a domestic demand to reduce carbon dioxide emissions in the United States because the United States is the largest carbon dioxide emitter while it still relies on fossil-fuel energy sources. There is also an international expectation for the United States to take a role in overcoming the climate change crisis.

The two main government agencies that are involved in CCS development and regulation are the Department of Energy (DOE) and Environment Protection Agency (EPA). DOE is in charge of technological development regarding CCS, and the National Energy Technology Laboratory (NETL) under the DOE runs various programs, such as the Carbon Sequestration Program.¹⁹² EPA plays a key role in establishing the regulatory regime to protect human health and the environment from possible risks of CCS. The representative outcome regarding CCS regulation by the EPA is the UIC Class VI rule.¹⁹³ Aside from these two main agencies, the Department of Transportation (DOT) and Pipeline and Hazardous Materials Safety Administration (PHMSA) play a role in creating

¹⁹² The DOE/NETL runs ten programs regarding coal research, which includes the carbon sequestration program. For the efficient operation of programs, DOE has seven regional carbon sequestration partnerships: Big Sky Regional Carbon Sequestration Partnership (BSCSP), Midwest Geological Sequestration Consortium (MGSC), Midwest Regional Carbon Sequestration Partnership (MRCSP), Plains CO₂ Reduction Partnership (PCOR), Southeast Regional Carbon Sequestration Partnership (SECARB), Southwest Regional Partnership on Carbon Sequestration (SWP), and West Coast Regional Carbon Sequestration Partnership (WESTCARB), *available at* <http://energy.gov/fe/science-innovation/carbon-capture-and-storage-research/regional-partnerships>. Additionally, DOE utilizes scientific analysis in order to find economically efficient and safe sequestration sites, such as the National Carbon Sequestration Database and Geographic Information System (NATCARB), *available at* <http://www.netl.doe.gov/research/coal/carbon-storage/natcarb-atlas>

¹⁹³ See ENVIRONMENTAL RESOURCES MANAGEMENT [ERM], REGULATORY CHALLENGES AND KEY LESSONS LEARNED FROM REAL WORLD DEVELOPMENT OF CCS PROJECTS 23 (2012).

regulations with regard to the CCS pipeline system.¹⁹⁴ The United States shows a strong point in the cooperation among government agencies in addressing CCS technology adoption. For example, the DOE/NETL and EPA (both at the federal and state level) are cooperating closely in developing and regulating CCS. Furthermore, the United States organized a task force that encompasses many agencies relevant to CCS.¹⁹⁵ This means that the U.S. government has established the CCS regulatory system well, particularly considering that one of the system's characteristics is that it is related to many areas.

The United States has a wide experience in Enhanced Oil Recovery (EOR) and is running many projects connecting CCS technology with EOR technology.¹⁹⁶ Currently, besides the projects that are trying to link CCS with EOR, a large number of CCS projects have been conducted in the United States.¹⁹⁷ To name a few representative CCS projects, there are the Hydrogen Energy California, Texas Clean Energy, Indiana Gasification, and FutureGen projects.¹⁹⁸ Additionally, the United States is collaborating

¹⁹⁴ See WRITTEN STATEMENT OF PHMSA DEPUTY ADMINISTRATOR KRISTA L. EDWARDS BEFORE THE SENATE COMMITTEE ON ENERGY AND NATURAL RESOURCES (January 31, 2008).

¹⁹⁵ The Interagency Task Force on Carbon Capture and Storage was established in 2010. See "Interagency Task Force on Carbon Capture and Storage," OFFICE OF FOSSIL ENERGY, *available at* <http://energy.gov/fe/services/advisory-committees/interagency-task-force-carbon-capture-and-storage>

¹⁹⁶ See ENVIRONMENTAL RESOURCES MANAGEMENT [ERM], *supra* note 193, at 37.

¹⁹⁷ See "Large Scale CCS Projects." GLOBAL CCS INSTITUTE, *available at* <http://www.globalccsinstitute.com/projects/large-scale-ccs-projects>

¹⁹⁸ See ENVIRONMENTAL NON-GOVERNMENT ORGANISATION [ENGO], PERSPECTIVES ON CARBON CAPTURE AND STORAGE (CCS) 24 (2012). The FutureGen is a CCS project for permanent sequestration of carbon dioxide captured in the capturing facilities using the oxy-fuel combustion technology. The FutureGen project aims to sequester more than 100 tons of carbon dioxide captured and transported in Mededosa in southern Illinois. This project ceased due to a funding problem, but resumed with FutureGen 2.0.

with other countries, such as Canada, and also striving for international cooperation (e.g., the creation of the Carbon Sequestration Leadership Forum (CSLF)).

2. CCS relevant legislation and regulations on the federal and state level

The U.S. Congress and government have established legislation and regulation on both federal and state levels before the deployment and commercialization of CCS. To begin with, it is necessary to review overall federal environmental regulations, which could be related or give implications to CCS legal and regulatory systems, as well as direct regulations for CCS.

First, the representative regulation on the federal level is the EPA's Underground Injection Control (UIC) Class VI rule.¹⁹⁹ The UIC Class VI rule was created by adding a new rule to the existing UIC program under the law of the *Safe Drinking Water Act* (SDWA).²⁰⁰ Therefore, the main purpose of the Class VI rule is to provide minimum federal requirements that protect Underground Sources of Drinking Water (USDW) from the injection of carbon dioxide for geological sequestration.²⁰¹ The Class VI rule

¹⁹⁹ See 40 C.F.R. Parts §124, 144, 145, et al. Federal Requirements Under the Underground Injection Control (UIC) Program for Carbon Dioxide Geologic Sequestration (GS) Wells; Final Rule. This rule was proposed by the EPA in 2008 and adopted in 2010.

²⁰⁰ The existing UIC program was composed of five Class rules from Class I to V, which provide the standards required for underground storage of hazardous materials. Through the analysis of the existing Class rules, a new separate classification for CCS has been demanded. See LABORATORY FOR ENERGY AND THE ENVIRONMENT, THE UNDERGROUND INJECTION CONTROL OF CARBON DIOXIDE, A SPECIAL REPORT TO THE MIT CARBON SEQUESTRATION INITIATIVE 22 (2005). Therefore, the Class VI rule includes more stringent provisions in order to clearly address the unique characteristics and potential risks of CCS. See ENVIRONMENTAL RESOURCES MANAGEMENT [ERM], *supra* note 193, at 23.

²⁰¹ See Arnold W. Reitze Jr., *Electric Power in a Carbon Constrained World*, WM. & MARY ENVTL. L. &

embraces general contents regarding the comprehensive regulation of CCS, ranging from site selection standards and establishment and operation of injection wells to closure injection standards and monitoring requirements. Below are some important details associated with the UIC Class VI rule.

In the process of storage site selection, well owners or operators are required to provide geological and geochemical information on proposed sites and also required to identify all wells in the Areas of Review (AoR).²⁰² Additionally, the Class VI rule requires the well owners or operators to submit a series of comprehensive site-specific plans to ensure that injection zones and site-specific circumstances of the underground are appropriate and safe, or in other words, not posing a threat to the USDW.²⁰³ As for the injection well construction and well operations, the UIC Class VI rule states that the well must be cemented to prevent movement of carbon dioxide toward the USDW and to withstand the injected carbon dioxide at proper conditions. For this, the well must be constructed and cemented with appropriate instruments and materials. For example, when constructing wells, wells are required to meet the American Petroleum Institute (API) or American Society for Testing and Materials (ASTM) International standards.²⁰⁴

POL'Y REV. 821, 862 (2010).

²⁰² See 40 C.F.R. §146.84 (a) (“The area of review is the region surrounding the geologic sequestration project where USDWs may be endangered by the injection activity. The area of review is delineated using computational modeling that accounts for the physical and chemical properties of all phases of the injected carbon dioxide stream and is based on available site characterization, monitoring, and operational data.”)

²⁰³ For the details regarding site characterization that gives technical guidance to owners, operators, and authorities, see EPA, UNDERGROUND INJECTION CONTROL (UIC) PROGRAM CLASS VI WELL SITE CHARACTERIZATION GUIDANCE (2013).

²⁰⁴ See 40 C.F.R. §146.86 (b) (providing that “Casing and cement or other materials used in the

Additionally, for the regulation during injection operation, it provides prior tests, injection methods, and injection pressure limits. For example, the injection pressure should not exceed 90 percent of the fracture pressure in the injection area so as not to generate new cracks or accelerate existing cracks. Another requirement is that injection between the outermost casing protecting USDWs and the well bore is prohibited.²⁰⁵ The well owners and operators have an obligation of monitoring the injected fluids to ensure that ground water is protected from injected fluids of carbon dioxide.²⁰⁶ The outcomes attained from the data (e.g., injection fluids characteristics, injection pressure, injection flow rate, injection volume, annular pressure, and ground water monitoring) should be reported twice per year.²⁰⁷

Even after injection well operation, a series of processes is required to make sure no harm is inflicted on USDW. In the last phase of the closing of the injection well, there is an important obligation of Post-Injection Site Care monitoring (PISC), which lasts for

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.”) *See also* 40 C.F.R. §146.86 (c) (providing that “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.”).

²⁰⁵ 40 C.F.R. §146.88 (a) and (b).

²⁰⁶ The methods of monitoring include both direct and indirect monitoring methods. These monitoring obligations need to be conducted continuously through the whole processes of before and after the injection as well as during the injection period. *See* 40 C.F.R. §146.90

²⁰⁷ 40 C.F.R. §146.91 (a).

fifty years.²⁰⁸ Finally, through the whole process of well construction, operation, and post-operation, the UIC Class VI rule provides the emergency and remedial response plan in preparation for any endangerments to USDW.²⁰⁹ Furthermore, the EPA recommends that information be provided to the community early on with respect to the UIC Class VI, and provides considerations regarding public participation for UIC program directors.²¹⁰

Second, the EPA established the Vulnerability Evaluation Framework (VEF) in 2008 regarding CCS regulation on the federal level.²¹¹ The VEF was designed to systematically organize the conditions under which negative impacts could increase or decrease. Even though the VEF is not a quantitative risk assessment tool, the VEF can function as a tool for evaluating susceptibilities to adverse impacts associated with geological sequestration.²¹² In other words, the VEF would assist regulators and other technical experts in identifying key areas for in-depth, site-specific risk assessment, monitoring, and management.²¹³ Additionally, when it comes to environmental risk

²⁰⁸ 40 C.F.R. §146.93.

²⁰⁹ 40 C.F.R. §146.94.

²¹⁰ See EPA, GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE – UIC QUICK REFERENCE GUIDE : ADDITIONAL CONSIDERATIONS FOR UIC PROGRAM DIRECTORS ON THE PUBLIC PARTICIPATION REQUIREMENTS FOR CLASS VI INJECTION WELLS, *available at* <https://www.epa.gov/uic/quick-reference-guides-class-vi-program-implementation>

²¹¹ See EPA, Climate Change, Vulnerability Evaluation Framework, *available at* <https://www.epa.gov/climatechange/vulnerability-evaluation-framework>

²¹² See EPA, TECHNICAL SUPPORT DOCUMENT, VULNERABILITY EVALUATION FRAMEWORK FOR GEOLOGIC SEQUESTRATION OF CARBON DIOXIDE, 2, 27-42 (2008) (addressing various potential impacts, such as human health and welfare, atmospheric, ecosystems, groundwater and surface water, and geosphere impacts).

²¹³ However, it is not expanded to include the vulnerabilities regarding capture and transport of carbon

assessment relevant to CCS implementation, the *National Environment Policy Act* (NEPA) will be applied as a federal law. DOE will play an important role regarding the enforcement of NEPA.²¹⁴ On the other hand, the legal and regulatory regime regarding a transportation of carbon dioxide needs to be more developed, compared to the sequestration phase. There still exists a question on which department will be in charge of the transportation of carbon dioxide. It is analyzed that a new regime, which is different from current natural gas pipeline regulations, will be needed.²¹⁵ The Hazardous Liquid Pipeline Act (HLPa) regulates current interstate carbon dioxide pipeline; however, no new and specific pipeline law in preparation for CCS implementation has yet been enacted on the federal level.

Meanwhile, on September 20, 2013, the EPA proposed a revised NSPS (which has been proposed in an earlier form in 2012) under the CAA in order to regulate carbon dioxide emissions from Electric Generation Units (EGUs). The NSPS requires coal-fired power plants to achieve an emission limit of 1,100 lb CO₂/Mwh on a 12-month rolling average compliance period, which consequently makes the coal-fired power plants use the CCS technology.²¹⁶ Although the EPA regulations do not mandate the introduction of

dioxide.

²¹⁴ A recent Environmental Impact Statement (EIS) of the FutureGen 2.0. project by DOE is a good example of how environmental impact assessments in the United States are comprehensive and thorough. Environmental risk assessments play a key role within the CCS legal and regulatory system, which will be addressed more deeply in Section V.

²¹⁵ See SEAN MCCOY, CARBON CAPTURE AND SEQUESTRATION: FRAMING THE ISSUES FOR REGULATION, AN INTERIM REPORT FROM THE CCSREG PROJECT 36 (2008)

²¹⁶ See EPA releases Revised Proposal for Electric Generating Unit New Source Performance Standards for Carbon Dioxide Emissions, SIDLEY (Sep. 20, 2013), available at <http://www.sidley.com/news/epa->

CCS technology to comply with this standard, the EPA finds that CCS technology is the best system of emissions reduction (BSER) in the case of new coal-fired power plants.²¹⁷

Third, it is necessary to review some other existing federal laws, such as the *Resource Conservation and Recovery Act (RCRA)* and *Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)*, due to the potential relevance and implications to the CCS legal and regulatory system.²¹⁸ As mentioned before, the legal liability issue on the carbon dioxide leakage accidents that could happen after the long-term sequestration is a unique problem that must be resolved. In this regard, there is a discussion on how RCRA and CERCLA will be addressed in creating a CCS liability system in case of CCS failure and leakage accidents.²¹⁹ Recently, with regard to the direct application of RCRA to the CCS liability regime, the EPA decided that carbon dioxide waste streams would be exempted from RCRA's hazardous waste requirements in order to encourage the CCS industry.²²⁰ However, the legal and regulatory system

releases-revised-proposal-for-electric-generating-unit-new-source-performance-standards-for-carbon-dioxide-emissions-09-20-2013.

²¹⁷ See EPA, FACT SHEET: CARBON POLLUTION STANDARDS –FINAL LIMITS ON CARBON POLLUTION FROM NEW, MODIFIED AND RECONSTRUCTED POWER PLANTS, 2-3 (2015), *available at* <https://www.epa.gov/cleanpowerplan/carbon-pollution-standards-final-rule-august-2015>

²¹⁸ RCRA establishes federal regulations in which Subtitle C regulates hazardous wastes from generation to final disposal, which is referred to as a cradle to grave program. CERCLA provides responsibilities for clean-up activities and a unique liability system called Superfund. For the history and detailed contexts of RCRA and CERCLA, *see* JOHN S. APPLIGATE ET AL., *THE REGULATION OF TOXIC SUBSTANCES AND HAZARDOUS WASTES* (2nd ed. 2011).

²¹⁹ See SEAN MCCOY, *supra* note 215, at 106.

²²⁰ There has been a discussion on whether or not the RCRA and CERCLA are applied to CCS. However, prevailing views object to the application of RCRA and CERCLA to the CCS legal and regulatory system for several reasons. One reason is the different characteristics between hazardous wastes or hazardous

regarding CCS liabilities needs to be considered more thoroughly about whether the existing environmental laws could accommodate CCS technology or whether there are any gaps for CCS deployment. Therefore, the main concepts of RCRA and CERCLA could have implications for the CCS liability regime, even though these laws would not be applied directly to the CCS legal and regulatory system.²²¹ For example, joint responsibility under RCRA would be recommendable for a strong liability mechanism for CCS. Specifically, financial mechanisms, such as insurance and trust funds under RCRA and CERCLA, could have a positive effect on the CCS liability system.²²² In other words, the strictness of liability, compensation, and financial security, could highly affect the CCS legal and regulatory system.²²³

On the other hand, as mentioned before, the CCS regime needs to consider both purposes of CCS regulation and CCS facilitation. In this context, the *Surface Mining Control and Reclamation Act* (SMCRA) of 1997 and *Price-Anderson Act* of 1957 could also give insights for CCS legal and regulatory system.²²⁴ These laws are insightful to

substances under RCRA and CERCLA and carbon dioxide under the CCS process. Another reason is that the application of RCRA and CERCLA might shrink the CCS industry by laying a burden on the business or operator relevant to CCS deployment.

²²¹ See AMERICAN PUBLIC POWER ASSOCIATION [APPA], CARBON CAPTURE AND SEQUESTRATION LEGAL AND ENVIRONMENTAL CHALLENGES AHEAD 4 (2007).

²²² See Kelly Greenman, *A Regulatory Framework for Carbon Sequestration: Liability and Financial Mechanisms*, 5 Washington University Undergraduate Research Digest 16 (2009).

²²³ These aspects have positive implications for CCS operators by motivating them to give attention to their activities and to minimize possible risks.

²²⁴ See DOE/NETL, INTERNATIONAL CARBON CAPTURE AND STORAGE PROJECTS OVERCOMING LEGAL BARRIERS 15 (2006).

evaluate because they have established liability regimes, which also consider developing the coal mining and nuclear industries respectively.²²⁵ For example, the Price-Anderson Act has a provision of limiting the liability of private parties in order to encourage the nuclear industry.²²⁶ Additionally, the SMCRA has a specific regulatory framework for bonding reclamation performance in case of mine bankruptcies.²²⁷

Fourth, on the state level, some states in the United States attempted to deal with CCS relevant specific issues. As demonstration-level CCS projects are in progress and enforced, about nine states in the US initiated CCS-relevant legislation. In addition to the UIC Class VI rule, some states have developed a CCS regulatory regime of their own, dealing with overall or partial issues relevant to CCS.²²⁸ For instance, states such as Illinois, Kansas, and Louisiana, have incorporated many legal issues into state legislation. These states' pieces of legislation include a lot of issues, such as permit system, monitoring, liability, and financial issues, even though these states cannot answer all the

²²⁵ It is estimated that the chances of leakage accidents are very low, compared to nuclear accidents. However, establishing a moderate criteria referring to these laws may be helpful for the facilitation of CCS.

²²⁶ See Kelly Greenman, *supra* note 222, at 16.

²²⁷ See *SMCRA: It's Back in the News and That's Not Good News For Coal*, CROWELL MORING, 2014, <http://www.crowell.com/NewsEvents/All/SMCRA-Its-Back-in-the-News-and-Thats-Not-Good-News-For-Coal>.

²²⁸ The SDWA and UIC Class VI rule are federal law and regulation. However, the SDWA allows each state to choose this UIC program, which is called primacy. Currently, thirty-three states have adopted UIC program primacy. See Thomas A. Campbell et al., *Carbon Capture and Storage Project Development*, PILLSBURY (2011), http://www.pillsburylaw.com/siteFiles/Publications/Carbon_Capture_Texas_andStorageProjectDevelopment.pdf. It is also expected for many states to adopt primacy in the case of Class VI rule for CCS. See ENVIRONMENTAL RESOURCES MANAGEMENT [ERM], *supra* note 193, at 28.

legal issues relevant to CCS.²²⁹ On the other hand, other states have established more direct provisions regarding unresolved issues (e.g., pore space ownership, eminent domain for carbon dioxide pipeline, long-term liability, etc.)²³⁰ For example, Wyoming, North Dakota, and Montana have provisions regarding the property rights issue. However, these provisions show different attitudes in approaching this legal issue of pore space ownership.²³¹ Additionally, when it comes to addressing the legal issue of liability transfer to the government, around six states have provisions about it.²³² Similarly to the pore space ownership issue, the specific contents of these provisions regarding the liability transfer vary in each state.²³³

²²⁹ See JOHN REED, CALIFORNIA CARBON CAPTURE AND STORAGE REVIEW PANEL, CCS REGULATORY AND STATUTORY APPROACHES IN OTHER STATES (2010).

²³⁰ See HOLLY JAVEDAN, MASSACHUSETTS INSTITUTE OF TECHNOLOGY [MIT], REGULATION FOR UNDERGROUND STORAGE OF CO₂ PASSED BY U.S. STATES (2013), http://sequestration.mit.edu/pdf/US_State_Regulations_Underground_CO2_Storage.pdf.

²³¹ For example, it is noteworthy that these three states have explicit provisions of the surface owner's ownership for the subsurface pore space. However, on the issue of allowance for severance, these three states (Wyoming, North Dakota, and Montana) have different attitudes. The issue of pore space ownership has not been addressed sufficiently in many states as well as in a federal aspect either. The approach for this issue could vary in each state. Additionally, different attitudes and many different possible scenarios may bring up other legal issues, such as eminent domain, and influence CCS projects' procedure. See McCoy, *supra* note 17, at 56; American Public Power Association [APPA], *supra* note 221, at 3. For these reasons, the legal issue of pore space ownership will be delved into in Section V.

²³² See Montana (SB 498, 2009), Texas (HB 1796, 2009), North Dakota (SB 2095, 2009), Illinois (HB 661, 2009 and HB 1220, 2008), and Kansas (HB 2418, 2010).

²³³ A state law of Kansas provides that the liability transfer is not allowed. On the other hand, North Dakota and Montana have a provision that allows the liability transfer to the state governments. However, the requirement period for the transfer is different in these two states: North Dakota provides ten years and Montana requires thirty years for the liability transfer from CCS operators to the state government. See HOLLY JAVEDAN, *supra* note 230, at 5. There is an analysis showing that this difference is due to the deficiency of data on the effects of long-term storage and potential risks from it. See WENDY B. JACOBS, EMMETT ENVIRONMENTAL LAW & POLICY CLINIC HARVARD LAW SCHOOL, PROPOSED LIABILITY

ii. Australia

1. Current status of CCS technology and projects in Australia

Australia is the most remarkable country in technical research, legislation and international cooperation of CCS. As the level of dependency on coal and brown coal for its total power production reaches up to 83 percent, Australia is very interested in continuing coal development and reducing emissions of carbon dioxide through CCS. The Australian government and its coal companies are also well aware of the importance of CCS and have been actively participating in CCS projects, since Australia seeks to maintain its coal exports while reducing the emissions of carbon dioxide.²³⁴ In addition, analysis shows that Australia can consider both offshore and onshore storage due to geographical characteristics and secure enough storage capacity.²³⁵

The distinctive feature of Australia's CCS plan is that the government takes a leading role. The most representative case would be that the Department of Resources, Energy and Tourism (DRET) and Department of Innovation, Industry, Science and Research (DIISR) concentrate on legislation development and technical research for CCS.

FRAMEWORK FOR GEOLOGICAL SEQUESTRATION OF CARBON DIOXIDE 12 (2010). The issue of liability transfer needs to be further researched from the theoretical basis to specific contents, which will be addressed in Section V as well.

²³⁴ Even in Australia, there have been pros and cons on the issue of CCS adoption. There exists an opinion saying that CCS is inconsistent with the goal of conversion to renewable energy in Australia. However, recognizing that there is a limit in massive power production with renewable energy in Australia in reality, the Australian government focuses on R&D of technology and legislation for CCS.

²³⁵ The reason for selecting Australia as a target of comparative legislation is that Australia is not only the most leading nation in CCS, but also has various implications for CCS research development. South Korea also considers both onshore and offshore sequestration like Australia, and it is expected that South Korea will cooperate with Australia in CCS implementation.

The DRET operates the Carbon Capture and Storage Flagship Program for CCS commercialization to the world, and the DIISR leads the National Low Emissions Coal Initiative program for the purpose of CCS technology and distribution under cooperation with the Australian government. In addition, the Global CCS Institute (GCCSI) and Cooperative Research Centre for Greenhouse Gas Technology (CO2CRC), which have been established under the active support of the federal government, play significant roles in international cooperation for CCS.²³⁶

In Australia, CCS projects, accounting for more than fifteen projects at both the commercial and demonstration scale, have been carried out over all the states.²³⁷ As representative cases, there are the Otway project and CarbonNet project carried out by CO2CRC in Victoria state and ZeroGen and Collide projects in Queensland state. Similarly, the South West Hub and Gorgon projects have been carried out in West Australia state.²³⁸ As shown from many government activities and projects enforcement, in Australia, both the government and companies have taken the initiative in participating in the technical development of CCS, distribution of projects, and establishment of international networks.

2. CCS-relevant legislation and regulations on the federal and state level

²³⁶ The CO2CRC was established in 2003 and focuses on CCS R&D as a non-profit research institute. The GCCSI was established in 2009, and many countries and governmental institutions have participated in the GCCSI, including South Korea.

²³⁷ See Allen Lowe et al., *Carbon Capture Storage (CCS) in Australia*. in CARBON CAPTURE – SEQUESTRATION AND STORAGE 80 (R.E. Hester eds., 2010).

²³⁸ Specifically, the Gorgon project is known for addressing the management of long-term storage of carbon dioxide. See DOE/NETL, *supra* note 224, at 24.

Australia established regulatory principles for CCS legal and regulatory system to put in mind before enacting CCS-relevant legislation, and is the leading country to early implement direct legislation of CCS. In addition, the country has achieved legislation related to CCS at the state level as well as the federal level. Australia has enacted laws and detailed rules for adopting CCS technology in preparation for both onshore and offshore sequestration of carbon dioxide. Thus, the following parts will look into how the legislation regarding CCS has been arranged at both federal and state levels and how major issues have been addressed by those pieces of legislation.

The federal government of Australia revised existing petroleum legislation and prepared legislation regulating CCS activities, which is the *Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Cth)* (OPGGGS Act).²³⁹ This law prescribes a series of procedures for approval of offshore sequestration. Operators must file an application for a GHG assessment permit, obtain a declaration of affirmed GHG storage formation, and file an application for an injection license. In addition, required procedures for closure are also prescribed. For example, operators must acquire site closure certificates and a minimum fifteen years' monitoring period is required. After the monitoring period, the Minister can declare that the closure assurance period has been reached. Moreover, provisions on the federal level regarding transfer of liability are clearly prescribed, so that the federal commonwealth is required to indemnify regarding certain liabilities.²⁴⁰

²³⁹ In Australia, the federal government has authority from the high-water mark to the edge of the continental shelf, while state governments have authority over the ocean floor and water column between the high-water mark and three nautical miles out.

²⁴⁰ Under the CCC Directive of the European Union, operators are responsible for twenty years after

Furthermore, in terms of federal offshore geological storage, not only the OPGGS Act itself but also regulations under the OPGGS Act have been established.²⁴¹ On the other hands, prior to the OPGGS Act, guiding principles for making national-level, consistent CCS frameworks have been adopted by the Ministerial Council on Mineral and Petroleum Resources (MCMPR).²⁴² The guiding principles have suggested main principles in six areas of evaluation and approval procedure: ownership, transportation, monitoring and verification, legal responsibility, and finance. Meanwhile, as a state-level legislation regulating offshore storage, there is the *Offshore Petroleum and Greenhouse gas Storage Act 2010* (Victoria Offshore Act) of Victoria State. However, different from the OPGGS Act, this law does not have a provision prescribing long-term storage.

In Australia, while offshore geological storage is regulated by the federal government, onshore geographic storage is regulated by the state government. At first, Victoria State prepared the *Greenhouse Gas Geological Sequestration Act* (GGGS Act),

closure, while all legal responsibilities are transferred to the nation when certain requirements are satisfied. In the case of Australia, considering that it would take several years up to a declaration of the Minister, the latter period will be about twenty years.

²⁴¹ For example, there is the Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulations of 2009. According to this regulation, any case would be an illegal act if there is no effective environmental plan. Therefore, the Environmental Impact Assessment (EIA) has to be carried out without fail. Besides, several regulations have been arranged: Offshore Petroleum and Greenhouse Gas Storage (Safety) Regulations 2009; Offshore Petroleum and Greenhouse Gas Storage (Injection and Storage) Regulations 2010; and the Offshore Petroleum and Greenhouse Gas Storage (Resource Management and Administration) Regulations 2011.

These many regulations contain the provisions for clearly describing the OPGGS Act. See BAKER & MCKENZIE, REPORT TO THE GLOBAL CCS INSTITUTE ON LEGAL AND REGULATORY DEVELOPMENTS RELATED TO CARBON CAPTURE AND STORAGE BETWEEN NOVEMBER 2010-JUNE 2011, 26-27 (2011).

²⁴² See Ministerial Council on Mineral and Petroleum Resources [MCMPR], *supra* note 157.

which allows a permit, injection and monitoring license, and formation retention lease.²⁴³

Queensland State legislated the *Greenhouse Gas Storage Act* in 2009. New South Wales State is still legislating CCS legislation and regulations for onshore, and the *Greenhouse Gas Storage Bill* was proposed in 2010. Western Australia State has the *Barrow Island Act* that specializes in the Gorgon project.²⁴⁴

The next parts will examine how key legal and regulatory issues are included and provided in Australian federal and state legislation. First, as for a permitting system, the Minister may approve permissions for storage site exploration, insertion permits, and closure permits under certain conditions. There are limits on exploration permits for certain periods, so that the exploration opportunity can be provided to all persons satisfying requirements and exploring in time under the legislation of the federal government the states of Victoria and Queensland.²⁴⁵ In terms of injection licenses, requirements include providing details of materials to be injected and technical and financial evidence proving that necessary commercial quantity would be addressed. As for closure permission, the federal government requires a comprehensive procedure.²⁴⁶ Second, for the environmental impact evaluation, there is existing federal law in the

²⁴³ Accordingly, Victoria State has both laws for offshore geological storage and onshore geological storage.

²⁴⁴ See ENVIRONMENTAL RESOURCES MANAGEMENT [ERM], *supra* note 193, at 8.

²⁴⁵ See GCCSI, STRATEGIC ANALYSIS OF THE GLOBAL STATUS OF CARBON CAPTURE AND STORAGE REPORT 3: COUNTRY STUDIES AUSTRALIA 37 (2009).

²⁴⁶ Additionally, Victoria State has regulations requiring preparation of an opinion that activity of inserted materials is available to be estimated and the related risk is reasonably low, while Queensland State has regulations requiring prohibition of suspension until the entire capacity of the well is fully filled.

Environment Protection and Biodiversity Conservation Act 1997(Cth)(EPBC Act).²⁴⁷ It is estimated that Australia has improved its environmental risk assessment system by utilizing various tools including both qualitative and quantitative evaluation as a life cycle assessment.²⁴⁸ Additionally, as an important factor in the entire process of CCS, a monitoring system is provided with specific contents (e.g., obligations of monitoring, reporting and verification of operators, and the authorities and responsibilities of monitoring of federal and state governments.)²⁴⁹ Third, in terms of property rights, it is prescribed that the ownership of pore space is granted to the Crown in Victoria State. In other states, such ownerships may be granted to the Crown or the State.²⁵⁰ Fourth, the legal issue regarding long-term liability has not yet been addressed sufficiently on a state level.²⁵¹ Finally, under Australian legislation for transportation, existing pipeline laws are included in or well-combined in laws and regulations which are addressed above, at both

²⁴⁷ This Act requires an environment impact evaluation including all the activities that impact marine habitats and wetlands.

²⁴⁸ See M.C. Gerstenberger et al., *Integrated Risk Assessment for CCS*, ENERGY PROCEDIA (2013); COMMONWEALTH SCIENTIFIC AND RESEARCH ORGANIZATION [CSIRO], ENVIRONMENTAL IMPACT OF AMINE-BASED CO₂ POST-COMBUSTION CAPTURE (PCC) PROCESS (2012).

²⁴⁹ See GCCSI, *supra* note 245, at 53.

²⁵⁰ See LOANNIS CHRYSOSTOMIDIS & EVAN STAMATIOU, CO₂ CAPTURE PROJECT, UPDATE ON SELECTED REGULATORY ISSUES FOR CO₂ CAPTURE AND GEOLOGICAL STORAGE: FOCUSING ON THE EU, US, CANADA AND AUSTRALIA, 59-60, 71-72 (2010).

²⁵¹ As examined above, under the federal law of the OPGGS Act, licensees are responsibilities for a fifteen years' closing period, after which those responsibilities are to be transferred to the federal government. On the other hand, there is no provision on the liability transfer regarding long-term liability in Victoria and Queensland States. Meanwhile, Western Australia State consented to sharing long-term responsibilities in proportion of 80/20 between federal and state governments in the Gorgon project. See Andrew Beatty et al., *The Gorgon Project: Legal and Policy Issues*, <http://blogs.ucl.ac.uk/law-environment/files/2012/12/Think-piece-5-Beatty.pdf>

the federal and state level.²⁵²

iii. China

1. Current status of CCS technology and projects in China

China is the largest emitter of carbon dioxide in the world and more than 80 percent of its power production depends on coal energy.²⁵³ In China, which has a goal of rapid economic growth, the demand of coal will continue to increase for the time being, and it is also expected that the emission of carbon dioxide will continue to increase.²⁵⁴ Accordingly, in order to mitigate climate change, the effort and role of China are important. In addition, CCS technology would be more significant to China by enabling both the competing goals of economic growth and environmental protection.²⁵⁵ There are pros and cons in terms of the adoption of CCS technologies in China.²⁵⁶ However, China recognizes the significance and potentials of CCS and carries out technical development

²⁵² Meanwhile, under both the federal OPGGS Act and GGGGS Act of Victoria State, existing petroleum licensees are granted the right to request the prohibition of approval of any pipeline license, such as the right to objection for protection of their right to petroleum.

²⁵³ See CRAIG HART & HENGWEI LIU, CHINA ENVIRONMENT SERIES, ADVANCING CARBON CAPTURE AND SEQUESTRATION IN CHINA: A GLOBAL LEARNING LABORATORY 102 (2011).

²⁵⁴ See RICHARD K. MORSE ET AL., PROGRAM ON ENERGY AND SUSTAINABLE DEVELOPMENT, THE REAL DRIVERS OF CARBON CAPTURE AND STORAGE IN CHINA AND IMPLICATIONS FOR CLIMATE POLICY 1 (2009)

²⁵⁵ See MCKINSEY & COMPANY, CHINA'S GREEN REVOLUTION –PRIORITIZING TECHNOLOGIES TO ACHIEVE ENERGY AND ENVIRONMENTAL SUSTAINABILITY 104 (2009).

²⁵⁶ There is analysis both that there are enough storage sites geographically and other opposing opinions that suggest there are not enough storage sites, due to complicating geographical features of China, which requires various researches to be made in the future.

and projects.²⁵⁷

The National Development and Reform Commission (NDRC) and its affiliated National Energy Commission (NEC), which addresses general matters of coal, petroleum, and natural gas projects in China, take responsibility for carrying out CCS projects.²⁵⁸ In addition, the Ministry of Science and Technology (MOST) is in charge of carrying out technical development and R&D projects for CCS and concentrating on the development of capturing techniques of carbon dioxide. Currently, with regard to the CCS industry in China, there are two representative programs: the 863 program and 973 program.²⁵⁹ China's 863 program supports the development of techniques for capture, sequestration, and monitoring of carbon dioxide for CCS, while the 973 program researches geologic sequestration for EOR.²⁶⁰ In addition, about thirteen projects, including the Shenhua CTL, Huaneng Beiging, and GreenGen projects, are being carried out currently in China.²⁶¹ Furthermore, the Chinese government appears to be active in cooperating with

²⁵⁷ IEA predicted that China would carry out six hundred projects in around 2050.

²⁵⁸ See CHRISTOPHER BURKE, CENTRE FOR CHINESE STUDIES, FORMULATION OF ENERGY POLICY IN CHINA: KEY ACTORS AND RECENT DEVELOPMENTS 8 (2009).

²⁵⁹ See ENVIRONMENTAL NON-GOVERNMENT ORGANISATION [ENGO], *supra* note 198, at 27. These two programs are researches programs named after the beginning year and month; 863 program addresses national high technology and 973 program is related to national key fundamental research development. See RICHARD K. MORSE ET AL., PROGRAM ON ENERGY AND SUSTAINABLE DEVELOPMENT (PESD), THE REAL DRIVERS OF CARBON CAPTURE AND STORAGE IN CHINA AND IMPLICATIONS FOR CLIMATE POLICY, 10-11 (2009).

²⁶⁰ See Dennis Best and Ellina Levina, FACING CHINA'S COAL FUTURE –PROSPECTS AND CHALLENGES FOR CARBON CAPTURE AND STORAGE, OECD/IEA WORKING PAPER, 20 (2012); CRAIG HART & HENGWEI LIU, *supra* note 253, at 112.

²⁶¹ The GreenGen project is a representative CCS project which gains approval from the NDRC. While the number of CCS projects is few, the companies, especially state-owned utility entities, are interested and

developed countries for implementing CCS and has entered into agreements with various countries for CCS R&D businesses.²⁶² While there are financial problems in implementing CCS technology in China, China is overcoming those problems in obtaining support from the European Union and the Asian Development Bank (ADB).²⁶³

2. Current status of legal and regulatory systems regarding CCS in China

China started technical development related to CCS technology, focused on this development, and achieved performance. However, there is a lack of legal and regulatory foundations, and clear policies regarding CCS are also insufficient, which suggests a need for comprehensive CCS legislation.²⁶⁴ In order to draw massive commercialization and participation for CCS, it is necessary for legislators in China to establish comprehensive standards and a legal foundation for CCS activities.²⁶⁵

participated in CCS technology. *See* CRAIG HART & HENGWEI LIU, *supra* note 253, at 107.

²⁶² For example, China concluded cooperation programs with EU, such as COACH (Cooperation Action with CCS China-EU) and NZEC (China-EU Near Zero Emission Coal), *see Id.*, at 115. Additionally, under analyzing that there are advantages and benefits from cooperation with the US, China is trying to cooperate with the US regarding CCS deployment. *See* ASIA SOCIETY CENTER ET AL., A ROADMAP FOR U.S.-CHINA COLLABORATION ON CARBON CAPTURE AND SEQUESTRATION (2009).

²⁶³ The ADB has been assisting the People's Republic of China (PRC) through technical assessment projects since 2009 and has provided financing for them. *See generally*, ASIAN DEVELOPMENT BANK [ADB], ROADMAP FOR CARBON CAPTURE AND STORAGE DEMONSTRATION AND DEPLOYMENT IN THE PEOPLE'S REPUBLIC OF CHINA (2015).

²⁶⁴ *See* DEBORAH SELIGSOHN ET AL., WORLD RESOURCE INSTITUTE BRIEF [WRI], CCS IN CHINA: TOWARD AN ENVIRONMENTAL, HEALTH, AND SAFETY REGULATORY FRAMEWORK 2 (2010). Until now, there are not been many performances, such as enactment of laws and regulations for CCS until now in China. However, standards as a form of guidelines on CCS activities are suggested.

²⁶⁵ *See* YAN GU, CARBON CAPTURE & STORAGE POLICY IN CHINA, CENTER FOR CLIMATE CHANGE LAW 2 (2013). In preparation for CCS legislation in the future, it is expected that governmental agencies, such as

In 2009, the Chinese government through the National Development and Reform Commission (NDRC) proposed China's Policies and Actions on Climate Change in order to respond to climate changes and suggest basic directions for national energy policies. Additionally, the National People's Congress announced the 12th five-year plan for Development of National Economy and Society for creating sustainable development in 2011.²⁶⁶ Currently, there are many environmental laws that could be related in terms of the adoption of CCS in China, such as the Environmental Protection Law, Water Pollution Control Law, and Air Pollution Control Law.²⁶⁷

However, there exists a doubtful view that these laws are not enough to deal with CCS, when those laws are examined.²⁶⁸ Specifically, with regard to environmental impact assessments, there is a concern that existing legislation is not enough to incorporate the environmental impact and risks of CCS.²⁶⁹ Since China mainly considers onshore sequestration similar to the United States, it is also required to strictly prevent groundwater contamination in creating CCS-relevant legislation.²⁷⁰ Additionally, an

the Ministry of Land and Resources (MLR) and Ministry of Environmental Protection (MEP), will participate in and take roles.

²⁶⁶ See Dennis Best and Ellina Levina, *supra* note 260, at 16.

²⁶⁷ See DEBORAH SELIGSOHN ET AL., *supra* note 264, at 6; *see also*, YAN GU, *supra* note 265, at 12-15. The decision on whether it will either use existing environmental laws and regulations or enact laws and regulations only for CCS must be made after comprehensive analysis of existing legislation.

²⁶⁸ See LAN-CUI LIU, TOWARD A FRAMEWORK OF ENVIRONMENTAL RISK MANAGEMENT FOR CO₂ GEOLOGICAL STORAGE IN CHINA: GAPS AND SUGGESTIONS FOR FUTURE REGULATIONS (2014).

²⁶⁹ Specifically, it is estimated that a legal and regulatory system after well closure needs to be established thoroughly.

²⁷⁰ See DEBORAH SELIGSOHN ET AL., *supra* note 264, at 7.

elaborate permit system also needs to be provided. In particular, since China is considering the retrofitting of existing power plants, it is necessary to prepare for detailed standards and procedures in the approval of capturing facilities.²⁷¹ Specifically, the stage of sequestration of carbon dioxide is significant, and it is estimated that new legislation for the carbon dioxide sequestration phase is highly required at the time of preparation of a legal system for CCS due to the significance and uniqueness of CCS. In this context, legislative preparation would also be necessary for the areas of monitoring obligations, frequency and scope, and long-term liability.²⁷² Meanwhile, there is no clear legal decision on the property right issues and this issue must be resolved before commercializing the technology. Finally, it is noteworthy that China has focused on Clean Development Mechanism (CDM), and a lot of CDM projects have been carried out.²⁷³ It is evaluated that in China, in case of incorporation of CCS within CDM, there

²⁷¹ See Ying Fan et al., *Analysis of Global CCS Technology, Regulations and Its Potential for Emission Reduction with Focus on China*, ADVANCES IN CLIMATE CHANGE RESEARCH 2(2) 65 (2011). Meanwhile, in the case of China, a specific issue of lack of water significantly arises regarding the installation of capturing facilities. As large amounts of water are needed in the process of capturing carbon dioxide, particular attention to this issue is shown in China. Accordingly, as for the permit approval system for CCS, it is necessary to examine how this issue of water shortage is considered and included in requirements. See DEBORAH SELIGSOHN ET AL., *supra* note 264, at 8, *see also* Peter Fairley, *Can China Turn Carbon Capture into a Water Feature?* (Nov. 25. 2014), available at <http://spectrum.ieee.org/energywise/green-tech/clean-coal/can-china-turn-carbon-capture-into-a-water-feature>.

²⁷² For the preparation of a CCS regulatory system, several principles have been suggested. Major principles suggested in the area of sequestration include: select storage based on geological data, need of proper monitoring suitable to storage, comprehensive evaluation of environmental hazards, issues of post-insertion management, issues of transfer of responsibility in case of long-term storage, and public participation. These principles include legal issues, which have been mainly addressed in existing CCS legislation in developed countries. See DEBORAH SELIGSOHN ET AL., *supra* note 264, at 10-12.

²⁷³ See Dennis Best and Ellina Levina, *supra* note 260, at 31.

will be more benefits and advantages.²⁷⁴ These have much greater implications to Korea, which means that it is necessary that South Korea must pay attention to CDM projects and prepare for them.

iv. South Korea

1. Current status of CCS technology and projects in South Korea

South Korea is listed as one of the top ten largest carbon dioxide emitters and shows the fastest increase speed of carbon dioxide emissions among OECD member countries. Even though South Korea is not a country that has an obligation of reducing greenhouse gases under the Kyoto Protocol, South Korea faces a high possibility of assuming reduction obligations after 2020.²⁷⁵ South Korea has a strong interest in CCS technology and is rapidly trying to develop CCS relevant technologies and projects, particularly focusing on offshore sequestration.²⁷⁶

The Ministry of Science, ICT, and Future Planning (MSIP), Ministry of Trade, Industry, and Energy (MOTIE), and Ministry of Environment (MOE)) are the main government agencies, which are engaged in developing core technologies relevant to CCS implementation in South Korea. In order for technological improvements and

²⁷⁴ See HAAKON VENNEMO ET AL., DOMESTIC ENVIRONMENTAL BENEFITS OF CHINA'S ENERGY-RELATED CDM POTENTIAL (2006).

²⁷⁵ See MINISTRY OF KNOWLEDGE ECONOMY [MKE], *supra* note 151, at 200.

²⁷⁶ Specifically, South Korea has strength in developing capturing technologies and also has a strategy to become a leading CCS technology provider by securing original and economical technologies.

researches for CCS, there are some representative institutions, such as the Korea Carbon Capture and Sequestration R&D Center (KCRC) under MSIP and Korea Carbon Capture and Storage Association (KCCSA). The main program conducted by the KCRC is the “Korea CCS 2020” program, which was initiated in 2011. It aims to provide core CCS technologies and construct a foundation for CCS in South Korea by 2020.²⁷⁷

Additionally, the KCCSA, which is an association registered with the Ministry of Knowledge Economy (MKE), purports to establish strategic plans regarding CCS implementation.²⁷⁸

Additionally, South Korea is carrying out two CCS projects in a type of offshore sequestration. These CCS projects aim to sequester carbon dioxide in the East and West Seas respectively; carbon dioxide captured from electricity power plants, such as Korea Electric Power Corporation (KEPCO) and its subsidiaries, will be transported to the East and West Seas for each CCS project.²⁷⁹ Recently, there was an announcement of finding an appropriate storage site for CCS in the East Sea, which urges a regulatory system for

²⁷⁷ Korea Carbon Capture & Sequestration R&D Center [KCSC], <http://www.kcrc.re.kr/html/business.html> South Korea has been holding international conferences annually from 2011 with the assistance of KCRC and other institutions. *See* KOREA INTERNATIONAL CCS CONFERENCE, *available at* <http://www.koreaccs.or.kr/>

²⁷⁸ *See* KOREA CARBON CAPTURE AND STORAGE ASSOCIATION [KCCSA], *available at* <http://www.kccsa.or.kr/?ckattempt=1>

²⁷⁹ With regard to an industrial structure of electricity power generation, South Korea shows a characteristic of being led by public enterprises, such as KEPCO. KEPCO is responsible for more than 93 percent of South Korea’s electricity generation. These characteristics need to be considered when creating a legal and regulatory system for CCS in South Korea. Unlike developed countries where the CCS implementation is operated by the private sector, South Korea can also consider a framework where government leads the CCS industry.

CCS.²⁸⁰

2. Current status of legal and regulatory systems regarding CCS in South Korea

The Green Growth Committee, which is a presidential committee, came up with the “National Comprehensive CCS Strategic Plan” in 2010. The plan was established with the aim of developing core technologies under the government and private investment and promoting a demonstration project for constructing plants by 2020.²⁸¹ Additionally, the Ministry of Land, Transport, and Maritime Affairs (MLTM) created an Action Plan for Carbon Dioxide Marine Geological Storage in 2010. However, there is no comprehensive legislation for CCS that can deal with CCS technology at this time in South Korea.²⁸²

South Korea has just started reviewing their existing CCS-relevant laws.²⁸³ The possible existing laws relevant to CCS need to be chosen and reviewed in South Korea. For example, with regard to onshore sequestration, the High-Pressure Gas Safety Control Act and Waste Control Act can be applied at each phase of capture and sequestration.

²⁸⁰ The Ministry of Land, Transport, and Maritime Affairs (MLTM) announced the Ulleung Basin in the East Sea at a suitable storage site in April of 2012.

²⁸¹ See COMMITTEE ON GREEN GROWTH, http://www.greengrowth.go.kr/menu001/sub002/GRG_001_201.do.

²⁸² See JongYoung Lee, *Legal Issues on Carbon Capture and Storage*, JOURNAL OF LEGISLATION RESEARCH Vol 42, 355 (2012).

²⁸³ See Jonghoon Han, *Study on CCS infrastructure from the Analysis of the domestic and international CCS industry*, GREEN TECHNOLOGY REPORT 143 (2011).

After the analysis of the characteristics of CO₂, the applicable law should be decided in order to avoid the conflict of law between them. Additionally, the Marine Environment Management Act can be discussed for the offshore sequestration. In September 2010, South Korea amended the Marine Environment Management Act's enforcement regulations to allow for CCS in the ocean.²⁸⁴ However, there is a debate whether or not these laws are capable of accommodating CCS technology and dealing with the possible risks of CCS.²⁸⁵ There are some key elements to have in mind in creating CCS relevant legislation. South Korea needs to establish strict standards regarding permit systems for the CCS facilities.²⁸⁶ It is also necessary to make sure that the permit system is operated with transparency and consistency, decreasing the discretion of a relevant authority. Additionally, the risk assessment system also needs to be looked into for its enforcement and strictness through the whole process of CCS.²⁸⁷ Furthermore, a discussion on pore space ownership is necessary, since there is a possibility of onshore sequestration in South Korea.²⁸⁸

In conclusion, South Korea has established an overall plan and started reviewing the existing relevant laws. These relevant existing laws are already functioning in each field but CCS characteristics were not considered when these laws were enacted.

²⁸⁴ See KYOUNG HEE SHIN, KOREA ENVIRONMENT INSTITUTE, CCS RELATED FOREIGN ENVIRONMENTAL MANAGEMENT SYSTEM AND RESEARCH TREND ANALYSIS 34 (2010).

²⁸⁵ See MINISTRY OF KNOWLEDGE ECONOMY [MKE], *supra* note 151, at 266.

²⁸⁶ See JongYoung Lee, *supra* note 282, at 352-354.

²⁸⁷ See HyoSook Yim, *Applicability and Utility of the Precautionary Principle in Developing Measures for CCS Risk Management*, ENVIRONMENTAL STRATEGY RESEARCH Vol 13(1) 18-21 (2013).

²⁸⁸ See Sookyun Wang, *A Proposal for Regulating the Geological Sequestration of Carbon Dioxide*, JOURNAL OF THE GEOLOGICAL SOCIETY OF KOREA, Vol 45(4), 576 (2009).

Therefore, before the commercialization of CCS, it is important to review if there is a need for revisions or new regulations, specifically for the permit system, risk assessment system, and pore space ownership under CCS implementation. Additionally, South Korea shows an interest and participation in CDM, similar to China. However, legislation or ordinances that address the CDM activities are also lacking in South Korea, which may lead to a problem in the future.²⁸⁹ For this reason, when it comes to creating CCS legislation, it is also necessary to review whether CCS legislation can include CDM-relevant issues.

CHART 1. Analysis on current domestic legislation and regulation

	Current domestic legislation and regulation relevant to CCS	
	Federal level	State level
United States	<ul style="list-style-type: none"> ● EPA's UIC Class VI rule (direct legislation) <ul style="list-style-type: none"> -Minimum federal requirements -General contents from site selection to after-injection monitoring ● EPA's VEF <ul style="list-style-type: none"> -Evaluating susceptibilities -In-depth site specific risk assessment, monitoring and management ● NEPA (National Environmental Policy Act) ● RCRA, CERCLA <ul style="list-style-type: none"> -Not applied to CCS, but can give implications -Strictness of liability, compensation, and financial security 	<ul style="list-style-type: none"> ● Some states' legislation effort <ul style="list-style-type: none"> -Deals with overall or partial issues ● Illinois, Kansas, Louisiana etc. <ul style="list-style-type: none"> -Includes permit, monitoring, liability, and financial issues ● Wyoming, North Dakota, Montana <ul style="list-style-type: none"> -Covers specific issues (e.g., pore space ownership and liability transfer to the government) -But, not consistent among those states

²⁸⁹ See JeongGil Seo & HwanBeum Lee, *A Study on Maximizing Achievements for the Clean Development Mechanism in Local Government –The Case Study of Daegu Metropolitan City*, KOREAN JOURNAL OF LOCAL GOVERNMENT STUDIES Vol. 14(2), 184 (2010).

	Federal level	State level
Australia	<ul style="list-style-type: none"> ● Offshore Petroleum and Greenhouse Gas Storage Act 2006 (Cth)(OPGGGS Act) <ul style="list-style-type: none"> -Permit, monitoring, liability transfer to the government ● Regulations <ul style="list-style-type: none"> -Offshore Petroleum and Greenhouse Gas Storage (Environment) Regulation 2009 etc. ● Environment Protection and Biodiversity Conservation Act 1997 (Cth)(EPBC Act) ● MCMPR's Guiding Principles 	<ul style="list-style-type: none"> ● Victoria <ul style="list-style-type: none"> -Offshore Petroleum Greenhouse Gas Storage Act of 2010 (Victoria Offshore Act) -Greenhouse Gas Geological Sequestration Act of 2008 (Victoria onshore Act) -Pore space ownership ● Queensland <ul style="list-style-type: none"> -Greenhouse Gas Storage Act of 2009 -Pore space ownership ● New South Wales <ul style="list-style-type: none"> -Greenhouse Gas Storage Bill of 2010 ● Western Australia <ul style="list-style-type: none"> -Barrow Island Act (Gorgon Project) -Liability transfer to the government
China	<ul style="list-style-type: none"> ● No CCS legislation ● Relevant existing laws <ul style="list-style-type: none"> -Environment Protection Act, Water Pollution Control Act, Air Pollution Control Act, etc. 	
South Korea	<ul style="list-style-type: none"> ● National Comprehensive CCS Strategic Plan of 2010 ● No CCS legislation ● Relevant existing laws <ul style="list-style-type: none"> -High-pressure Gas Safety Control Act, Water Control Act, Marine Environment Management Act, Environment Impact Assessment Act, etc. 	

B. International level analysis for CCS

It is necessary to see if CCS implementation is compatible with existing environmental treaties at an international level along with the domestic level analysis.²⁹⁰

²⁹⁰ See RAY PURDY & RICHARD MACRORY, *supra* note 160, at 4-5; MJ MACE, *supra* note 159.

Currently, there is no general treaty that only deals with CCS implementation.²⁹¹ As seen previously, CCS is a type of technology in which its purpose is to overcome climate change problems, but it still has potential risks to the environment. Specifically, offshore sequestration is closely related to the issue of marine environmental protection. Therefore, two main fields of international environmental laws, climate change-relevant treaties and marine environment-relevant treaties, must be reviewed for the analysis of CCS compatibility with existing international norms.²⁹²

i. Climate change legislation regarding CCS

1. United Nations Framework Convention on Climate Change (UNFCCC)

The United Nations Framework Convention on Climate Change (UNFCCC) is a treaty that was concluded in order to internationally respond to the negative effects of greenhouse gas emissions with serious concerns of environmental destruction that have been aggravated increasingly.²⁹³ The UNFCCC has no provision that mentions CCS

²⁹¹ As an agreement at the regional level, there is the European Union's CCS Directive. The European Union has researched whether CCS implementation is incorporated in the existing norms or whether CCS implementation requires amendments of them. Along with coming up with the CCS Directive, the European Union has amended other Directives which are relevant to CCS implementation. Additionally, there exists the Convention for the Protection of the Marine Environment of the North-east Atlantic (OSPAR Convention) in the European Union, which addresses marine environmental protection in the area of the north-east Atlantic. The European Union has amended OSPAR in order to allow for offshore sequestration in this area. The European Union's effort gives an implication to other countries in that they need to look into their regional marine protection treaties, such as the Convention of the Protection of the Marine Environment and the Coastal Region of the Mediterranean, continuously at the regional level. *See* FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 167.

²⁹² The reason why the climate change relevant treaties are reviewed first, prior to marine relevant treaties, is that it is more logical from a positive approach to CCS technology as a contribution to solve global warming problems and that it is reasonable to review treaties that apply to both onshore and offshore sequestration.

²⁹³ *See* DAVID HUNTER, JAMES SALZMAN & DURWOOD ZAEKE, INTERNATIONAL ENVIRONMENTAL LAW

technology, which means that the UNFCCC does not explicitly allow or prohibit CCS technology literally.²⁹⁴ No reference of CCS under the UNFCCC may be based on two reasons: the UNFCCC is a framework convention, and CCS technology was not thought of when the UNFCCC was created. As CCS technology has been drawn as a useful alternative to curb greenhouse gas emissions, it becomes necessary to review whether the CCS technology is compatible with the UNFCCC.²⁹⁵

The UNFCCC provides its purpose and principles to be followed by parties in article 2 and article 3. There are conflicting opinions regarding the consistency of CCS technology with the UNFCCC.²⁹⁶ Article 2 provides that the ultimate goal of this treaty is to make greenhouse gas levels stabilized to the extent that current climate systems will not be disturbed dangerously. Also, it provides that this goal has to be achieved within a reasonable time, making ecosystems adjust to climate change naturally and also allowing economic development to proceed in a sustainable way. Additionally, article 3 provides (1) the leading role of developed countries, (2) consideration of specific situations of developing countries, and (3) preventative measures. Specifically, regarding the application of the precautionary principle, article 3, section 3 provides that parties should take preventative measures to predict causes of climate change and prevent and minimize

AND POLICY 632 (3rd ed. 2007).

²⁹⁴ See Ray Purdy, *The Legal Implications of Carbon Capture and Storage Under the Sea*, 7 SUSTAINABLE DEV. L. POL'Y 22, 24 (2006).

²⁹⁵ See Ray Purdy & Ian Havercroft, *Carbon Capture and Storage: Developments under European Union and International Law*, 4 J. EUR. ENVTL. & PLAN. L. 353, 358 (2007).

²⁹⁶ The opinions supporting consistency say that CCS technology is consistent with the purpose and principles. On the other hand, opinions denying consistency say that CCS technology is not consistent with those of the UNFCCC, more focusing on the possible threats of CCS technology.

negative effects of climate change. The precautionary principle under article 3, section 3 means that preventative measures should not be postponed for the reason of no scientific certainty, and policies and measures should be conducted in a cost effective way for guaranteeing global benefits.²⁹⁷

In Section III, it was shown that CCS technology has its rationale for establishing legal and regulatory systems and is economically efficient. Accordingly, it is reasonable to analyze that CCS technology is not prohibited by the UNFCCC. Rather, relating the UNFCCC and CCS, there exists an opinion where article 2 and article 3 actually promote CCS implementation.²⁹⁸ Under this interpretation, it is argued that CCS deployment can function efficiently as a necessary and preventative measure to overcome the current climate change crisis. Even though CCS technology is allowed in the context of the precautionary principle under the UNFCCC, the precautionary principle needs to be interpreted by considering the meaning and contents of the precautionary principle under other international treaties.²⁹⁹ When it comes to the integration of CCS within international environmental norms, the precautionary principle can function by creating a strong regulatory framework for CCS implementation.

2. Kyoto Protocol

The parties of the UNFCCC concluded the Kyoto Protocol in 1997 under the

²⁹⁷ UNFCCC, 9 May 1992, 31 ILM 849 (1992) art. 2&3.

²⁹⁸ See Yvette Carr, *supra* note 67, at 146.

²⁹⁹ See Jurgen Friedrich, *Carbon Capture and Storage: A New Challenge for International Environmental Law* 211, 227 (2007); FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 5.

recognition that it is difficult to meet greenhouse gas reduction targets only with the UNFCCC.³⁰⁰ The UNFCCC has a commitments provision in article 4, but it is not a binding obligation. On the other hand, the Kyoto Protocol pushes developed countries to set reduction targets and take on the obligation to meet those targets.³⁰¹ The binding obligation is to reduce greenhouse gas emissions by 5.2 percent (from 1990s levels) between 2008 and 2012.³⁰² The Kyoto Protocol finally entered into force in 2005.³⁰³ As an effective method to enable parties to accomplish assigned emission targets, the Kyoto Protocol adopted a market economy-based system known as the Kyoto mechanism. The Kyoto mechanism is comprised of three main systems: Joint Implementation (JI), Clean Development Mechanism (CDM), and Emissions Trading Scheme (ETS).³⁰⁴ This Kyoto mechanism is also called a flexibility mechanism, in that these three systems (JI, CDM, and ETS) are fungible through the issuing of ERUs (Emissions Reduction Units), CERs

³⁰⁰ The Kyoto Protocol was adopted in 1997, and entered into force in 2005 when the effective requirements were met.

³⁰¹ See “Kyoto Protocol,” UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, *available at* http://unfccc.int/kyoto_protocol/items/2830.php

³⁰² See Ray Purdy, *supra* note 294, at 23. The developed countries which have binding commitments account for 38 countries, and reductions obligations have been assigned to them at different levels based on their specific situation.

³⁰³ The United States joined the Kyoto Protocol but left in 2001. Since the United States is not a party of the Kyoto Protocol, the United States does not have a binding obligation under the Kyoto Protocol. However, greenhouse gas emission reduction targets have been set up voluntarily in the United States.

³⁰⁴ JI, CDM, and ETS are prescribed in the Kyoto Protocol’s articles 6, 12, and 17, respectively. JI is a system utilized between Annex I countries by recognizing Annex I countries’ reduction performance conducted in other Annex I countries. CDM is a system that enables Annex I countries to accomplish their reduction performance conducted in non-Annex I countries. Finally, ETS is a system that enables Annex I countries to carry on credit transactions, based on their reduction results. In order to implement these systems, parties of the Kyoto Protocol created the Marrakesh Accords in 2001 that cover specific implementation methods and procedures.

(Certified Emission Reductions), and AAUs (Assigned Amount Units), respectively.³⁰⁵

The evaluation of this flexibility mechanism reveals that greenhouse gas reduction goals can be achieved in an effective and competitive way in a market economy.³⁰⁶

The Kyoto Protocol also has no explicit provision regarding CCS, and it is unclear whether the CCS technology is allowed or prohibited under the Kyoto Protocol. As in the UNFCCC, there exists different opinions on the compatibility of CCS with the Kyoto Protocol. Some argue that CCS technology is not consistent with the purpose of the Kyoto Protocol, which is likely to be supported by those who have skeptical views on CCS technology.³⁰⁷ On the other hand, the proponents of the compatibility of CCS with the Kyoto Protocol say that CCS implementation can be a policy strategy under article 2 and a contributing measure to meet reduction targets under article 3. In other words, they state that CCS technology can be supported by these provisions of the Kyoto Protocol.³⁰⁸ This approach is more persuasive considering the fact that globally there is a consensus of needing urgent action for the climate change problems, and CCS technology is regarded as a necessary alternative for performing obligations assigned under the Kyoto Protocol.³⁰⁹

³⁰⁵ See FARHANA YAMIN & JOANA DEPLEDGE, *THE INTERNATIONAL CLIMATE CHANGE REGIME – A GUIDE TO RULES, INSTITUTIONS AND PROCEDURES* 146 (2004).

³⁰⁶ In this regard, this mechanism will be supported as a positive methodology to resolve climate change problems in this paper.

³⁰⁷ This approach is mainly from developing countries, and they are also likely to not be in favor of the inclusion of CCS within the CDM, one of the Kyoto mechanisms.

³⁰⁸ See FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 195.

³⁰⁹ The view that CCS implementation is necessary for fulfilling reduction obligations of carbon dioxide is still supported, after both the more recent Paris Agreement (regulating after the Kyoto Protocol) as well as

To sum up, CCS technology is consistent with the purpose and principles of the UNFCCC and further promotes the provisions of the Kyoto Protocol as a useful measure. Then, the next task is to examine how CCS implementation can be integrated well within the system of the Kyoto Protocol. This issue will be addressed in part iv after reviewing the compatibility of CCS with relevant marine treaties.

ii. Marine environmental protection legislation regarding CCS

1. United Nations Convention on the Law of the Sea (UNCLOS)

The United Nations Convention on the Law of the Sea (UNCLOS) is a fundamental framework that provides rules regarding ocean governance, such as countries' rights and obligations in various ocean areas.³¹⁰ It was concluded in 1982 after long discussions beginning in 1958. The UNCLOS functions as the standard when each country creates domestic marine regulations. Similar to the UNFCCC and Kyoto Protocol, the UNCLOS did not have CCS in mind when it was created and has no reference to the CCS. However, the UNCLOS included some broad concepts that may embrace and be relevant to CCS activities. Therefore, whether offshore sequestration is allowed or not is unclear in the UNCLOS, which needs more analysis of some specific provisions of the

under the Kyoto Protocol. See Abby Harvey, *Paris Agreement a Game Changer for CCS, Expert Say*, GHG DAILY, (Feb. 8, 2016); GCCSI, *The global Status of CCS: 100 days after the COP21 Paris Agreement*, available at <https://www.globalccsinstitute.com/insights/authors/BradPage/2016/03/21/global-status-ccs-100-days-after-cop21-paris-agreement>

³¹⁰ The UNCLOS is a treaty which has a vast number of provisions, accounting for 320 articles. Specifically, Part XII of the UNCLOS deals with protection and preservation of marine environments. General provisions of Part XII, article 192 through 196, can be related to offshore sequestration.

UNCLOS.³¹¹

It is necessary to review some articles of the UNCLOS relevant to marine environment pollutions in order to determine the permissibility of CCS within the UNCLOS. First, article 1, section 4 provides a definition of marine pollution and article 194 is a provision addressing marine pollution prevention, relieving, and controlling measures. At this point, the question on whether CCS technology in the ocean falls within the definition of marine pollution may be raised.³¹² However, it is difficult to say that CCS itself is a technology that causes marine pollution, since offshore sequestration was created for the purpose of protecting the environment. Furthermore, one analysis suggests that offshore sequestration may even play a role in resolving ocean pollution problems of acidification, not worsening ocean acidification. This analysis reasons that the ocean acidification problem is already caused by increasing levels of carbon dioxide in the atmosphere. According to this analysis, CCS technology may be helpful for reducing levels of carbon dioxide in the ocean if leakage accidents could be forestalled.³¹³ Second, article 195 of the UNCLOS provides the obligation to avert damage or risk and not to transform a form of pollution. With regard to article 195 of UNCLOS, there may be a question about the violation of this provision by offshore sequestration. However, it is reasonable to analyze that CCS does not violate article 195, since safe geological reservoirs in the ocean can be found, and permanent sequestration and monitoring for it

³¹¹ See MJ MACE, *supra* note 159.

³¹² See Moon Ji Rhee, *Legal and Regulatory Issues of CCS projects*, ANAM LAW REVIEW, Vol. 36, 696 (2011).

³¹³ See Ray Purdy, *supra* note 294, at 25.

are possible with current technological improvements of CCS.³¹⁴

Consequently, CCS implementation is not prohibited by relevant articles of the UNCLOS. Even so, it can also be questionable whether a definite provision for explicitly permitting offshore sequestration is necessary or not. However, it is inadequate to amend the UNCLOS for clearly allowing offshore sequestration since the UNCLOS is a comprehensive framework for overall ocean governance. Additionally, there are specific treaties that deal with marine environmental protection, and it is reasonable to discuss the need for specific provisions regarding CCS in more specific treaties.³¹⁵ Meanwhile, the UNCLOS provides meaningful provisions, such as attributions of jurisdictions, which can be applied in carrying out ocean CCS businesses. For example, CCS projects can be performed in the ocean area of continental shelves or exclusive economic zones. In these situations, coastal states have jurisdiction to regulate CCS activities.³¹⁶

2. London Convention and London Protocol

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (London Convention) is a treaty that embodies regulations on marine environmental pollution by dumping, which is one form of ocean pollution. Additionally, the Protocol to the Convention on the Prevention of Marine Pollution by Dumping of

³¹⁴ See Moon Ji Rhee, *supra* note 312, at 695.

³¹⁵ See RAY PURDY & RICHARD MACRORY, *supra* note 160, at 9; Ray Purdy & Ian Havercroft, *supra* note 295, at 354.

³¹⁶ For example, article 77 of the UNCLOS provides that coastal states have a sovereign right on the continental shelf. It also provides that this right is an exclusive right, in that other countries can neither explore the continental shelf nor pursue natural resources development activities. See FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 55.

Wastes and Other Matter (London Protocol) was concluded in 1996 in order to regulate pollution by dumping in the ocean with more detailed provisions. In the event that a party of the London Convention becomes a member country of the London Protocol, the London Protocol substitutes the London Convention.³¹⁷ These two treaties are the most relevant international norms in addressing legal and regulatory issues regarding offshore sequestration. The main difference between the London Convention and London Protocol is that the London Protocol generally prohibits the act of dumping in the ocean unless the act constitutes Annex I and obtains permission, whereas the London Convention prohibits listed dumping activities. Given the different contracting parties and contents of the London Convention and London Protocol, the applicability and permissibility of ocean CCS within the two treaties will be reviewed.

When it comes to the relation of CCS with the London Convention, first, there exist two different attitudes of either recognizing the application of CCS to the London Convention or denying the application of it. Those who say that the London Convention is not applied to CCS interpret the words of its provisions narrowly. One reason is that since the London Convention regulates dumping “at sea,” sub-seabed (which is required for offshore sequestration) does not fall within the scope of it. Another reason is that the London Convention provides the act of “disposal,” but sequestration in CCS does not constitute a disposal. However, these reasons from opponents on the applicability of CCS to the London Protocol are not appropriate. In other words, it is reasonable to interpret

³¹⁷ Currently, parties of the London Convention account for 87 countries and parties of the London Protocol include 45 countries. Since a country is only bound to a treaty that the country joined, the London Convention is still valid to a country that just joined the London Convention only. *See* Ray Purdy, *supra* note 294, at 24.

that the London Convention is an applicable treaty for offshore sequestration. The phrase “at sea” is sufficient to include the area of sub-seabed, and the word “disposal” can also be interpreted to include sequestration.³¹⁸

Second, given that the London Convention applies to CCS implementation, there is a question on whether or not offshore sequestration is restricted by the London Convention.³¹⁹ About this question of the permissibility of offshore sequestration, there has been a discussion between parties of the London Convention.³²⁰ On this issue, a Working Group under the London Convention determined that carbon dioxide captured and sequestered in the ocean constitutes “industrial waste,” which means that offshore sequestration is not allowed by the London Convention.³²¹

Third, given the application of the London Convention and restriction of CCS under the London Convention, the question is whether there is a need for an amendment of the London Convention to remove barriers to CCS implementation. However, it is unlikely that the London Convention will be amended, considering current situations. Because the London Convention was substituted by the London Protocol and the London Protocol is expected to have more parties than the London Convention in the future, amendment to the London Convention are unlikely.

³¹⁸ See Yvette Carr, *supra* note 67, at 144.

³¹⁹ Meanwhile, the London Convention has exception provisions on certain activities. The Enhanced Oil Recovery (EOR) projects and CCS activities conducted through land-based pipeline are allowed as exceptions under the London Convention. See Ray Purdy & Ian Havercroft, *supra* note 295, at 355.

³²⁰ See IAN HAVERCROFT & RAY PURDY, *supra* note 162.

³²¹ See Ray Purdy & Ian Havercroft, *supra* note 295, at 355.

On the other hand, the London Protocol specifies “sub-seabed” as a place where dumping activities happen. Therefore, there is no doubt that the London Protocol applies to CCS, unlike discussions regarding the London Convention. However, there are ongoing debates on whether or not CCS activities are prohibited under the London Protocol’s provisions, which is similar to the UNCLOS and the London Convention as well as the UNFCCC and Kyoto Protocol.³²² It is a predominant opinion that CCS implementation is prevented under the London Protocol because it constitutes a dumping of waste.³²³

Therefore, parties of the London Protocol have discussed an amendment to allow CCS activities.³²⁴ After discussions, parties of the London Protocol agreed on the decision to amend the London Protocol on the ground that the negative effects by CCS implementation are small and areas required for CCS are limited. Finally, parties passed the amendment of the London Protocol’s Annex 1, which was initiated by a proposal from Australia, by adding the provision of “carbon dioxide stream” in April 2006.³²⁵ The

³²² See FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 114.

³²³ See Ray Purdy, *supra* note 294, at 24.

³²⁴ See INTERNATIONAL ENERGY AGENCY [IEA], *supra* note 115, at 33.

³²⁵ New paragraph 4 of Annex 1 provides that “carbon dioxide streams may only be considered for dumping if: 1. Disposal is into a sub-seabed geological formation; and 2. they consist overwhelmingly of carbon dioxide. They may contain incidental associated substances derived from the source material and the capture and sequestration processes used; and 3. no wastes or other matter are added for the purpose of disposing of those wastes or other matter.” This amendment entered into force in February 2007. See INTERNATIONAL ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE AND THE LONDON PROTOCOL – OPTIONS FOR ENABLING TRANSBOUNDARY CO₂ TRANSFER 10 (2011). Furthermore, parties of London Protocol are discussing the amendment of article 6 since the export of carbon dioxide is not allowed due to article 6 of the London Protocol currently. See INTERNATIONAL ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE AND THE LONDON PROTOCOL – OPTIONS FOR ENABLING TRANSBOUNDARY CO₂ TRANSFER 11 (2011); RICHARD MACRORY ET AL., UCL CARBON CAPTURE LEGAL PROGRAMME, LEGAL STATUS OF CO₂ – ENHANCED OIL RECOVERY, 9 (2013).

amendment entered into force in February, 2007. Despite the amendment for admitting CCS activities in the London Convention, unclear contents of the amendment may be a problem. For example, the word “overwhelmingly” leaves room for interpretation, which can lead to the need for clear figures regarding carbon dioxide purity.³²⁶

As shown from the discussions so far, CCS activities are compatible with international marine environmental protection norms and clearly allowed by the London Protocol.³²⁷ Even though the London Protocol clearly allows for offshore sequestration, it is also important to pay attention to the precautionary approach prescribed in article 3, section 1 of the London Protocol.³²⁸ Therefore, it is important to not overlook the potential risks of CCS for marine environmental protection. In other words, it is necessary to establish a strong regulatory system with restraints on CCS activities, such as strict requirements and procedures.³²⁹

iii. Other international legislation, guidelines, and standards relevant to CCS

1. Environmental Impact Assessment and Biodiversity

Enforcing environmental impact assessments is important for minimizing negative effects to other countries when constructing crucial infrastructures. Specifically, this risk assessment is more significant since CCS implementation requires many facilities,

³²⁶ See MJ MACE, *supra* note 159.

³²⁷ See Ray Purdy, *supra* note 294, at 26.

³²⁸ See Jurgen Friedrich, *supra* note 299, at 222; Yvette Carr, *supra* note 67, at 146.

³²⁹ See FRIEDERIKE MARIE LEHMANN, *supra* note 170, at 307.

including underground facilities for sequestration as well as ground facilities.³³⁰

Therefore, it is important to establish specific and apparent standards for risk assessment. Additionally, underground facilities for CCS need to be focused on more. In this context, it is necessary to review if the existing treaties regarding environmental impact assessments are enough to cover CCS-relevant impact assessments.³³¹ Also, it is necessary to review if the existing treaties have any implications when a country creates risk assessment relevant legislation. For example, the Convention on Environmental Impact Assessment in a Transboundary Context (ESPOO Convention) can be relevant to CCS implementation since CCS facilities may cause negative effects on other countries.³³² Meanwhile, if these kinds of environmental treaties have few parties, the effectiveness may be weaker, even though they have positive implications. Specifically, more concerns may exist in countries that do not join such treaties and do not have strong environmental risk assessment systems domestically. Therefore, continuous review is needed for finding possible gaps between current international environmental assessment systems for CCS implementation.

Additionally, as mentioned before, CCS deployment may be related to many environmental factors, such as water, soil, and the ocean. Relatively, research on CCS implementation's effects on the ecosystem and biodiversity is lacking compared to research on the direct factor, such as ocean pollution. As a representative treaty on

³³⁰ See Moon Ji Rhee, *supra* note 312, at 702

³³¹ See Ray Purdy & Richard Macrory, *supra* note 160, at 39.

³³² The ESPOO Convention was adopted in 1991 and entered into force in 1997. It was complemented by the Protocol on Strategic Environment Assessment.

biodiversity, there is the Convention on Biological Diversity (CBD).³³³ Specific provisions of the CBD need to be examined insofar as CCS technology may have a risk of reducing biodiversity when physical leakage accidents take place. Article 14 of the CBD has a provision that requires each contracting party to conduct a risk assessment and to take appropriate measures when a project has a possibility of enormously affecting biodiversity. For example, under article 14 of the CBD, the need for some measures and regulations can be brought based on research, such as how negative effects on biodiversity can differ depending on the location of storage sites or locations and routes of pipelines.³³⁴ Furthermore, in the case of offshore sequestration, issues on marine biological diversity need to be looked into as well.³³⁵ The treaty conclusion has not been reached in this area until now. However, in 1995, the 2nd Conference of Parties (COP) of the CBD recognized the importance of this issue and agreed to take action for sustainable use of the ocean and marine biodiversity, which is called the Jakarta Mandate.³³⁶ More scientific research on the CCS impacts to biodiversity and marine biodiversity needs to proceed. Based on the results from this research, the compatibility of CCS implementation with the CBD or the possibility of amendment needs to be examined.

³³³ See RAY PURDY & RICHARD MACRORY, *supra* note 160, at 44.

³³⁴ *Id.* at 45-48.

³³⁵ See David Langlet, *Safe Return to the Underground? The Role of International Law in Subsurface Storage of Carbon Dioxide*, REVIEW OF EUROPEAN COMMUNITY AND INTERNATIONAL ENVIRONMENTAL LAW 18(3), 293 (2009).

³³⁶ See “The Jakarta Ministerial Statement on the Implementation of the Convention on Biological Diversity,” INTERNATIONAL ENVIRONMENTAL AGREEMENTS (IEA) DATABASE PROJECT, http://iea.uoregon.edu/pages/view_treaty.php?t=1995-JakartaMandateConventionBiologicalDiversity.EN.txt&par=view_treaty_html

2. IMO & IPCC guidelines

International soft laws, such as decisions and guidelines, have been recognized as an important source of law in the field of international law, even though they have no binding authorities.³³⁷ Sometimes, these soft laws may play an important role by addressing delicate or specific issues in an area where treaties and protocols are not easy to conclude due to procedural complexities or domestic political or social situations. International institutions, such as the International Maritime Organization (IMO) and Intergovernmental Panel on Climate Change (IPCC), have come up with guidelines on specific issues regarding CCS implementation. The first example is the IMO's guideline regarding risk assessment for offshore sequestration activities in 2007.³³⁸ This guideline requires CCS business operators to establish risk assessment and management systems for the entire process of offshore sequestration. The second example is the IPCC's guideline for National Greenhouse Gas Inventories, proposed in 2006. This IPCC's guideline offers standards on how to account carbon dioxide emission quantities in conducting CCS projects.³³⁹

³³⁷ Article 38 (1) Statutes of the International Court of Justice (ICJ) provides the main sources of international law: treaties, customs, and general principles. However, this article 38 (1) does not list all sources of international law. Even though soft laws are not binding, they play an important role in international environmental laws.

³³⁸ The need for uniform standards at an international level is higher in the ocean with regard to CCS regulatory systems. Accordingly, current CCS regulations associated with ocean regulations may be softly harmonized through guidelines. *See* David Langlet, *supra* note 335, at 303.

³³⁹ Unlike the IPCC guideline of 1996, the IPCC guideline of 2006 addresses how to estimate net capture and storage of carbon dioxide and how to deal with accounting emission quantities in case of leakage accidents. *See* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 5. However, the IPCC guideline is about the Annex I countries' duties to report emission inventories. In other words, it does not include the accounting issue in the CCS projects which are conducted through the CDM. *See* Anatole Boute, *Carbon Capture and Storage Under the Clean Development Mechanism – An Overview of Regulatory Challenges*,

These two guidelines by the IMO and IPCC show that international norms regarding CCS implementation can be improved in the form of soft laws, particularly given the current situation of no existence of a general treaty regarding CCS. Additionally, these two guidelines imply that CCS relevant international norms can be developed with soft laws addressing specific factors, not covering overall legal issues regarding CCS.

3. ISO's standards

As CCS technology becomes increasingly necessary and its implication is expected to expand, the International Standards Organization (ISO), which is a non-governmental organization, is working to bring about international standardization regarding CCS.³⁴⁰ The ISO has approved the formation of the Technical Committee (TC), and the TC held its first meeting in 2012. Currently, the ISO's TC has been working with six Working Groups (WG) to establish CCS-related standards in the entire chain: WG 1

2008 CARBON & CLIMATE L. REV. 339, 341 (2008).

³⁴⁰ There are still few studies on how Non-Governmental Organizations (NGOs) are taking positions in CCS and how environmental NGOs can affect the implementation of CCS. NGOs have played a vital role in raising important environmental risks creating public interest, providing credible critical information, and drawing up cooperation in conflicting environmental issues. *See* Jason Anderson & Joana Chiavari, *Understanding and improving NGO position on CCS*, ENERGY PROCEDIA 1, 4811, 4811-4812 (2009). Therefore, it would be meaningful to study the role of environmental NGOs regarding CCS, and more specifically how these NGOs approach and solve key issues associated with CCS.

Some groups, such as Greenpeace and Friends of the Earth, have fundamentally questioned the safety of CCS, but there are also domestic and international NGOs that support the introduction and expansion of CCS. *See* Jason Anderson & Joana Chiavari, *supra* note 340, at 4815; Muriel Cozier, *Carbon Capture and Storage (CCS) – Viable Alternative?*, GREENHOUSE GAS SCI TECHNOL. VOL (5), 225-228 (2015). The differing views of NGOs on specific issues of CCS can have a positive impact as they are able to identify the real problems that are posed by CCS, thus generating solutions that address these various issues. At the same time, NGOs provide a resolution in which working with government agencies can create effective discussions and coordinate these various issues as well. *See* Jason Anderson & Joana Chiavari, *supra* note 340, at 4815-4816.

(capture), WG 2 (transportation), WC 3 (storage), WG 4 (quantification and verification), WG 5 (cross-cutting issues), and WG 6 (EOR issues).³⁴¹ Among them, standards associated with capture and transportation have been published, and standards for other issues are under development.³⁴²

The creation of these international standards has the advantage of speeding up regulatory processes and promoting harmonization of rules across jurisdictions in the current absence of clear international norms addressing CCS, although the application of these ISO standards is voluntary. Additionally, the standards set out in the ISO can help to stimulate investment in the CCS industry by providing knowledge and information to various early stakeholders (especially participating companies) involved in the CCS industry.³⁴³

iv. The CCS incorporation into the CDM

In order for CCS technology to function effectively, it needs to be extended to developing countries, not just developed countries. Additionally, incorporation of CCS into the UNFCCC and Kyoto Protocol mechanism is also necessary for CCS to become

³⁴¹ See GCCSI, *Developing International Standards for CCS*, <http://www.globalccsinstitute.com/insights/authors/markbonner/2013/03/04/developing-international-standards-ccs>

³⁴² The published standards are ISO/TR 27912: 2016 (capture) and ISO 27913: 2016 (pipeline transportation system), see International Standards Organization (ISO), <http://www.iso.org/iso/home/search.htm?qt=carbon+capture+and+sequestration&sort=rel&type=simple&published=on>

³⁴³ See STEVEN M. CARPENTER AND KIPP CODDINGTON, INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO) TECHNICAL COMMITTEE 265 (TC-265): CARBON DIOXIDE CAPTURE, TRANSPORTATION, AND GEOLOGICAL STORAGE (2014); GCCSI, *supra* note 341.

globally commercial. From this point of view, the recent decision to include CCS into the CDM, one of the Kyoto mechanisms, is appropriate and has an important meaning.

However, at the same time, some problems and regulatory risks derived from this decision can be brought up. In this context, the rationales, benefits, and possible issues regarding the inclusion of CCS with the CDM will be addressed after reviewing the basic background of CDM.

1. Concept, current status, and procedure of CDM

CDM is a system that enables developed countries to reduce greenhouse gas emissions in a cost-effective way and that allows developing countries to gain technical and economic benefits as well.³⁴⁴ In order for a business to be approved as a CDM project, the business must have additional benefits through the CDM project from technical, economical, and environmental aspects. In other words, it requires participants to clearly demonstrate that the possible business cannot happen naturally under the host country's situation but can be performed through additional efforts.³⁴⁵ This concept is called additionality, which is an important requirement in the CDM. Another important requirement is that the CDM business has to contribute to the sustainable development of

³⁴⁴ This CDM started from the idea of the Clean Development Fund (CDF). CDF's original purposes was to assist developing countries with a fund raised by developed countries, which violated binding commitments of reducing greenhouse gas emissions. This idea failed to be adopted due to the opposition mainly by developed countries, which led to a more compromising idea of CDM. Meanwhile, the 1st COP of UNFCCC adopted Activities Implemented Jointly (AIJ) programs as pilot projects. With the AIJ programs advances, the 3rd COP of UNFCCC created the two differentiated systems of JI and CDM; JI applies between Annex I countries and CDM applies between an Annex I and non-Annex I country. *See* SEUNGHO, HAN, CLEAN DEVELOPMENT MECHANISM, AN INNOVATIVE TOOL FOR COMBATING CLIMATE CHANGE UNDER THE UNFCCC 36-38 (2010).

³⁴⁵ The detailed contents regarding additionality requirement are described in article 43 of CDM modalities and procedures under the Marrakesh Accords. If a business has a legal obligation to be performed, the business has to be excluded from CDM projects. In other words, a project which has a legal obligation is estimated that it is no additional.

developing countries, which is called sustainability. Regarding types of CDM projects, there are two kinds of CDM: bilateral CDM and unilateral CDM. The bilateral CDM is a traditional type of CDM, and it means a CDM project conducted between Annex I countries and non-Annex I countries. On the other hand, the unilateral CDM is carried out in non-Annex I countries unilaterally, and CERs are issued and then purchased by Annex I countries.³⁴⁶

The first CDM project was initiated in Brazil in 2005. After that project, CDM projects have increased rapidly. Currently, the number of CDM projects enrolled in the UN is 3,000, and the amount of CERs issued from all CDM projects accounts for 500 million tCO₂.³⁴⁷ From this strong growth, it is estimated that the CDM under the Kyoto Protocol has been successful. The main host countries that perform CDM projects are China, India, Brazil, and South Korea. Specifically, CDM projects in China and India account for 80 percent of all projects.³⁴⁸ Additionally, CDM projects are performed primarily in two areas: renewable energy and waste disposal-relevant businesses.

In order for a CDM project to be conducted, a series of processes is required: (1) drawing up a Project Design Document (PDD), (2) approval by Designated National

³⁴⁶ Unilateral CDM was newly adopted in the 18th CDM EB meeting. According to the allowance of Unilateral CDM, a non-Annex I country can carry out CDM projects in its own country or another non-Annex I country.

³⁴⁷ The United Nations Environment Programme (UNEP) provides a more accurate accounting of CDM projects. The UNEP counts all CDM projects including registered, requested, and rejected CDM projects.

³⁴⁸ See *What if the Clean Development Mechanism (CDM)?*, THE GUARDIAN (July 26, 2011). The percentage of Unilateral CDM projects enrolled in the UN accounts for 50 percent of all projects. With regard to this high proportion, there is an opinion that it is necessary to analyze the reason why Unilateral CDM projects are preferred in developing countries. See ARIEL DINAR, DONALD F LARSON & SHAIKH M RAHMAN, THE CLEAN DEVELOPMENT MECHANISM (CDM) – AN EARLY HISTORY OF UNANTICIPATED OUTCOMES 169 (Robert Mendelsohn ed. 2013)

Authority (DNA)³⁴⁹, (3) registration to the UN, (4) validation and verification review by the Designated Operational Entity (DOE), and (5) CERs issuance by the CDM Executive Board (CDM EB). As the first step of writing a PDD, project participants must describe the baseline methodologies and monitoring methodologies in their PDD, which is reviewed by the DOE.³⁵⁰ Among the CDM-relevant institutions, the DOE plays a significant role in the two main processes of validation and verification review. The validation review is to estimate if a project is qualified as a CDM project. On the other hand, the verification review is to evaluate reduction results of the CDM project based on the chosen methodology.³⁵¹ The DOE performs these processes through documents review, interviews, and field checks; document review is mainly used in the DOE's validation review and field checks are mainly utilized in the DOE's verification review process. The results from the DOE's review are sent to the CDM EB, and finally the CDM EB issues CERs which make transactions more available in the global carbon market.³⁵²

³⁴⁹ A host country that expects to perform a CDM business should install DNA. The DNA plays an important role in determining if the CDM business contributes to sustainability of the host country. For the standards to review sustainability, multi-standards, which utilize qualitative and quantitative criteria, are recommended. *See* SEUNGHO HAN, *supra* note 344, at 53.

³⁵⁰ The baseline methodology is to predict the emission quantity that naturally occurs on the presumption of no existence of the CDM project. This presumption is called baseline scenarios, which is a basic and important concept in proving additionality. On the other hand, the monitoring methodology is to periodically evaluate and monitor the emission quantities that actually occur. There are some monitoring standards and methods under the CDM modalities and procedures. Based on the choice of standards and methods, credit issuances are determined and may differ. Besides baseline and monitoring methodology, the PDD includes many items, such as sustainability, environmental effects, and stakeholders' opinions.

³⁵¹ Currently, the number of DOE installed worldwide is around 30. In South Korea, the Korea Energy Agency (KEA) was designated as a DOE in 2005.

³⁵² With regard to the issuance of CERs, there are two kinds of credit periods: a fixed 10 year period and renewable crediting period of 7 years.

2. Importance and benefits of the CCS inclusion within the CDM

The issue of incorporating CCS in the CDM has been debated between developed and developing countries.³⁵³ The progress has been drawn at the UNFCCC 16th COP, which was held in Cancun, Mexico, and the final decision of the inclusion of CCS within the CDM was made at the 17th COP in Durban, South Africa. The importance and rationale for CCS was shown in Section III. Therefore, the benefits and rationales for the CCS inclusion in the CDM will be strengthened by proving advantages of CDM.

CDM has its own benefits. First, CDM is the only system which enables developing countries to participate in the Kyoto mechanism, whereas JI and ETS are systems that can be utilized between developed countries. In this context, the CDM play a positive role, since the emission reduction targets cannot be accomplished only with the effort of developed countries, which means that the participation of developing countries is inevitable.³⁵⁴ Second, CDM provides developing countries with technology transfer and economic incentives. The foreign capital influx into the developing countries can be a more reasonable way to increase their autogenic power than just offering direct financial aid.³⁵⁵ Third, CDM has an advantage of contributing to the local community's economic improvement by including local governments and the private sector in the host countries' CDM projects as well as the central government. Additionally, it is expected

³⁵³ For the brief history and negotiations of CCS inclusion in CDM, *see* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 8.

³⁵⁴ There is an analysis that the systems, which are utilized only within Annex I countries, may negatively affect non-Annex I countries. On the other hand, CDM has been evaluated that it is successfully performed, compared to the other two systems of JI and ETS under the Kyoto mechanism.

³⁵⁵ *See* HyoSook Yim et al., *Possibility of CDM Project to Respond Climate Change in Africa*, AFRICA REVIEW VOL 29, 65 (2009).

that during CDM activities the local citizens' opinions can be incorporated and their environmental surroundings can be improved. Fourth, CDM is also beneficial to developed countries by enabling them to trade CERs in a market.³⁵⁶

Along with the benefits of CDM, positive effects can be brought and expanded by incorporating CCS within the CDM. The first advantage is a symbolic meaning of acknowledgement of CCS under the Kyoto mechanism, which many countries have joined.³⁵⁷ Furthermore, when the successful inclusion and settlement of CCS within the ETS is added, CCS deployment can be well-embraced in the flexibility mechanism based on the market economy.³⁵⁸ Second, incorporation of CCS into CDM can help in early adoption of CCS technology. As mentioned before, CCS is a bridge technology and it is also important to be commercialized within a properly fast time. However, a high cost burden in the early stages exists in developing countries, which discourages developing countries to conduct CCS projects. Additionally, an analysis shows that without the help of inclusion of CCS within CDM, CCS technology is difficult to commercialize at the pace developing countries expect.³⁵⁹ Third, the inclusion of CCS within CDM expands the room for choices and provides an effective way of reducing greenhouse gases by

³⁵⁶ See Ray Purdy, *supra* note 294, at 23.

³⁵⁷ While a nuclear power-relevant project is excluded from a CDM project, CCS technology is incorporated into the CDM. This decision may be helpful in increasing social awareness of CCS technology.

³⁵⁸ When it comes to the relation of CCS with the ETS, it is worth paying attention to the EU ETS. The European Union has incorporated CCS implementation on an opt-in basis in 2nd period of the EU ETS (2008-2012) and incorporated it completely in 3rd period of the EU ETS (2013-2020). See INTERNATIONAL ENERGY AGENCY [IEA], *supra* note 115, at 36. There exists a positive view that the inclusion of CCS in the EU ETS can provide CCS participants with many benefits. See Ray Purdy & Ian Havercroft, *supra* note 295, at 361.

³⁵⁹ See INTERNATIONAL ENERGY AGENCY [IEA], *supra* note 58, at 16.

adding CCS implementation. The economic benefits may be increased by trading enough CERs issued from the CCS implementation as CDM projects.³⁶⁰ Fourth, business performance under the CDM can be well controlled and monitored, since the CCS under the CDM cannot be authorized without approval of methodologies, such as baseline and monitoring methodologies. Finally, the CCS inclusion in CDM can have a positive effect in the climate change negotiations. Specifically, two important countries, the United States and China, are interested in CCS, and the CCS inclusion into CDM can give more room for compromise.³⁶¹

3. Problems and desirable directions of the CDM and its incorporation of CCS

Some disadvantages and problems can be pointed out even though the CDM is a system that has many benefits, as shown. However, even the disadvantages and problems can be overcome through the inclusion of CCS within CDM, which will improve the rationale for the inclusion. For this reason, analyses on the problems of CDM are necessary.

The first concern for CDM is that when developing countries are faced with reduction obligations in the future, costly greenhouse gas mitigation businesses will remain in developing countries due to CDM.³⁶² However, it would be unwise to avoid CDM activities due to this concern because greenhouse gas reduction is urgent and any form of mitigation projects is necessary in developing countries. Furthermore, one

³⁶⁰ See Ray Purdy & Ian Havercroft, *supra* note 295, at 360.

³⁶¹ See Kirsten Braun, *Carbon Storage: Discerning Resource Biases that Influence Treaty Negotiations*, 22 GEO. INT'L ENVTL. L. REV. 649, 669 (2010).

³⁶² See SEUNGHO HAN, *supra* note 344, at 41.

encouraging factor is that this concern can be alleviated by the inclusion of CCS in CDM, since the inclusion of CCS within CDM can relieve the burden of developing countries by providing CCS technology that requires a lot of cost at an early stage, as one type of CDM activity.

Second, critical opinion on CDM is that CDM may cause administrative leakage problems, which was mentioned in Section II.³⁶³ However, an analysis rebuts this critical view on CDM. It says that CDM can rather be helpful in reducing administrative leakage problems.³⁶⁴ Additionally, the inclusion of CCS in CDM can also be helpful in reducing administrative leakage problems that may be caused by a rapid change in coal and oil markets by allowing the use of fossil fuel energy sources.

Third, the disproportion representation of certain countries and fact that CDM activities are biased for specific greenhouse gas emission reductions are problematic in the CDM. Currently, CDM activities are concentrated in some emerging economies, such as China and India.³⁶⁵ Additionally, CDM projects are focused on the reduction of only certain greenhouse gases, not carbon dioxide, among the six kinds of greenhouse gases.

³⁶³ See KNUT EINAR ROSENDAHL & JON STRAND, THE WORLD BANK, SIMPLE MODEL FRAMEWORKS FOR EXPLAINING INEFFICIENCY OF THE CLEAN DEVELOPMENT MECHANISM 2 (2009); *see also* Knut Einar Rosendahl & Jon Strand, *Carbon Leakage from the Clean Development Mechanism*, ENERGY JOURNAL 27 (2011)

³⁶⁴ See STEFFEN KALLBEKKEN, LINE S. FLOTTORP & NATHAN RIVE, CENTER FOR INTERNATIONAL CLIMATE AND ENVIRONMENTAL RESEARCH – OSLO [CICERO], WHY THE CDM WILL REDUCE CARBON LEAKAGE (2005).

³⁶⁵ For example, Africa has difficulties in attracting CDM businesses. Even though Africa shows a strong interest, such as a high rate of DNA installation, most CDM projects are concentrated in a few emerging economies. It is due to the fact that CDM projects primarily take place in professional businesses' accompanying businesses and only emerging economies, such as China and India, are affordable to perform these professional businesses (e.g., semiconductor and electronics). *See* HyoSook Yim et al., *supra* note 355, at 70-71.

This means that reduction projects regarding carbon dioxide, the most important greenhouse gas that needs to be reduced, are lacking in CDM. Under this situation of disparity, the inclusion of CCS within CDM can contribute to relieve this problem.

CHART 2. CDM and CCS incorporation into the CDM

	Benefits of CDM	Challenges of CDM
CDM	<ul style="list-style-type: none"> -Enables developing countries to participate in the Kyoto Mechanism -Provides developing countries with technology transfer and economic incentives through foreign capital influx -Contributes to the local community's economic improvement by including local governments and private sector in host countries' CDM projects -Provides economic benefits to developed countries by enabling to trade CERs 	<ul style="list-style-type: none"> -Remains costly greenhouse gas mitigation options in the future in developing countries -May cause administrative leakage problems by a rapid change in coal and oil markets -Disproportion of CDM projects concentrated in some emerging economies -Disparity problem of CDM activities focused only on certain greenhouse gases
	How to improve the benefits through CCS inclusion into the CDM	How to overcome the challenges through CCS inclusion into the CDM
CCS incorporation into the CDM	<ul style="list-style-type: none"> -Symbolic meaning of acknowledgement of CCS under the Kyoto Mechanism -Expectation on early adoption and implementation of CCS in developing countries -Increased economic benefits by trading enough CERs issued from CCS-CDM projects -Well controlled and monitored CCS implementation under the CDM -Positive effects in climate change negotiations by participating the US and China which are interested in CCS 	<ul style="list-style-type: none"> -Relieves the burden of developing countries by providing CCS technology (requiring high cost at an early stage) as a type of CDM activity -May reduce administrative leakage problems by CCS-CDM projects which allow the use of fossil fuel energy sources -Reduces the disproportion and disparity problems by including CCS

Consequently, the weaknesses and problems indicated from skeptical views on CDM can be eased up to a point by the inclusion of CCS in the CDM. However, despite the high validity of the CCS inclusion in the CDM, the inclusion of CCS in the CDM itself can also have many difficulties and challenges in implementing it.³⁶⁶

First, at the discussion of the inclusion of CCS in the CDM by parties of the Kyoto Protocol, the developing countries indicated the concern that much more CERs issuance than before through the inclusion of CCS may lower the price of CERs and disturb carbon markets.³⁶⁷ The Marrakesh Accords is establishing relevant provisions regarding CDM so that market confusion by excessive issuance of CERs does not happen. However, the current Marrakesh Accords may be not enough to cope with the inclusion of CCS within CDM. Therefore, it is necessary to come up with corresponding measures, such as limitations of CERs issuances regarding CCS activities and suggestions on how to use CERs issued by CCS projects in CDM.

Second, current baseline and monitoring methodologies may not be enough for

³⁶⁶ There have been critiques on CDM and thus the need for reform has been emphasized by some scholars. According to this critical view, the CDM system itself may be affected by political factors or pressures that may bring a negative effect on exact and appropriate credit issuance, therefore the CDM-related rules need to be prepared and operated more robustly. See David G. Victor, *The Politics and Economics of International Carbon Offsets*, in MODELING THE ECONOMICS OF GREENHOUSE GAS MITIGATION: SUMMARY OF A WORKSHOP 132 (2011); MICHAEL W. WARA & DAVID G. VICTOR, PROGRAM ON ENERGY AND SUSTAINABLE DEVELOPMENT [PESD] WORKING PAPER #74, 24 (2008) (stating that “improving the quality of the CDM would require much stronger regulatory oversight and much improved verification systems”). The criticisms of CDM itself need to be reviewed carefully in the preparation of the specific offset system under the Paris Agreement.

³⁶⁷ See IEA GREENHOUSE GAS R&D PROGRAMME, USE OF THE CLEAN DEVELOPMENT MECHANISM FOR CO₂ CAPTURE AND STORAGE (2004).

CCS projects.³⁶⁸ This concern is reasonable because CCS is regarded as not only technologically complex, but also strategically delicate technology as a type of bridge technology. About this problem, more comparative and thorough analysis in relation with renewable energy is needed in evaluating baseline methodologies. Additionally, with regard to estimating monitoring methodologies, CCS experts' participation is needed.³⁶⁹

Third, the possible risk of physical leakage of CCS may require institutional preparations in CDM. The inherent characteristic of CCS itself as a technology with a potential risk of leakage can involve many complex problems regarding CDM.³⁷⁰ For example, leakage accidents may happen after the period of calculating credits, which could lead to a difficulty in accounting carbon dioxide emission quantity associated with CERs issuance.³⁷¹ About this problem, there is a suggestion that temporary issuance of CERs may be an alternative, such as tCERs in the afforestation CDM.³⁷² However, the characteristic of being temporary and instable may cause other problems, and more specific and ultimate alternatives are needed in dealing with leakage- relevant problems

³⁶⁸ See Anatole Boute, *supra* note 339, at 339.

³⁶⁹ There exists a view that establishing an international body is necessary for increasing professionalism and uniformity in the process of methodology approval. Additionally, this view shows that the existence of an international body can alleviate the burden of a developing host country, which may lack professionalism. See *id.* at 350.

³⁷⁰ In other words, if carbon dioxide leaks later in duration of long-term sequestration, it will cause problems, not only in the failure of CCS implementation, but also questioning how credits are handled and issued under the CDM. Due to these concerns, when CCS is implemented under the CDM, it has been discussed how to grant credits on a temporary basis or over time, rather than granting full credit from the beginning.

³⁷¹ See *id.* at 346.

³⁷² See *id.* at 347. With regard to tCERs, afforestation CDM needs to be examined. The afforestation CDM has a characteristic of non-permanence due to a risk of deforestation and forest fires. Based on this reason, tCERs are used in the afforestation CDM in which the issued credits are effective for a limited time and have to be exchanged with other credits after the limited time.

and measuring the amount of leakage.³⁷³ As a result, whichever methodology is chosen, it is important to accurately measure the amount of carbon dioxide reduced and the amount of carbon dioxide leaked in the event of leakage accidents. Additionally, in the same vein, long-term monitoring is important to improve the integrity of CCS.³⁷⁴

Finally, the issue of how to address liabilities caused by leakage accidents is also problematic regarding CCS activities in the CDM.³⁷⁵ This problem is not easy to solve because of many stakeholders (e.g., credit buyer, project participants, and host countries). It is not likely that the credit buyer assumes liabilities relevant to CCS activities. The alternative of assigning liabilities between project participants and host countries has been supported.³⁷⁶ For example, the project participant may be liable during the credit issuance and monitoring period, and then the liability may be transferred to the host country after the period.

C. An evaluation and analysis of the regulatory gaps under the current domestic and international systems

³⁷³ See Ana Maria Radu, Long-term Liability for Carbon Capture and Storage Project Activities within the Clean Development Mechanism (Dec. 2012)(unpublished thesis, University of Calgary). Additionally, with reference to the difficulty of accounting emission quantities, there is another problem on how to account additionally required energy in CCS implementation. *See Id.* at 340.

³⁷⁴ The significance of these monitoring standards is evidenced by the fact that countries are actively engaged in the implementation of Monitoring, Reporting, and Verification (MRV) related to greenhouse gas emissions and the creation of legal and regulatory standards for the MRV.

³⁷⁵ The CCS liability issue associated with long-term liability will be closely further analyzed in Section V. The liability problem under the inclusion of CCS into CDM may be different from CCS liability.

³⁷⁶ See CEDRIC PHILIBERT, JANE ELLIS & JACEK PODKANSKI, OECD/IEA, CARBON CAPTURE AND STORAGE IN THE CDM 26 (2007).

Recognizing the importance and appropriateness of CCS technology to mitigate GHG emission, some developed countries, such as the United States, Australia, and EU member countries, have already established components of a legal and regulatory system for CCS implementation.³⁷⁷ The important and fundamental consideration is to review whether existing systems are compatible and sufficient to govern the implementation of CCS technology.³⁷⁸ CCS legal and regulatory systems need to be comprehensive yet flexible enough to reflect the complex nature of CCS implementation, such as the interconnectedness of each phase and uniqueness of permanent sequestration as a new form of technology. Some countries have tried to find these compatibilities and regulatory gaps with these considerations in mind. Specifically, the United States and Australia, two representative developed countries, have established CCS legal and regulatory systems at the federal level and state level, as well.

i. The United States

The most substantive action by the United States toward implementation of a specific regulatory framework to oversee CCS activity lies in the use of new regulations under existing statutes. The U.S. EPA added a new class of wells to the existing Underground Injection Control (UIC) program under the existing law of the Safe Drinking Water Act (SDWA). This action is focused on preventing groundwater contamination problems, which could be possibly caused by sequestration. This is called

³⁷⁷ Current circumstances regarding CCS legal and regulatory frameworks are diverse due to the differences in CCS purposes and types that each country pursues as well as their domestic legal systems.

³⁷⁸ See INTERNATIONAL ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE – LEGAL AND REGULATORY REVIEW EDITION 2, 20 (2011).

the UIC Class VI program, a federal level regulation, and the EPA regulates carbon sequestration activities under the rules of this program. These rules provide basic requirements regarding injection wells (well location, construction, operation, etc.), specific standards regarding monitoring, and site-specific information which has to be submitted.³⁷⁹ However, some problems have been raised with regard to the UIC Class VI program. The first critique is that it does not deal with many of the legal issues surrounding CCS, such as long-term liability, monitoring, and property rights issues, by only focusing on the groundwater contamination.³⁸⁰ Second, since the UIC Class VI program addresses only the sequestration phase, there is a lack of regulations on the phases of capture and transportation of carbon dioxide. For example, there are no provisions and standards regarding carbon dioxide stream purities, which is a possible and important regulation in the capture process. The absence of a purities-relevant regulation can negatively affect CCS safety by causing physical leakage.³⁸¹ Additionally, there are relevant state laws and regulations for the transportation of carbon dioxide in the United States, but new federal-level laws and regulations for only addressing transportation phase of CCS have not been established yet.³⁸² However, the issue of new

³⁷⁹ For detailed site-specific information that must be provided, *see generally*, ENVIRONMENTAL PROTECTION AGENCY [EPA], *supra* note 203.

³⁸⁰ *See* Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 27.

³⁸¹ In the capture process, which is conducted above the ground and has a possibility of releasing regulated pollutants, other environmental laws like the Clean Air Act (CAA) can be reviewed and applied. With regard to the impurities, New Source Review (NSR) requirements under the CAA can be triggered. *See* GOVERNMENT ACCOUNTABILITY OFFICE [GAO], *supra* note 118, at 41.

³⁸² *See* INTERSTATE OIL AND GAS COMPACT COMMISSION (IOGCC) / SOUTHERN STATES ENERGY BOARD (SSEB) PIPELINE TRANSPORTATION TASK FORCE [PTTF], A POLICY, LEGAL, AND REGULATORY EVALUATION OF THE FEASIBILITY OF A NATIONAL PIPELINE INFRASTRUCTURE FOR THE TRANSPORT AND STORAGE OF CARBON DIOXIDE, 2 (2010).

and comprehensive pipeline constructions across states may rise, which may lead to a need for federal-level regulatory systems for carbon dioxide transportation.³⁸³ Finally, at a federal level, there is a lack of answers to key issues relevant to CCS activities, such as pore space ownership and liability issues. Currently, these specific issues have mainly been discussed in some states.³⁸⁴ To guarantee that the United States responds to all phases of CCS implementation, the United States needs to take necessary actions to ensure that CCS legal and regulatory systems are more thorough. It is positively evaluated that some states have made efforts to solve legal issues regarding CCS implementation while filling gaps in federal regulation.³⁸⁵ Additionally, it is also necessary to consider diversity and flexibility between states in creating a regulatory framework.³⁸⁶ However, the problem of different regulations between states in the United States can cause regulatory inefficiency and finally prevent CCS industry

³⁸³ See Robert R. Nordhaus et al., *Carbon Dioxide Pipeline Regulation*, 30 ENERGY L.J. 85, 85 (2009); Cyrus Zarraby, *Regulating Carbon Capture and Sequestration: A Federal Regulatory Regime to Promote the Construction of a National Carbon Dioxide Pipeline Network*, 80 GEO. WASH. L. REV. 950, 968 (2012).

³⁸⁴ For more detailed contents and regulatory efforts at a state level, see Arnold W. Reitze et al., *Control of Geological Carbon Sequestration in the Western United States*, 41 ELR 10455 (2011).

³⁸⁵ Currently, about twenty five states implemented CCS relevant legislation including incentive programs, See *Carbon Capture and Storage in the States*, NATIONAL CONFERENCE OF STATE LEGISLATURES, available at <http://www.ncsl.org/research/energy/carbon-capture-and-storage-in-the-states.aspx> (last visited on Nov. 5). As mentioned before, very few states have provisions regarding key issues, such as pore space ownership and liability transfer to the government. However, the attitude for these issues is not concerted.

³⁸⁶ In order to reduce the release of carbon dioxide into the atmosphere from fossil fuel power plants, the EPA proposed CAA 111(d) to limit carbon dioxide emissions. This provision features cooperative federalism, which considers flexibility of states as well. See Tomas Carbonell, *EPA's Proposed Clean Power Plan: Protecting Climate and Public Health by Reducing Carbon Pollution From the U.S. Power Sector*, 33 YALE L. & POL'Y REV. 403, 426 (2015).

improvement.³⁸⁷

ii. Australia

Australia created CCS legislation at the federal level in preparation for offshore sequestration, while utilizing the existing analogous petroleum laws. This legislation includes considerably detailed provisions regarding approval and authorizations in the area of carbon dioxide sequestration. Additionally, CCS legislation has been established at the state level as well, such as in the state of Victoria, which has both onshore and offshore sequestration relevant laws. Other states in Australia, such as Queensland and New South Wales, have also created CCS-relevant laws, which regulate onshore sequestration or a specific CCS project. It is desirable that Australia's CCS-relevant laws from both the federal and state level address key legal issues. However, an inconsistency problem in approaching the key legal issues still exists, which is the same problem the United States faces. For example, Victoria and Queensland provides the liability transfer to the government, and Western Australia provides the liability transfer but set out the distribution of liability between the federal and state government. Likewise, Australia has the same critique of the lack of a legal and regulatory system which addresses the capture process of CCS. Even though Australia's carbon dioxide transportation system for CCS is incorporated well into the existing transportation framework, there is also a need for further research regarding a legal system for nationwide carbon dioxide pipelines and ship transportation of carbon dioxide. Finally, a critical opinion says that more effort to

³⁸⁷ See Mark A. Latham, *supra* note 35, at 75-77 (pointing out that current state CCS legislation in the United States is patchwork and stating that it needs to consider the fact that the nature of CCS means it may possibly be implemented between states.) However, almost all states do not address the issue of interstate relation. See HOLLY JAVEDAN, *supra* note 230, at 4.

improve procedural rights, such as public participation, needs to be included in Australia's legal and regulatory systems for CCS.³⁸⁸

iii. China and South Korea

Both South Korea and China show a strategy of enhancing competitiveness in the field of CCS industry by reinforcing CCS industry-relevant techniques and enforcing CCS research and development. However, the overall legal and regulatory framework established regarding CCS is insufficient, in spite of the technical improvement. In other words, both countries are in an initial step of reviewing existing relevant laws, and no specific CCS legislation has been enacted so far in these two countries. Specifically, considering concerns about the weakness of general environmental law regimes compared to developed countries, more careful review to find regulatory gaps is needed.³⁸⁹ Additionally, South Korea became one country to enforce an Emission Trading System (ETS) and China is highly expected to establish a nationwide ETS, expanding current regional ETS.³⁹⁰ Therefore, it is important to continue researching on the relation between CCS and ETS and to reflect the results into a legal and regulatory

³⁸⁸ See Guy J Dwyer, *Emerging Legislative Regimes for Regulating Carbon Capture and Storage Activities in Australia: To What Extent Do They Facilitate Access to Procedural Justice?*, 32 ENVIRONMENTAL AND PLANNING LAW JOURNAL 3, 50-53 (2015).

³⁸⁹ For example, in South Korea, there is a concern that existing pipeline-relevant legislation is not enough to cover approval or permit systems associated with CCS activities and facilities. Additionally, South Korea has legislative and regulatory gaps in the area of risk assessment (including risk management) and long-term liability of CCS. Even though it is a drawback of South Korea currently, it can provide a positive opportunity of enabling a new, singular, comprehensive CCS legislation, which encompasses capture, transportation, and sequestration.

³⁹⁰ See Tianbao Qin, *The Emissions Trading System in the Context of Climate Change: China's Response* in CLIMATE CHANGE: INTERNATIONAL LAW AND GLOBAL GOVERNANCE VOLUME I: LEGAL RESPONSES AND GLOBAL RESPONSIBILITY 496 (Oliver C. Ruppel et al., 2013).

system of CCS.³⁹¹

v. Summary of current domestic and international CCS systems

An analysis of these four countries' legal and regulatory circumstances shows that existing systems are insufficient to fully cover new and important issues regarding CCS implementation: permits, risk assessment, property rights of pore space, and long-term liability. These areas have some problems, such as regulatory gaps and inconsistency, which may not only threaten CCS safety but also hinder CCS facilitation.³⁹² The government, both federal and cooperative state governments, can play a key role in implementing CCS successfully and safely by providing thorough, uniformed, and effective regulatory systems when addressing the key legal issues.³⁹³ For this reason, the future domestic system of any country needs to come up with concrete ways as to what degree the government can function well in and contribute to creating comprehensive and concerted CCS systems.

On the international level, relevant treaties were reviewed and revised, but their effort falls short, only addressing the initial step for making the new CCS technology

³⁹¹ In the United States, a few states are enforcing the Emission Trading System (ETS). For instance, California has adopted cap and trade program, which is second in size only to the EU ETS. *See California Cap and Trade*, CENTER FOR CLIMATE AND ENERGY SOLUTIONS, available at <http://www.c2es.org/print/us-states-regions/key-legislation/california-cap-trade>. Cap and trade relevant legislation in the US, such as H.R. 2454 and S. 1733, include CCS provisions. *See* PETER FOLGER ET AL., CONGRESSIONAL RESEARCH SERVICE [CRS], CARBON CAPTURE AND SEQUESTRATION IN H.R. 2454 AND S. 1733, 1-3 (2009). Additionally, there is a positive evaluation that the adoption of cap and trade systems can contribute to CCS implementation. *See* Arnold W. Reitze Jr et al., *supra* note 384 at 10479.

³⁹² *See* Donna M. Attanasio, *Surveying the Risks of Carbon Dioxide: Geological Sequestration and Storage Projects in the United States*, 39 ELR 10376, 10388 (2009).

³⁹³ *See* Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 31.

acceptable. As CCS technology expands internationally, it is necessary to look for possible relevant treaties continuously. Meanwhile, the adoption of CCS in the CDM is positively evaluated in that the adoption makes it possible for developed countries to implement CCS in developing countries. Therefore, more specific standards need to be established within the framework of the Kyoto Protocol under the UNFCCC.

Furthermore, a more internationally coherent legal and regulatory framework should be required, as it can embrace countries which try to implement coordinated CCS projects between countries outside the CDM.³⁹⁴ In this context, the following tasks will be an effort to find possible and necessary elements that can be included in a global CCS regime.³⁹⁵ Creating a CCS-specific international treaty and providing standards of technical areas can be considered. Along with this effort, it is also necessary to utilize soft law effectively, such as IMO guidelines and ISO standards, in order to provide a uniformed framework.³⁹⁶ Finally, similar to the domestic-level analysis, the international legal regime needs to look into and cope with the areas that have legal and regulatory

³⁹⁴ For example, the need for a CCS treaty regime, including multilateral and bilateral treaties, can be raised.

³⁹⁵ See ADEBOLA OGUNLADE, CENTRE FOR ENERGY, PETROLEUM AND MINERAL LAW AND POLICY [CEPMLP], CARBON CAPTURE AND STORAGE: WHAT ARE THE LEGAL AND REGULATORY IMPERATIVES?, 22 (2009), <http://www.dundee.ac.uk/cepmlp/gateway/index.php?category=62&sort=title&pg=2>; David Langlet, *supra* note 335, at 303.

³⁹⁶ In current climate governance, polycentric approaches need to be emphasized. This implies that bilateral, regional-scale, and multilateral approaches are all needed in climate-related global negotiations, and furthermore, this supports a broad attitude to climate change policy that involves private actors as well as public actors. See Daniel H. Cole, *Advantages of a polycentric approach to climate change policy*, NATURE CLIMATE CHANGE 5, 114-117 (2015).

gaps and ambiguities beyond the current initial step.³⁹⁷

V. Potential changes to legal and regulatory frameworks for CCS covering current gaps

A. Main elements and possible additions to domestic CCS legal structure

i. The government's role in permit systems

A relationship between the government and CCS business operators in which the government can play a diverse role with regard to CCS activities is important. For example, the government can conduct CCS-relevant activities, support CCS operators by providing better business environment, and surveil operator's activities. All these roles of the government are important, but it is essential for the government to play a strong role in regulating and surveilling CCS businesses.³⁹⁸ In creating a legal and regulatory system, the government needs to establish strict permit systems, encompassing each phase of capture, transportation, and sequestration, and targeting for each process within each phase.

First, in the capture process, there is a question of whether mandatory

³⁹⁷ In other words, there exist highly expected areas for review in the future, which are less explored and necessary to be regulated under an international legal and regulatory framework of CCS. *See* Kirsten Braun, *supra* note 361, at 649. For example, transboundary movement of carbon dioxide and transboundary liability from leakage occurrences can be included in this area, and they will be addressed through the next part of Section V. C (Future international regulatory system).

³⁹⁸ Meanwhile, in South Korea, whether the government can function as a CCS operator can be an important research question. *See* Sookyun Wang, *supra* note 288, at 574. This situation calls for a careful approach in order to prevent the government from undermining its regulatory role.

construction of a carbon dioxide capturing facility is reasonable or not. It is supposed that the CCS technology is first applied to fossil fuel electricity plants, steel companies, and cement manufacturers. However, these large carbon dioxide emitters are not easy to voluntarily install carbon dioxide capture facilities because of the high costs.³⁹⁹ In other words, without the obligation of mandatory installation of capture facilities, the concern of less participation in the CCS industry can arise. When it comes to the importance of timely adoption and implementation of CCS technology as a bridge technology, there is a need for a mandatory installation to some degree. For example, legislation and policies that mandate capture facility installation to new power plants over a certain scale have been proposed in some countries, such as the United States and Germany.⁴⁰⁰ Unlike the mandatory establishment applied to newly-built power plants, the forced establishment for existing power plants can be problematic, which leads to issues regarding violation of the principle of protection of confidence or principle of estoppel.⁴⁰¹ Additionally, the mandatory system has its own disadvantage of preventing the regulated from exercising the right to choose carbon dioxide mitigation options.⁴⁰² Furthermore, there is a possibility that legal obligations may be a barrier in implementing CCS within the CDM. For these reasons, the regulatory issue of mandatory installation of capture facility needs

³⁹⁹ See JongYeong Lee, *Study on the EU CCS Directive*, CHUNGANG LAW REVIEW VOL. 14(2), 11 (2012).

⁴⁰⁰ For example, German CCS legislation imposes the obligation to install facilities on new electricity generation plants larger than the scale of 300 MW.

⁴⁰¹ See SoonJa Lee, *Legal Issues Related to Carbon Dioxide Capture and Storage – Focusing on Carbon Dioxide Capture*, ENVIRONMENTAL LAW RESEARCH VOL. 37(1), 249, 279 (2015).

⁴⁰² See Michael I. Jeffery, *supra* note 105, at 466.

to be addressed carefully, while having these concerns in mind and also considering various technical and economic circumstances. It can be said that the Clean Power Plan of the United States also takes this careful attitude in that it does not include provisions that mandate the application of CCS technology.⁴⁰³

Another regulatory issue in a capture process is what elements should be included under the capture permit system.⁴⁰⁴ For example, whether the operators have enough sites for installation and whether the captured carbon dioxide stream includes any impurities can be important regulatory standards. Since capture facilities require a certain degree of space, the government needs to make sure that operators secure enough room when issuing a capture permit.⁴⁰⁵ Additionally, it is likely that carbon dioxide stream has other chemical substances (SO₂, NO, H₂S, H₂, CO, CH₄, N₂, Ar, O₂ etc.) represented during the capturing process.⁴⁰⁶ Since these impurities can be a cause of erosion of relevant facilities, which lead to a physical leakage of the carbon dioxide stream, the regulation of impurities or purities is necessary.⁴⁰⁷ The situation that no impurities are

⁴⁰³ See *infra* p. 65.

⁴⁰⁴ This permit system enables the government to identify, regulate, and control carbon dioxide emitters and relevant facilities. See BARRY BARTON ET AL., CENTRE FOR ENVIRONMENTAL RESOURCES AND ENERGY LAW, CARBON CAPTURE AND STORAGE: DESIGNING THE LEGAL AND REGULATORY FRAMEWORK FOR NEW ZEALAND, 110 (2013). Therefore, if it is necessary, the government can cancel the permit or impose administrative penalties.

⁴⁰⁵ In South Korea, there is an analysis that establishment of capture facilities in 10MW power plants is less efficient, and capture facilities installation is needed more for power plants on the 100MW scale. However, in reality, there is a concern on the shortage of space for capture facilities to accommodate these larger plants.

⁴⁰⁶ Among impurities, H₂S is categorized among toxic and corrosive substances and is known to be harmful to aquatic organisms.

⁴⁰⁷ For example, Japan has very strict standards on impurity regulations, which requires more than ninety

included is ideal, but too strict standards can create a cost burden on operators. Therefore, a careful approach in determining reasonable purity standards is also needed.

Next, when it comes to the phase of transportation of carbon dioxide, a permit system which provides installation and operation relevant standards is necessary.⁴⁰⁸ In a case of newly-established pipelines for carbon dioxide transportation, the transportation permit needs to propose specific criteria to ensure pipeline safety. For instance, the regulatory system can include standards regarding components used for installation, diameter, length, and depth of pipelines.⁴⁰⁹ Due to the need for maintaining carbon dioxide stream purity, regulations on purity can be required in the phase of transportation, as well.⁴¹⁰ On the other hand, along with the facility and operation standards which fall under pipeline operators' obligations, it is also necessary for a regulatory regime to address pipeline operators' rights. For example, provisions or regulatory policies on rates

nine percent purity of the carbon dioxide stream in CCS implementation. The kinds of purity and impurity relevant standards vary depending on the technical development. Therefore, there is an opinion that these technical elements need to be reflected in determining the level of purity and impurity regulations. *See* BARRY BARTON ET AL., *supra* note 404, at 111. Additionally, this possibility of variation and flexibility can also bring a legal and regulatory issue of delegation in which specific criteria are provided in subordinate legislation.

⁴⁰⁸ With regard to the need for pipeline permits, there exists an opposing view saying that it is unnecessary and pipeline-relevant activities are allowed by the achievement of a sequestration-relevant permit, under the preference of one single kind of permit. Another example of the single permit approach is that obtaining an injection permit even enables permit obtainers to do exploration-relevant activities. However, this concept is criticized and the phased permit concept is preferable. *See id.* It is because each phase's characteristics and risks are different and the difference brings the need for independent regulatory systems.

⁴⁰⁹ *See* Joris Koornneef et al., *Quantitative Risk Assessment of CO₂ Transport by Pipelines – A Review of Uncertainties and their Impacts*, JOURNAL OF HAZARDOUS MATERIALS VOL. 177(1), 12 (2010).

⁴¹⁰ *See* Jenifer Skougard Horne, *Getting from Here to There: Devising an Optimal Regulatory Model for CO₂ Transport in a New Carbon Capture and Sequestration Industry*, 30 J. LAND RESOURCES & ENVTL. L. 357, 372 (2010).

and access need to be included under the transportation permit system.⁴¹¹ A flexible and effective regulatory system by the government in addressing these issues can encourage the carbon dioxide pipeline industry and contribute to CCS facilitation.

Meanwhile, the nature of the interconnected system of CCS requires the middle phase of transportation, and the transportation system may need a long-distance pipeline network based on the analysis on the geological or economic elements. For this reason, a careful approach is needed in creating a legal and regulatory system for the phase of transportation. When installing carbon dioxide pipelines for CCS deployment, siting has to be inevitably conducted, and eminent domain-relevant issues can be associated with this pipeline siting. The siting can be a complicated problem, which involves a lot of landowners and stakeholders, and it needs to be resolved in an effective way.⁴¹² For example, Germany has a regulatory regime in which transportation-relevant permit issuance entails the right of eminent domain.⁴¹³ Additionally, unlike the capture process that happens in a limited area where carbon dioxide emitters are located, the transportation of carbon dioxide can be associated with many jurisdictions. Furthermore, in case of ocean sequestration, the applicable area is expanded to the ocean, which even requires pipeline facilities linking land and the ocean. This complexity of applicable areas can lead to a difficult problem in determining the appropriate government department to

⁴¹¹ The rate issue is about determining transportation service price that pipeline operators can charge. Additionally, the access concept concerns pipeline owners' allowance of their transportation capacity to others. *See id.*, at 371.

⁴¹² *See id.*, at 373.

⁴¹³ Under the article 4(5) of the German CCS legislation, the permit issuance of the pipeline installation plan empowers eminent domain of relevant estates for installing CCS pipelines.

control the transportation phase of CCS.⁴¹⁴ Regarding this concern, there is an opinion that clarity regarding government jurisdiction is required especially in the transportation system, and connection between relevant jurisdictions is also necessary if there are multiple of jurisdictions.⁴¹⁵ Moreover, considering the nature of the transportation phase and involvement of various stakeholders (operators, landowners, regulators etc.), the regulatory system needs to provide the stakeholders with the procedural opportunity to discuss together.⁴¹⁶

Finally, in the storage phase of carbon management, a more detailed and thorough legal and regulatory system has to be established since the permanent sequestration of carbon dioxide is a new concept, which still has scientific uncertainties. It is essential to propose a strong permitting system, which helps regulate a series of processes within the sequestration process, such as exploration, injection, storage, and closure. The preferable regulatory approach shown from the developed countries or recommended by the IEA is a detailed and step-by-step permit system within the area of sequestration. This attitude can enable the government to look for the unique risk of each step and to control relevant activities with detailed regulations in order for CCS risks to be prevented.

The first permit under discussion and to be required is the exploration permit or

⁴¹⁴ See SooBin Bae, A Study on the Legislative System of Carbon Dioxide Capture and Storage, at 57 (Unpublished thesis, Korea Maritime and Ocean University).

⁴¹⁵ Too many government agencies' involvement can slow CCS deployment. See Jenifer Skougard Horne, *supra* note 410, at 373.

⁴¹⁶ The German CCS legislation implemented this kind of system.

license.⁴¹⁷ The reason why this kind of permit is necessary is that exploring appropriate sites for storing carbon dioxide permanently needs to be conducted by experts with high technical skills since indiscriminate exploration causes a risk of contaminating underground. Once an exploration permit is issued, permit holders have to act within the boundary of the permit authority, which provides permit holders' rights and obligations.⁴¹⁸ For example, the exploration permit retainer has the exclusive right to explore the possible sites in the allowed area, and the exploration activities have to be performed within the limited time line.

Second, a permit regarding injecting and storing carbon dioxide is required as a main regulatory regime in the phase of sequestration. This injection permit is necessary to regulate overall injection activities with stringent requirements, and risk assessment has to be conducted as a prerequisite to obtain this permit.⁴¹⁹ The strong and detailed requirements under injection permits need to provide technical standards associated with installation and operation of injection wells. For example, criteria regarding volume, pressure, mobility of injected substances, and its maximum and minimum requirements

⁴¹⁷ The task of exploring geologically appropriate sequestration sites is required for sequestering carbon dioxide permanently. This process is essential to guarantee CCS safety as mentioned in Section III. B (technical and scientific elements for CCS). Sequestration of carbon dioxide in inappropriate sites due to wrong exploration may lead to not only a waste of CCS costs but also environmental threats.

⁴¹⁸ Additionally, in a legal and regulatory system which adopts an exploration permit system, it may be considered to provide obtainers of exploration permits with priority for the right to achieve an injection permit.

⁴¹⁹ Sequestering carbon dioxide permanently in deep underground is newly tried technology, and it is an area with difficulty in predicting potential risks. For this reason, risk assessment is significant in CCS implementation. The risk assessment needs to be submitted in each phase: exploration, injection, and closure phases. Additionally, it is necessary to conduct risk assessment in the capture and transportation process as well as sequestration process.

of the criteria as well as standards guaranteeing a sufficient geological storage site will be included in requirements under the injection permit.⁴²⁰ Additionally, for a thorough system of injection permits, permit requirements also need to include the financial ability to satisfy these technical requirements and obligations of testing and monitoring.⁴²¹

Third, for the step of closing storage sites after ceasing operation, a separate permit, named a closure permit, is required.⁴²² The important thing is that the closure permit can be issued when an operator proves that any risk of leakage is not detected and foreseen and that the government approves of the operator's proof. The main regulatory system in a closure step is about operators' periodical monitoring obligations. When the government determines that the sequestration site is safe enough for closure through the results of periodical monitoring, the closure permit will be finally issued. Many countries require a certain monitoring period spanning ten to fifty years in order to apply for a closure permit. The closure permit has meaning in that it can exempt operators from obligations which have been burdened on operators, such as liability of damage compensation caused by leakage accidents as well as monitoring duties.⁴²³

⁴²⁰ See Thomas A. Campbell, Robert A. James & Julie Hutchings, *Carbon Capture and Storage Project Development: An Overview of Property Rights Acquisition, Permitting, and Operational Liability Issues*, 38 TEX. ENVTL. L. J. 169, 179 (2008). The UIC Class VI regulation provides these technical requirements in detail.

⁴²¹ Monitoring a sequestered carbon dioxide stream's movement and detecting possible leakages are important for securing CCS safety, and monitoring needs to be conducted continuously even after CCS operation. Therefore, a long-term monitoring plan and these operators' obligations are required.

⁴²² The site closure of CCS is to close down filled space after injecting carbon dioxide, not to shut down an empty space after mining. Therefore, specific standards regarding sequestration site closure are necessary.

⁴²³ In this context, sequestration site closure is related to the issues of CCS liability and liability transfer to

ii. The government's role in risk assessment

The risk assessment is necessarily required under the legal and regulatory permit system, and thorough risk assessment conducted in each permit process can help predict and prepare for possible risks that CCS may cause.⁴²⁴ In order to apply main international environmental principles to CCS deployment as mentioned before, the risk assessment, which is based on the approach of the precautionary principle, needs to be emphasized.⁴²⁵ Additionally, the CDM's incorporation of CCS will enhance the importance of risk assessment in that authorization of CDM projects, which creates credit issuance, requires risk assessment enforcement.⁴²⁶ In these contexts, risk assessment is a key element for creating a CCS legal and regulatory system, and it is necessary for the government to come up with strengthened regulatory systems for risk assessment.

First of all, it is important to make sure that the risk assessment is enforced in each phase of CCS implementation through capture, transportation, and sequestration.

the government. *See* BARRY BARTON ET AL., *supra* note 404, at 124. These liability-relevant issues will be addressed in a later chapter because of further need for clear contents and reasonable directions.

⁴²⁴ The term "Environmental Risk Assessment" can be expressed differently in each country, such as Environmental Impact Assessment. Meanwhile, continued monitoring, verification, and monitoring are required even after risk assessment. This area is called risk management. As for the term to indicate a long-term CCS risk management, this paper uses the term "long-term stewardship."

⁴²⁵ The main purpose of risk assessment is to prevent or minimize possible harms by assessing the degree of harms as precisely as possible in advance. In addition, subsequent risk management can be conducted on the well-established risk assessment. Additionally, the risk assessment can be a useful tool to build up information or materials, which can be utilized as evaluation standards. It also can effectively contribute to greenhouse gas-relevant accounting system by providing quantitative evaluations. *See* BARRY BARTON ET AL., *supra* note 404, at 144.

⁴²⁶ *See* TaeSeob Choi et al., *Scheme on Environmental Risk Assessment and Management for Carbon Dioxide Sequestration in Sub-seabed Geological Structures in Korea*, JOURNAL OF THE KOREAN SOCIETY FOR MARINE ENVIRONMENTAL ENGINEERING VOL. 12(4), 307, 312 (2009).

The reason why phase-to-phase risk assessment is needed is that each phase of CCS has its own characteristics and inherent risks, as shown in the approach of the permit system.⁴²⁷ For example, in the capture process, chemical substances like amine-based materials can be used, and it necessitates environmental assessment of the chemical substances.⁴²⁸ Additionally, economic elements need to be considered more importantly in the risk assessment in the phase of transportation.

Specifically, the risk assessment under the phase of sequestration analyzes and evaluates health and safety hazards along with environmental effects of long-term storage of carbon dioxide, which takes place deep underground. As this is a new area, aspects of it may be hard to assess.⁴²⁹ For this reason, in order to combat this uncertainty, there is increased need to establish a strong risk assessment regime with stringent and detailed standards and comprehensive evaluation. Since each country already has legislation relevant to environmental risk assessment, it is necessary to review whether CCS risk assessment can be conducted in each phase of CCS under the existing risk assessment system. If legal and regulatory gaps regarding risk assessment are found in a phase in the series (capture, transportation, and sequestration) and a certain step within a sequestration phase (such as exploration, injection, and closure), legislative efforts to fill the gaps will

⁴²⁷ See Joris Koornneef et al., *The Environmental Impact and Risk Assessment of CO₂ Capture, Transport and Storage –An Evaluation of the Knowledge Base*, PROGRESS IN ENERGY AND COMBUSTION SCIENCE VOL. 38(1), 62 (2012).

⁴²⁸ See AIDAN WHITFIELD, AN ENVIRONMENTAL RISK ASSESSMENT FOR CARBON CAPTURE AND STORAGE, SYMPOSIUM SERIES NO. 156, 4 (2011).

⁴²⁹ According to an analysis from the IEA, it is expected that existing risk assessment system can work on CCS-relevant facilities that are located above the ground. However, it is predicted that risk assessment for CCS-relevant facilities under the ground can require a new, different approach in CCS risk assessment.

be needed.⁴³⁰

Additionally, determining which assessment items will be applied to CCS risk assessment and which methods will be utilized to evaluate CCS risks is significant. According to the assessment objectives and methods, the usefulness and effectiveness of risk assessment can vary.

First, assessment objectives, which mean targets or items listed for evaluation, need to be examined exhaustively. In other words, possible areas which may be affected by the CCS implementation need to be described in detail. For example, it can include toxicity on humans, atmosphere, groundwater, land, ecosystem, biodiversity, and acidification.⁴³¹ Additionally, there is a latest effort to incorporate evaluation standards which are relevant to social and economic elements.⁴³² As mentioned before, the social and economic elements are not only related to CCS deployment but are also important. Therefore, expanding evaluation criteria to these factors will make the CCS risk

⁴³⁰ For example, in New Zealand, two laws can be applied to risk assessment of CCS: the Resource Management Act (RMA) and CCS legislation. With regard to New Zealand's CCS risk assessment regime, it is emphasized that the contents and requirements under these two laws are closely aligned. Additionally, these two laws show a difference that the contents and requirements of the RMA are more general. On the other hand, those of the CCS legislation are more specific. *See* BARRY BARTON ET AL., *supra* note 404, at 142.

⁴³¹ It needs to be investigated if there is something omitted among evaluation targets and the affected by CCS implementation. For this, the Vulnerability Evaluation Framework (VEF) of the United States can be a useful example to systematically figure out the circumstances or conditions under which negative effects increase.

⁴³² In other words, multi-criteria decision analysis is recommended. Additionally, along with the inclusion of social and economic elements, trade-offs between socio-economic impacts and the environmental impacts need to be assessed and reflected in a CCS risk assessment system.

assessment system more complete and efficient.⁴³³

Second, evaluation methods have to be designed in the direction of proposing various and valuable scenarios, predicting behaviors based on the scenarios, and estimating effects of the behaviors.⁴³⁴ When it comes to the risk assessment methods, there may be different attitudes of emphasizing quantitative risk assessment⁴³⁵ and saying that a qualitative one is appropriate in CCS risk assessment.⁴³⁶ However, rather than stressing one evaluation methods, both methodologies need to be utilized for a more effective and realistic risk assessment. In other words, if the quantitative risk assessment is available, it is reasonable that the quantitative risk assessment has to be considered. For example, the possibility of corrosiveness increases according to the carbon dioxide concentration can be calculated.⁴³⁷ On the other hand, there are a lot of areas that have difficulty in evaluating the level of possible CCS risks quantitatively. In those cases,

⁴³³ See Hun Kang et al., *Research about the Management of CCS control with Specific Consideration of Life Cycle Assessment(LCA) and Life Cycle Costing(LCC)*, KOREAN JOURNAL OF LCA VOL. 12, 50 (2011); KyungHee Shin et al., *A Study on the Improvement Scheme of Environmental Impact Assessment in Social Environment*, ENVIRONMENTAL IMPACT ASSESSMENT VOL. 21(1), 24 (2012).

⁴³⁴ See ENVIRONMENTAL AGENCY [EA], ENVIRONMENTAL RISK ASSESSMENT FOR CARBON CAPTURE AND STORAGE 2011, 8-9 (2011).

⁴³⁵ See Behdeen Oraee-Mirzamani et al., *Risk assessment and management associated with CCS*, ENERGY PROCEDIA 1 (2013) (examining the ways probability and criticality can be calculated). From this point of view, risk analysis statistics from other fields, such as natural gas or EOR relevant risks, can be referred to for quantification. Additionally, quantified analysis issued by Occupational Safety and Health Administration (OSHA) or computer simulation models can be useful for calculating the CCS risks. See Sally M Benson et al., CARBON DIOXIDE CAPTURE AND STORAGE – ASSESSMENT OF RISKS FROM STORAGE OF CARBON DIOXIDE IN DEEP UNDERGROUND GEOLOGICAL FORMATIONS, 4 (2006).

⁴³⁶ See Jose Condor et al., *A Comparative Analysis of Risk Assessment Methodologies for the Geologic Storage of Carbon Dioxide*, ENERGY PROCEDIA 4036, 4036 (2011).

⁴³⁷ See HEE SANG GWAK, KOREAN INSTITUTE OF SCIENCE AND TECHNOLOGY INFORMATION [KISTI], QUANTITATIVE RISK ASSESSMENT OF CO₂ PIPELINE, 1-6 (2011).

qualitative risk assessment methods need to be used.⁴³⁸

Third, an important element to consider in a risk assessment system is to incorporate and reflect the public's opinions and attitudes on CCS deployment near their homes, residences and properties.⁴³⁹ The process of this public participation is called risk communication, which makes the risk assessment regime of CCS more robust, while enhancing social acceptability of CCS technology.

A few experiences on risk assessment regarding CCS projects, such as FutureGen of the United States, Det Norske Veritas (DNV) of Norway, and Gorgon of Australia, can be useful materials, since they show improved risk assessment systems with various and comprehensive tools for evaluating environmental effects from CCS implementation.⁴⁴⁰ Under the precautionary principle, the government has to play a key role in making sure evaluation objectives and methods are appropriate for CCS risk assessment and in

⁴³⁸ When it comes to assessing and analyzing CCS risks, arguments for comprehensive risk assessment system are becoming more persuasive. This option emphasizes a full range of environmental impacts assessment including consumption of energy and requires inclusion of indirect impacts as well as direct impacts. *See* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 13. For example, the European Union shows an improved system with various and analytical methods of assessment, such as comparative analysis between various scenarios and alternatives analysis between risk mitigation options, as well as an indirect environmental impacts analysis.

⁴³⁹ *See* John Strait Applegate, *A Beginning and Not an End in Itself: The Role of Risk Assessment in Environmental Decision-Making*, 63 U. CIN. L. REV. 1643, 1652 (1995).

⁴⁴⁰ In the United States, the National Energy Technology Laboratory (NETL) has produced an Environmental Impact Statement (EIS) regarding the FutureGen project. *See* US DEPARTMENT OF ENERGY [DOE], FUTUREGEN 2.0. PROJECT – DRAFT ENVIRONMENTAL IMPACT STATEMENT VOLUME I (2013). For more information on DNV reports, *see* Carbon Capture, Utilization and Storage (CCUS) –Enabling enhanced performance with carbon management technologies, *available at* <https://www.dnvgl.com/services/carbon-capture-utilisation-and-storage-ccus--5196>

responding to the need for additional evaluation tools.⁴⁴¹

Finally, even in the times prior to and after CCS operation, the government can play a positive role in risk governance regarding CCS. For example, when the government establishes an overall national strategy for CCS and delineates the scope of CCS implementation, strategic risk assessment can be utilized.⁴⁴² Since the strategic risk assessment regarding CCS features an overall evaluation of the applicability of CCS technology, it can be helpful in the step of site selection for CCS projects.

On the other hand, more importantly, the government needs to function with a long-term surveillance of safe sequestration of carbon dioxide even after site closes as a part of risk management. This is also called long-term stewardship of CCS, which is primarily comprised of (1) continued monitoring of CCS relevant risks, (2) verification, and (3) reporting of the monitoring results. The long-term monitoring is essential for CCS implementation since possible risks of leakage cannot be completely ruled out due to a change of geological strata or earthquake occurrence, even though no problem is detected for a few decades. Specifically, in enforcing monitoring for detecting long-term CCS risks, technical development is important. Additionally, monitoring techniques need to be used flexibly with an appropriate option because the technique that is applied to a CCS

⁴⁴¹ In South Korea, risk assessment enforcement regarding CCS implementation and detailed standards for the assessment may be lacking. Therefore, South Korea needs to analyze the risk assessment systems from the United States and European Union, and to adopt some necessary elements.

⁴⁴² See SUPPORT TO REGULATORY ACTIVITIES FOR CARBON CAPTURE AND STORAGE [STRACO2], SYNTHESIS REPORT, 118 (2009); Joris Koorneef et al., *Environmental Impact Assessment of Carbon Capture & Storage in the Netherlands*, 8th International Conference on Greenhouse Gas Technologies, 6 (2006). The European Union has adopted the Strategic Environmental Assessment (SEA). There are positive evaluations on the SEA because it contributes to the sustainable development concept by being carried out in early stage of businesses prior to risk assessment from a careful and precautionary approach.

project can vary depending on the site characteristics and monitoring targets.⁴⁴³

Furthermore, the question of how often the monitoring has to be enforced is also an important regulatory issue, which can be determined based on the flexibility.⁴⁴⁴

The government needs to make sure that periodic monitoring is enforced. Additionally, the government needs to function well by reviewing the consequences of the monitoring results and reflecting technical improvements of monitoring into regulatory systems. Moreover, periodical disclosure of monitoring results is significant not only in risk assessment but also in risk management. Therefore, the government needs to make the monitoring consequences easily accessible to other CCS operators and the public. Along with the public participation in risk assessment, information disclosure in risk assessment can also play a positive role for social acceptability of CCS.

iii. The need for liability transfer to the government

It is necessary to prevent CCS risks and reduce the possibility of CCS risks, but CCS technology has a potential risk of leakage accidents as a new technology.⁴⁴⁵

⁴⁴³ In other words, determining monitoring methods needs to be flexible. It is because geological formations are various and a monitoring tool which is suitable at a certain project may not be pertinent to another project. *See* BARRY BARTON ET AL., *supra* note 404, at 143. Additionally, according to criteria (e.g., measurable leakage, well integrity, injection pressure, and injection volume), different monitoring techniques can be applied to a CCS project. *See* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 12.

⁴⁴⁴ For now, there is a lack of consensus on the proper period for monitoring. *See* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 11. The countries or states that provide CCS-relevant legislation show a wide variation on monitoring periods, starting at ten years and reaching to fifty years.

⁴⁴⁵ Specifically, there is a risk of leakage accidents in the long-term, which comes with great liability. *See* Allan Ingelson et al., *Long-term liability for Carbon Capture and Storage in Depleted North American Oil and Gas Reservoirs –A Comparative Analysis*, 31 ENERGY L. J. 431, 467 (2010). When a leakage risk is perceived or a leakage accident happens, CCS operators have to take immediate measures to prevent the

Therefore, a long term liability and compensation regime is necessary, which would make the CCS legal framework more complete and induce operators or investors into participation in the CCS industry.⁴⁴⁶ Currently, ambiguous and conflicting areas regarding concepts and contents under CCS liability systems still exist. It means that a more clear interpretation and approach is required in the CCS liability context.⁴⁴⁷ More importantly, the CCS liability issue is not a simple matter but a complicated task. In the event of a CCS leakage accident, many issues, such as who will be liable, who will actually be compensated, how to determine the scope and extent of the damage, will be raised in various ways. Rather than ending with a single decision, when it comes to making a decision regarding liability issues, alternative and complementary measures for a certain decision need to be taken together while having a multi-faceted and balanced approach.⁴⁴⁸

accident and minimize the negative effects. In case of an urgent situation of a carbon dioxide leakage accident, the government's role can be imperative by directing operators to take measures or taking response measures itself.

⁴⁴⁶ See CCSREG INTERIM REPORT, CARBON CAPTURE AND SEQUESTRATION: FRAMING THE ISSUES FOR REGULATION 103 (2009).

⁴⁴⁷ See SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 15.

⁴⁴⁸ For example, in the view that the operator is liable for compensating for the damage in case of a leakage accident, there are possible issues that arise: whether it is desirable to introduce an insurance system which is unique for CCS, whether these insurances should be compulsory for operators, how to determine the coverage scope, and so on. See *Zurich Unveils Carbon Capture and Storage Insurance*, ECOLOGIST, March 1, 2009; *Zurich Creates Policies for Carbon Capture and Sequestration Needs*, CARBON OFFSETS DAILY., <http://carbonoffsetsdaily.com/news-channels/europe/zurich-creates-policies-for-carbon-capture-and-sequestration-needs-3878.htm>.

Moreover, there is a need for further discussion as to whether a more robust insurance structure in the form of reinsurance is necessary for CCS. See MARK DE FIGUEIREDO ET AL., MIT ENERGY INITIATIVE, THE LIABILITY OF CARBON DIOXIDE STORAGE 4 (2005).

It is true that operators have to be liable for leakage accidents, which is consistent with the polluter pays principle, one of the key environmental principles. However, considering the nature of CCS of extremely long-term sequestration of carbon dioxide, it is necessary to transfer the liability to the government after a certain period of time.⁴⁴⁹ This approach can be justified from a perspective of the need for a somewhat loose interpretation on the polluter pays principle in the case of CCS technology and from an aspect of the importance of the government's role in responding to the climate change crisis.⁴⁵⁰

First of all, it is necessary to review the liability regime itself before discussing the liability transfer. A variety of civil liability lawsuits, which are associated with operators' CCS activities in the processes of capture, transport and sequestration, can be raised. For example, a trespass lawsuit can arise while building CCS pipelines. Additionally, when CCS operators cause physical or property damages, such as noise and vibration, persons who are damaged from the operators' activities during the installation and operation of CCS-relevant facilities can raise negligence or nuisance lawsuits.⁴⁵¹ There is no doubt that these kinds of lawsuits will be resolved through the existing common law system.⁴⁵²

However, there is a concern that damages cannot be compensated due to the

⁴⁴⁹ See Paul Bailey, Elizabeth McCullough & Sonya Suter, *supra* note 191, at 47.

⁴⁵⁰ See *id.* at 51.

⁴⁵¹ See RICHARD MACRORY ET AL., *supra* note 325, at 28-31.

⁴⁵² See BARRY BARTON ET AL., *supra* note 404, at 217-222.

difficulty of proof of causation between operators' breach of due diligence and leakage accidents in certain circumstances. For instance, such circumstances with difficult proof of a causal link include when leakage accidents and damages from those accidents happen long after the injection and operation, or when the plaintiff does not recognize harm due to a gradual leakage and brings a lawsuit very late.⁴⁵³ In order to prepare for these situations, there is a need for strict liability. However, there are also still opposing views on the adoption of strict liability for CCS liability regimes.⁴⁵⁴

The opponents of strict liability say that it is important to consider encouraging the CCS industry and protecting CCS operators when creating a CCS liability regime. The opponents' concern is that adoption of strict liability may be a huge burden on CCS operators due to increasing liability costs.⁴⁵⁵ Additionally, they argue sequestering carbon dioxide in depleted oil reservoirs or saline aquifers cannot fall under abnormally dangerous activity required for a strict liability regime.⁴⁵⁶ On the other hand, proponents for strict liability argue that the quantity and quality of risks that CCS implementation

⁴⁵³ See *Id.*, at 215; Jan Glazewski, Legal and Regulatory Aspects of Carbon Capture and Storage: A Developed and Developing Country Perspective in *CLIMATE CHANGE: INTERNATIONAL LAW AND GLOBAL GOVERNANCE VOLUME I: LEGAL RESPONSES AND GLOBAL RESPONSIBILITY* 948 (Oliver C. Ruppel eds., 2013); NKAEPÉ ETTEH, CENTRE FOR ENERGY, PETROLEUM AND MINERAL LAW AND POLICY [CEPMLP], CARBON CAPTURE AND STORAGE: LIABILITY IMPLICATIONS 13 (2009).

⁴⁵⁴ Meanwhile, the liability transfer to the government needs to be distinguished from the concept of administrative liability. The administrative liability applies to the situation of government officers' own breach of duties. See IAN HAVERCROFT ET AL., GLOBAL CARBON CAPTURE AND STORAGE INSTITUTE [GCCSI], LEGAL LIABILITY AND CARBON CAPTURE AND STORAGE – A COMPARATIVE PERSPECTIVE 25 (2014). On the other hand, the liability transfer to the government shifts the liability, which is supposed to be burdened on operators, to the government.

⁴⁵⁵ See Victor B. Flatt, *Paving the Legal Path for Carbon Sequestration from Coal*, 19 DUKE ENVTL. L. 7 POL'Y F. 211, 220, 224 (2009).

⁴⁵⁶ See Christopher Bidlack, *supra* note 71, at 210.

may cause can constitute an abnormally dangerous activity. In addition, one opinion for strict liability points out that strict liability can relieve a court's burden or shortcomings. From the perspective, strict liability is necessary because a court's decision on whether operators exercise due diligence or not is tough and may differ depending on the characteristics of the sequestration sites.⁴⁵⁷

There are no actual law suits yet regarding CCS leakage accidents, and the issue of strict liability adoption in a CCS liability framework will be determined according to each country's legal and regulatory circumstances. However, in the early stage of CCS implementation, which has less scientific certainties, a strict liability regime needs to be established, and it has been accepted in some countries, such as Germany. Meanwhile, the liability cap under strict liability needs to be considered because too great a cost burden on CCS operators and the negative effect on CCS industry are not consistent with the CCS facilitation.⁴⁵⁸

The next discussion will go to the issue of liability transfer to the government. It is a controversial issue, and there is a great deal of difference among countries and states within a country.⁴⁵⁹ Critics who argue against the liability transfer to the government say that it is reasonable for CCS operators to assume the full liability and costs that they have

⁴⁵⁷ See Nathan R. Hoffman, *The Feasibility of Applying Strict-Liability Principles to Carbon Capture and Storage*, 49 WASHBURN L. J. 527, 560-561 (2010); David E. Adelman et al., *The Limits of Liability in Promoting Safe Geologic Sequestration of CO₂*, 22 DUKE ENVTL. L. & POL'Y F. 1, 50 (2011).

⁴⁵⁸ See Adam G. Rankin, *Geologic Sequestration of CO₂: How EPA's Proposal Falls Short*, 49 NAT. RESOURCES J. 883, 920 (2009). The CCS liability framework can have a broad spectrum, from lenient liability to a stringent one. See CCSREG INTERIM REPORT, *supra* note 446, at 105.

⁴⁵⁹ For example, the EU CCS Directive provides liability transfer to the government. On the other hand, Wyoming in the United States provides that liability transfer is not allowed. Meanwhile, Montana provides that the liability is transferred to the government under some conditions.

caused under the polluter pays principle. In other words, critics worry about violating the polluter pays principle.⁴⁶⁰ They also argue that the retention of long-term liability or indemnification of the potential hazards associated with the CCS storage process by the government provides less incentive to minimize the risks. Additionally, they point out that the government's assuming liability may be finally an undue burden to the public.⁴⁶¹

On the other hand, supporting opinions for the liability transfer to the government say that there is a high possibility of no existence of operators and it can create an unreasonable situation of not being able to be compensated by operators.⁴⁶² In other words, they say that a liability shift to the government can fill the gap regarding the subject of compensation. Additionally, they argue that the opponents' concerns can diminish when a reasonable time of liability transfer is established.⁴⁶³ In addition, they assert that CCS implementation can be included in the concept of public use, rebutting the opponents' argument.⁴⁶⁴

The liability transfer to the government is necessary for CCS legal and regulatory systems because the long-term liability under CCS implementation is an abnormally long period of time than is expected in current environmental law regimes. The government's

⁴⁶⁰ See Paul Bailey, Elizabeth McCullough & Sonya Suter, *supra* note 191, at 51.

⁴⁶¹ See Larry Nettles et al., *Carbon Dioxide Sequestration –Transportation, storage, and Other Infrastructure Issues*, 4 TEX. J. OIL GAS & ENERGY L. 27, 48 (2008).

⁴⁶² See BARRY BARTON ET AL., *supra* note 404, at 223.

⁴⁶³ See INT'L ENERGY AGENCY [IEA], *supra* note 115, at 100.

⁴⁶⁴ See Alexandra B. Klass & Elizabeth J. Wilson, *supra* note 10, at 428.

assuming liability under a CCS liability regime has more room to be justified, since overcoming the climate change crisis is an important and national level task, which can affect future generations.⁴⁶⁵ Therefore, it can be said that the liability transfer to the government would be consistent with the polluter pays principle.

Additionally, the government's liability under a CCS liability regime needs to be emphasized with regard to the CDM's incorporation of CCS.⁴⁶⁶ According to the IEA's recommendations, CCS operators from Annex I countries are obligated to take the compensation liability from leakage accidents and monitoring obligations, and then all liabilities are transferred to the host country after the end of monitoring period. When the requirements of liability and liability transfer to the government are clearly defined in a domestic CCS liability system, it can also help prepare for transboundary liability problems, which can arise within the CDM.⁴⁶⁷

Meanwhile, under the system of acknowledging the liability shift to the government, the time of the shift can vary. Generally, the liability of damage compensation can be transferred to the government along with the monitoring obligation after the monitoring period of ten years to fifty years.⁴⁶⁸ It is also important to establish

⁴⁶⁵ See EDITH BROWN WEISS, *supra* note 179, at 47; BUNWOONG KIM ET AL., ENVIRONMENTAL ADMINISTRATION 55 (2014).

⁴⁶⁶ See HyonJeong Noh et al., *Analysis of Modality and Procedures for CCS as CDM Projects and its Countermeasures*, JOURNAL OF THE KOREAN SOCIETY FOR MARINE ENVIRONMENTAL ENGINEERING VOL. 15(3), 270 (2012).

⁴⁶⁷ *Id.*

⁴⁶⁸ According to WRI's recommendations, the contents of liability, which is transferred to the government, include compensation liability for damaged persons or entities from unexpected leakage accidents and

reasonable standards regarding the time-line for the liability transfer, which is balanced and persuasive for both CCS operators and the government. Additionally, when it comes to the methods of compensation under government liability, some alternatives are considered.⁴⁶⁹ For example, industry-level funding is one option.⁴⁷⁰ It purposes to raise funds from CCS industry operators in advance in order to cover costs for compensating damages and for monitoring facilities installation.⁴⁷¹ This option can be more consistent with the polluter pays principle. Another option is government indemnification, which compensates CCS-relevant damages from government funds.⁴⁷² Additionally, both options can be utilized together. Each country needs to adopt an appropriate method of liability implementation, reflecting its own circumstances.

monitoring liability as a part of long-term stewardship. Furthermore, the climate liability under the international trading scheme, such as credit issuance-relevant liability, is transferred to the government as well according to the recommendations. *See* SARAH M. FORBES & MICAH S. ZIEGLER, *supra* note 19, at 15. However, it is possible to take an approach or interpretation that these kinds of liabilities are not necessarily transferred together at the same time. Currently, it seems that liability-relevant provisions created at a domestic level do not clearly explain the contents or scope of the liability which is transferred to the government. Therefore, clear definition or interpretations associated with the liability transfer are needed. *See* BARRY BARTON ET AL., *supra* note 404, at 226. Additionally, the concept of the government needs to be prescribed more in detail. By providing what the government means for greater certainty, such as federal, state, or both, the CCS liability regime can become more complete.

⁴⁶⁹ *See* ENERGY POLICY INSTITUTE [EPI], ANALYSIS OF LIABILITY REGIMES FOR CARBON CAPTURE AND SEQUESTRATION: A REVIEW FOR POLICYMAKERS 13 (2011).

⁴⁷⁰ Considering the possibility of any leakage or damage resulting from the CCS process in the long term, special funds or insurance schemes can be considered. However, it is also pointed out that insurers' decisions not to insure may reduce the willingness of some to invest in CCS technology. *See* DOE/NETL, *supra* note 224, at 14.

⁴⁷¹ The Price Anderson Act provides an industry-level funding scheme in preparation for the complex liability issues that can arise in the phase of post operation. *See* Thomas A. Campbell, Robert A. James & Julie Hutchings, *supra* note 420, at 185.

⁴⁷² For example, Germany requires CCS operators to deposit three percent of the allowances they obtained every year.

In conclusion, the government's role in setting up a CCS liability regime is important. The liability transfer to the government system along with operators' strict liability would be reasonable. By holding CCS operators liable stringently for the damages cause by CCS leakage accidents and at the same time making the liability transferred to the government after a certain period of time, it can be helpful and persuasive for both parties, for CCS operators and the government.⁴⁷³ Additionally, through this liability system, CCS operators can focus on preventing CCS risks due to the diminished burden within the limited period, and the government would make an effort for thorough regulating due to potential liability in the future.⁴⁷⁴

iv. Property right issues regarding CCS

1. Basic concept and importance of the pore space ownership

In order for a successful series of CCS implementation, including exploration for appropriate sites, pipeline construction, and injection facilities installation, it may be

⁴⁷³ In other words, great harmonization is needed. Furthermore, consistent and concerted agreement regarding liability scheme across national jurisdictions will be more effective when preparing for worldwide operation an implementation of CCS. *See* IAN HAVERCROFT ET AL., *supra* note 454, at 6.

⁴⁷⁴ A liability sytem is a legal issue to be solved by considering various factors, and CCS liability system should be created on the basis of considering both the relationship between the injurer and victim, and the characteristics of CCS. Additionally, it should be considered whether the cost of accidents is resolved fairly in terms of social aspects. *See* GUIDO CALABRESI, *THE COSTS OF ACCIDENTS –A LEGAL AND ECONOMIC ANALYSIS* 301-308 (1970) (stating that “The fault system may have arisen in a world one injurer and one victim were the most that society could handle adequately, and in such a world it probably was a fairly good mixed system. It did a good job of meeting our combination of goals: general and specific deterrence, spreading, justice, and even efficiency. But even assuming that such was the world in which the fault system grew, it is not today's world. Today accidents must be viewed not as incidental events linking one victim with one injurer, but as a more general societal problem”).

necessary to use or expropriate for land owners' property and/or subsurface rights. Specifically, the long-term sequestration of carbon dioxide in areas of depleted oil and gas reservoirs or saline aquifer formations inevitably raises the questions of who is the owner of the storage volume in these reservoirs (referred to as "pore space") and how CCS operators can obtain the right to use that pore space from the potential owner.⁴⁷⁵

As demonstrated before, this legal issue of large volume pore space ownership is a new and controversial topic brought by the novel aspect of CCS technology, and it needs to be resolved in the early stages of CCS activities.⁴⁷⁶ Early resolution for this issue is essential because only after the owner of pore space is determined and the right to use the area is obtained from the determined owners may CCS operators make significant progress in their activities. Additionally, the pore space ownership issue is significant, since successful and efficient CCS implementation can lie in how to deal with this issue.⁴⁷⁷ Despite its importance, there is a lack of clear delineation regarding property

⁴⁷⁵ In other words, the topic which is addressed in this part is about property rights regarding the pore space ownership. Meanwhile, as for the discussions which are associated with property in CCS legal and regulatory systems, other issues may exist, such as the ownership of carbon dioxide itself and on-land facilities during CCS implementation. It is estimated that these issues do not bring about a great disputes, and in such cases the property right of carbon dioxide or infrastructures falls within the ownership of operators concerned. Meanwhile, this part does not address intellectual property right issues. The intellectual property issues regarding CCS, such as patents for CCS relevant techniques (e.g., capture or monitoring techniques) may be worthy of other discussion.

⁴⁷⁶ The legal issue of pore space is raised in the onshore sequestration. The offshore sequestration does not involve this issue since the ocean is under state ownership or no ownership. Additionally, unlike discussions on use and expropriation of other person's estates regarding CCS implementation on the ground, the use and expropriation of the pore space for the phase of long-term sequestration of carbon dioxide under the ground may cause very complicated problems because it requires an enormous pore space based on density and sweep efficiency. *See* Alexandra B. Klass & Elizabeth J. Wilson, *supra* note 10, at 363.

⁴⁷⁷ Considering the importance of economic and social elements which were mentioned before, the establishment of a legal system, which includes methods to facilitate CCS implementation by reducing

rights of pore space at a state level as well as at a federal level. Moreover, the fact that each country or each state in a country is likely to take a different approach makes addressing this legal issue more difficult.⁴⁷⁸ The various options show that the pore space ownership can be granted to the surface owner, mineral owners, or the government. These options can be derived from each country's circumstances based on legislation or cases. Therefore, it will be practical to analyze advantages and disadvantages of these currently discussed possible options in order to find the most appropriate direction.

2. Historic and present circumstances of the pore space ownership issue including principles, cases, and legislation

In the US, the three states of Wyoming, Montana, and North Dakota have state legislation regarding pore space ownership for CO₂ storage. The state legislation provides that the surface landowners have the ownership of pore space, that is, the subsurface area below their own surface for this purpose.⁴⁷⁹ No other states have any provisions which are relevant to subsurface ownership (even though they recognize this legal issue and a

transaction costs and to enhance public acceptance of CCS by protecting private owners' interests, is needed. See Troy A. Rule, *Property Rights and Modern Energy*, 20 GEORGY MASON L. REV. 803, 804, 831 (2013). The legal regime of property has advanced along with the change of society and technology improvement. In this context, CCS technology is also requiring a new perspective and approach on an area which is considered useless from a property law perspective. See Troy A. Rule, *Property Rights and Modern Energy*, 20 GEORGY MASON L. REV. 803, 803 (2013).

⁴⁷⁸ Generally, property law has a characteristic of complexity in which various rights and accompanied obligations are involved, which is called a bundle of rights. Additionally, property law has a tendency of being developed variously and differently in each region.

⁴⁷⁹ See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *supra* note 109, at 33. The trend which supports surface owner's ownership of subsurface is gaining uniformity in the US. See Mark A. Imbrogno, *Pipedream to Pipeline: Ownership of Kentucky's Subterranean Pore Space for Use in Carbon Capture and Sequestration*, 49 U. LOUISVILLE L. REV. 291, 309 (2010).

need for legislation).⁴⁸⁰ The stance that the subsurface ownership is granted to the surface owner is based on the Latin maxim, which is called *Cujus est solum ejus est usque ad coelum et ad inferos* (hereinafter “*ad coelum et ad inferos*”), and the principle of *from heaven to hell* under the common law, which is drawn from the maxim.⁴⁸¹ These concepts say that the land owner owns space above and below the surface without limits on the extent.⁴⁸² On the other hand, due to the recognition that this *Ad Coelum et ad inferos* maxim is not an appropriate principle to apply to some underground resources, such as oil and gas, the *rule of capture* was adopted when addressing oil and gas, which are movable resources. The application of the *rule of capture* means that neighboring surface landowners cannot file a trespass lawsuit against operators associated with oil and gas development.⁴⁸³ From another aspect of the *rule of capture*, the relevant oil and gas

⁴⁸⁰ See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *supra* note 109, at 34. The CCS Review Panel of California also states that it is recommended to follow the stance shown in these three states.

⁴⁸¹ See Barry Barton, The Common Law of Subsurface Activity: General Principle and Current Problems in THE LAW OF ENERGY UNDERGROUND: UNDERSTANDING NEW DEVELOPMENTS IN SUBSURFACE PRODUCTION, TRANSMISSION, AND STORAGE 22-23 (Donald N. Zillman eds., 2014).

⁴⁸² This maxim was first introduced by an Italian lawyer Franciscus Accursius in the thirteenth century, and was later quoted by Justice Coke in the sixteen century, but after that it virtually disappeared. In the eighteen century, William Blackstone quoted this maxim again in his commentaries on the laws of England, and it subsequently influenced common law and precedents in the United States. See Daniel H. Cole, *Property Creation by Regulation –Right to Clean Air and Rights to Pollute*, in PROPERTY IN LAND AND OTHER RESOURCES 132-133 (Daniel H. Cole and Elinor Ostrom eds., 2012). It is noteworthy, however, that this was only a maxim of the Roman period, not actually Roman law. (Rather, according to Roman law, a landowner did not necessarily control the space above and below the surface, and the atmosphere was regarded as an open-access commons or common property of all. Similarly, thereafter, the maxim has never been the law in the United Kingdom. See Daniel H. Cole, *Property Creation by Regulation –Right to Clean Air and Rights to Pollute*, in PROPERTY IN LAND AND OTHER RESOURCES 134 (Daniel H. Cole and Elinor Ostrom eds., 2012); STUART BANNER, WHO OWNS THE SKY? –THE STRUGGLE TO CONTROL AIRSPACE FROM THE WRIGHT BROTHERS ON 75, 85 (2008).

⁴⁸³ See NIGEL BANKES, A PEMBINA INSTITUTE-ISEEE THOUGHT LEADER FORUM, LEGAL ISSUES

operators have no liability to the neighboring landowners, even though the developed resources came from the ground owned by those neighbors.⁴⁸⁴

Additionally, in the states with no provisions regarding pore space ownership, courts' decisions will be an important standard until legislative actions are taken. First, looking at the cases which addressed ownership above the ground can be a useful analogy when dealing with the underground ownership associated with CCS. When it comes to the ownership above the ground, the the maxim of *ad coelum et ad inferos*, which means surface owner's ownership extends to the airspace without limitation, was applied. However, the *Causby* case of 1946 changed this approach.⁴⁸⁵ In this case, the court held that the rights of the landowner can be restricted by adopting the concept of a public highway, which is discerned from the landowner's protectable property interest above the surface. Second, cases which are associated with oil and gas development, including rights of the surface owner and developer, can give more direct insights in to the

ASSOCIATED WITH THE ADOPTION OF COMMERCIAL SCALE CCS PROJECTS 8 (2008). At the time of early development of oil and gas in the US, it is likely that neighboring land-owners filed a trespass lawsuit based on the from heaven to hell doctrine, since there was an ambiguity on where the oil and gas was extracted from and whose subsurface held these resources. Due to the concerns of shrunken oil and gas development, the suggested rule of capture to prohibit this kind of trespass lawsuits was suggested. In this context that the rule of capture principle is designed for a social need of encouraging oil and gas development, it is also called as a convenience principle.

⁴⁸⁴ This is expressed as a reverse rule of capture principle. *See Id.* There is an opinion that when the reverse rule of capture principle is applied to CCS implementation, it will be a more efficient way of enabling CCS operators to obtain the right to use only from surface owners in whose land injection wells are constructed without a necessity of obtaining the right from all surface owners who have potential areas of carbon dioxide movement. *See Id.*, at 10, also *see* Christopher J. Miller, *Carbon Capture and Sequestration in Texas: Navigating the Legal Challenges Related to Pore Space Ownership*, 6 TEX. J. OIL GAS & ENERGY L. 399, 418 (2011).

⁴⁸⁵ *United States v. Causby*, 328 U.S. 256 (1946). *See* Alexandra B. Klass & Elizabeth J. Wilson, *supra* note 10, at 387.

ownership of pore spaces issue because CCS technology will be conducted in the area of depleted oil and gas reservoirs after development.⁴⁸⁶ For example, Texas is a state that has many representative cases. One case is the *Getty Oil Company* case.⁴⁸⁷ In this case, the court stated that the oil and gas developer can use the underground within the reasonable scope of a user, not as an owner, and the developer should not violate the rights of the surface owner. In the *Emeny* case, the court explicitly expressed that the ownership of pore space falls within the surface owner's right.⁴⁸⁸ Furthermore, the *Ball* case⁴⁸⁹ held that while the surface owner is the owner of the subsurface, the owner should guarantee the developer's right to use subsurface area within a necessary scope for oil and gas development, stating that the relation between the surface owner's right and developer's right is different but reciprocal.⁴⁹⁰ To sum up, the main approach of Texas is that the ownership of the subsurface is granted to the surface owner, which is similar to

⁴⁸⁶ Specifically, in a case where both surface owners and developers exist, it is necessary to address the issue of pore space ownership carefully since both of them can claim the right. In Texas, there are courts' decisions which deal with the relation between landowners and developers in their disputes. Furthermore, some cases in Texas provide the direct decision on the ownership of pore space.

⁴⁸⁷ *Getty Oil Company v. Jones*, 470 S.W.2d 618 (1971).

⁴⁸⁸ *Emeny v. United States*, 412 F.2d 1319 (1969).

⁴⁸⁹ *Ball v. Dillard*, 602 S.W.2d 521 (1980).

⁴⁹⁰ See Christopher J. Miller, *supra* note 484, at 407. There is an approach that it is reasonable for a CCS operator to get an allowance from a developer as user as well as a surface owner as owner of subsurface when inferred from these cases of Texas. See Thomas A. Campbell, Robert A. James & Julie Hutchings, *supra* note 420, at 174-175. However, another opinion argues that allowance only from the owner, regardless of the existence of land users, is enough for CCS operators since the first approach may cause a legal complexity, which lead to a delay of CCS activities. See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 35.

the stance in other states.⁴⁹¹

The civil law of South Korea, including property law, has no explicit provision to grant subsurface ownership to any entity. Instead, article 212 of the civil law provides that “Within the scope, where a justifiable profit exists, the ownership of land extends both above and below its surface.”⁴⁹² Therefore, depending on the interpretation of the word “justifiable profit,” the pore space ownership can be determined.⁴⁹³ In other words, through the interpretation of this article, the surface owner’s right can or cannot extend to the depth of pore space.⁴⁹⁴ Additionally, in South Korea, there is no explicit provision on the ownership of minerals.⁴⁹⁵ The Mining Industry Act of South Korea provides the basic contents associated with mining of underground resources, and article 2 of the Mining Industry Act stipulates that the authority to grant mining rights to minerals is the sole authority of the state.⁴⁹⁶ Thus, the development of coal can be conducted by establishing

⁴⁹¹ On the other hand, Canada takes a different attitude from the US. In Canada, the ownership of pore space after the end of development is granted to the developer, not the surface owner. *See* NIGEL BANKES, *supra* note 483, at 6.

⁴⁹² Minbeob [Civil Act], Act. No. 471, Feb. 22, 1958, art 216 (S. Kor).

⁴⁹³ In South Korea, different interpretations are possible with regards to this article 212. One opinion says that the surface owner’s ownership extends above and below the land unlimitedly, but just excising the right can be limited if necessary. On the other hand, another opinion says that this article 212 implies a limited ownership of the surface owner within a reasonable scope above and below the surface.

⁴⁹⁴ *See* KwonHong Ryu, *Ownership of Underground Pore Hole – Focused on CCS Cases in America*, DONGA UNIV. L. R. Vol. 67, 247, 265 (2015).

⁴⁹⁵ *See* JoonHo Lee, KOREA LEGISLATION RESEARCH INSTITUTE [KLRI], A COMPARATIVE LEGAL STUDY ON THE LEGAL SYSTEM OF ENERGY DEVELOPMENT IN MAJOR COUNTRIES: INTRODUCTORY REPORT, 28 (2009). (arguing that the provisions on the ownership of minerals are necessary to clarify legal relations in accordance with article 212 of the civil law)

⁴⁹⁶ Kwangup beob [Mining Industry Act], Act. No. 8355, Apr. 11, 2007, art. 2 (S. Kor.). Article 3 of the

the mining rights from the state.⁴⁹⁷

The general attitude shared by scholars is that the standard of interpretation should be based on an ordinary person's best availability to the land⁴⁹⁸, and it is within this standard that the scope of the rights of the surface landowner will be determined.⁴⁹⁹ Meanwhile, under the need for rapid underground development, there is a discussion that some area, which is assessed as valueless to the surface owner's interest in using the underground, can be exempted from the surface owner's private property right and be considered as part of the public domain.⁵⁰⁰ Similar to the debates in legislative interpretation, the supreme court of South Korea does not provide a clear and uniform standard for determining the pore space ownership. Additionally, regional courts' cases differ regarding the depth to which a surface owner's property right can extend below the

Mining Industry Act specifies the scope of minerals, including coal, oil and natural gas. Additionally, article 67 provides that access to other lands and elimination of obstacles for field surveys can be made. In order to exercise such rights, the landowner should be notified or approved, and compensated for the loss incurred (article 69).

⁴⁹⁷ Currently, there is little or no existing coal mine due to the fall of the coal industry in South Korea.

⁴⁹⁸ It means that the concept of "justifiable profit" must be objectively judged and that it does not take into account subjective circumstances, such as whether the landowner has the intention and ability to use that area. See ChangHo Ryu, A LEGISLATIVE STUDY ON PERPENDICULAR SCOPE ON LAND OWNERSHIP, KOREA LEGISLATION RESEARCH INSTITUTE [KLRI], 42 (2005).

⁴⁹⁹ Therefore, it is more likely that the approach of dividing the ownership of subsurface area with a one-size-fits-all depth is less supported and not consistent with the legislative intent in South Korea. See PanKi Kim, *A study on legal policy about use and ownership of underground space*, RESEARCH ON LAW AND POLICY VOL. 14(4), 1789, 1799 (2014).

⁵⁰⁰ However, there also exist criticisms on the public concept of land ownership. See YoungMin Cha & YuJeong Kim, *The Scope of Effect of Land Ownership of Underground Space*, LAW & POLICY VOL. 20(2), 521, 539 (2014).

surface.⁵⁰¹ However, these few cases in South Korea are not likely to have great implications in pore space ownership regarding CCS implementation because South Korea is a country which imports almost all of its oil and gas from other countries and has no analogous pore space situations to compare to the US.⁵⁰² Additionally, currently, cases concerned with subsurface ownership are primarily relevant in the area of subway construction, which relatively speaking is not deep but close to the surface when compared to the depleted oil and gas reservoirs. On the other hand, in one noteworthy case, the constitutional court of South Korea has acknowledged the *public concept of land ownership*.⁵⁰³ This concept has more room to be utilized as a reason enabling a surface owner's right to be restricted.

To sum up, with regards to subsurface ownership, the existing legislative actions and cases at a state level in the US say that the surface owner owns the subsurface. On the other hand, a clear attitude is not yet found in South Korea. Meanwhile, as explained above as the part of the domestic level analysis, Australia resolves this legal issue of pore space ownership by granting it to the Crown, which is consistent with the approach recommended by the International Energy Agency (IEA). China also grants pore space ownership to the State.⁵⁰⁴ However, even in the US and South Korea, there is still a

⁵⁰¹ See *Id.*, at 536.

⁵⁰² South Korea has an experience of producing oil and natural gas although not large quantities. This has been conducted on the continental shelf in the East Sea, and is almost nearing the end of production. Currently, South Korea shows an attitude for concentrating overseas resource development.

⁵⁰³ Constitutional Court [Const. Ct.], 88Hun-Ga13, 12 (consol.), Dec. 22, 1989 (S. Kor.).

⁵⁰⁴ Specifically, the Chinese constitution and the Mineral Resources law of China explicitly provides that the “mineral resources are owned by the State.” See GLOBAL ENERGY ASSESSMENT [GEA], GLOBAL

possibility of limiting private property rights of surface owners and acknowledging government ownership.

3. Possible options for pore space ownership and its contents, evaluations and implications

In order to implement CCS, underground areas for pipeline construction or enormous deep pore space for permanent sequestration are necessary, which requires CCS operators to obtain rights from the owners of these areas through a certain process and procedures. As demonstrated before, the CCS legal and regulatory system not only serves to regulate CCS operators for preventing risks but also to facilitate CCS implementation.⁵⁰⁵ Therefore, situations in which CCS operators' activities are delayed or disturbed from legal, regulatory, and economic barriers should be avoided. From an alternate perspective, the value of a surface owner's property rights also needs to be protected, and if the rights of the private sector are limited excessively, it may have a negative effect on social acceptance of CCS, one of the necessary elements in the CCS regime. So far, each possible option which has been suggested on who has the pore space ownership implies both advantages and disadvantages. Therefore, in current circumstances, a reasonable direction will be to first analyze both sides of each option

ENERGY ASSESSMENT: TOWARD A SUSTAINABLE FUTURE, 1044 (2012). Moreover, in China, all natural resources, such as forests, mountains, and grassland, fall within the State ownership. *See* DEBORAH SELIGSOHN ET AL., *supra* note 264, at 17.

⁵⁰⁵ *See infra* pp. 30-31.

and through the analysis explore ways to minimize disadvantages. In this context, the important principle to keep in mind is that an effort should be made in order to strike a balance between conflicting interests from CCS operators and private landowners while considering the economic and social elements of CCS.

The first option to be addressed is the surface owner's ownership. Under this approach, the maxim of *Ad Coelum et ad inferos* will be maintained, and the private owner's property right can be more protected.⁵⁰⁶ However, this approach has a great shortcoming of entailing many transaction costs, as a CCS operator must negotiate with all of the surface owners and achieve the right to use from them.⁵⁰⁷ It can make the CCS process very delayed and inefficient. Additionally, it can cause a problem of holdouts, which means that CCS projects may have difficulty in progressing activities due to private owners' opposition or suspension of the negotiations with CCS operators.⁵⁰⁸

For these reasons, it is necessary for alternatives to be suggested for overcoming such shortcomings. The first example to curb transaction costs is that the government exercises the power of eminent domain, which helps enable CCS operators to achieve

⁵⁰⁶ See CALIFORNIA CARBON CAPTURE AND STORAGE REVIEW PANEL, TECHNICAL ADVISORY COMMITTEE REPORT, APPROACHES TO PORE SPACE RIGHTS 1-2 (2010).

⁵⁰⁷ See *Id.*, at 4. This inefficiency problem of requiring all allowances from a variety of potential landowners can be expressed as the *tragedy of the anti-commons*. See Michael A. Heller, *The Tragedy of the Anticommons: Property in the Transition from Marx to Markets*, HARV. L. REV. 111 no. 3, 621, 670 (1998). The *tragedy of the anti-commons* is a contrary concept to the tragedy of the commons explained by Hardin. While the *tragedy of the commons* points out the problem of environmental damages due to the excessive use of public resources, the *tragedy of anti-commons* states that too many private rights may slow down the resource development and make valuable resources less used. See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *supra* note 109, at 54; Troy A. Rule, *supra* note 477, at 815.

⁵⁰⁸ See SEAN MCCOY, *supra* note 215, at 58.

rights for necessary sites for CCS implementation.⁵⁰⁹ With regard to the eminent domain, the Fifth Amendment of U.S. Constitution is applied, and it should be demonstrated that CCS activities fall within the public use. It is reasonable that CCS implementation is regarded as within the scope of public use, as CCS technology is a significant alternative to combat the climate change crisis, which is becoming urgent and real as shown before. However, even though the eminent domain may be rightfully exercised, the procedure of eminent domain and process of setting standards for just compensation are not straightforward, and the process may be accompanied with potential claims. In this context, the discussion on the need for proximity payment methods can be considered to reduce the time and cost, which enables efficient calculation of compensation.⁵¹⁰ Another example to relieve transaction cost problem is compulsory unitization, which enables unitization despite the objection of some surface owners.⁵¹¹ Through this, a

⁵⁰⁹ See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *supra* note 109, at 56. Currently, eminent domain power is applied to the natural gas industry in the US. See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 35.

⁵¹⁰ See Kenneth R. Richards, Joice Chang, Joanna E. Allerhand & John Rupp, *supra* note 109, at 60. For example, if the proximity payment is implemented at a state level, the state will require a CCS operator to submit expected areas to use and have the CCS operator make a dollar-per-acre payment to the surface owners. See INDIANA UNIVERSITY PUBLIC POLICY INSTITUTE, REPORT ON POLICY CHOICES AND OPTIONS 31 (February 2012)

⁵¹¹ See Bill Jeffery, *Carbon Capture and Storage: Promising Technology, But Many Legal Questions Remain*, 29 ENERGY & MIN. L. INST. 1, 24 (2008). This compulsory unitization method is utilized in the oil and gas industry in the US. In most states producing oil and natural gas (except Texas), compulsory unitization laws are adopted. According to the laws, if other potential unit members consent to constitute the unit with a sufficient percentage, it forces unwilling land owners to join the unit. The percentage can vary from state to state, ranging from 51 percent to 80 percent. See PAUL W. PARFOMAK, CONGRESSIONAL RESEARCH SERVICE[CRS], COMMUNITY ACCEPTANCE OF CARBON CAPTURE AND SEQUESTRATION INFRASTRUCTURE: SITING CHALLENGES 15 (2008). There is an opinion that this method can be applied to CCS implementation as it is used for Enhanced Oil Recovery. See AMERICAN PUBLIC POWER ASSOCIATION, CARBON CAPTURE AND SEQUESTRATION LEGAL AND ENVIRONMENTAL CHALLENGES AHEAD 3 (2007); See PAUL W. PARFOMAK, CONGRESSIONAL RESEARCH SERVICE[CRS], COMMUNITY ACCEPTANCE OF CARBON

quick negotiation with results can be reached, even though each surface owner's interest can be restricted to some extent. To sum up, in a country which grants subsurface ownership to surface owners under like the maxim in roman times, these alternatives to overcome the main drawback of high transaction costs need to be considered.

The second option is to put subsurface ownership in the area of public or government ownership, not in the area of private ownership as with the first option.⁵¹² This option says that a similar approach to the *Causby* case in which the ownership of area high above the surface is regarded as public realm, needs to be taken also in the area of deep underground below the surface.⁵¹³ The main advantage of this option is a contribution to CCS facilitation without the necessity of CCS operator's negotiations for contracts with all private owners concerned.⁵¹⁴ However, there also exist some disadvantages with this option. The first concern is that if the government declares that pore space for carbon dioxide sequestration is a public domain and therefore may be utilized without compensation to the surface owner, it may bring out a claim that this violates the takings clause of the Fifth Amendment of U.S. Constitution.⁵¹⁵ Another

CAPTURE AND SEQUESTRATION INFRASTRUCTURE: SITING CHALLENGES 15 (2008). (stating that "Oil and gas industry experience with compulsory unitization is important in the CCS context because a similar unitization process will need to be developed").

⁵¹² See James Robert Zadick, *The Public Pore Space: Enabling Carbon Capture and Sequestration by Reconceptualizing Subsurface Property Rights*, 36 WM. & MARY ENVTL. L. & POL'Y REV. 257, 260 (2011).

⁵¹³ See Thomas R. DeCesar, *An Evaluation of Eminent Domain and a National Carbon Capture and Geologic Sequestration Program: Redefining the Space Below*, 45 WAKE FOREST L. REV. 261, 289 (2010).

⁵¹⁴ See James Robert Zadick, *supra* note 514, at 268.

⁵¹⁵ See *Id.*, at 278.

critique is that this option comes from just administrative convenience. However, this public or government ownership option has an increasingly persuasive rationale on the grounds that the property value for the private sector to be anticipated or protected is less valuable than the public value of the function of CCS as a key mitigation option and the corresponding need for CCS facilitation.⁵¹⁶

The third approach is the options associated with finding a middle ground to compromise both the interests of a surface owner's property right and a CCS operator's business.⁵¹⁷ In other words, along with granting a private ownership to surface owners regarding the pore space, this approach provides that the rights of surface owners can be limited with certain standards. The first standard relates to a qualitative element. For example, a CCS operator is obliged to compensate surface owners who are also the owners of pore space only when surface owners' property value in the subsurface suffers from actual and substantial harm or the property is damaged from its ongoing economic use.⁵¹⁸ Another example under this standard is to limit surface owners' property rights only in cases when they have a reasonable and predictable interest regarding the use of subsurface.⁵¹⁹ The second standard is to limit surface owners' rights with quantitative

⁵¹⁶ The proponents for public domain of pore space state that CCS business can be facilitated by putting the management of pore space under the government. Furthermore, under this approach, the specific discussion on which government has jurisdiction over the pore space (e.g., federal, state, or regional government) is necessary.

⁵¹⁷ See CALIFORNIA CARBON CAPTURE AND STORAGE REVIEW PANEL, *supra* note 506, at 5.

⁵¹⁸ See Alexandra B. Klass & Elizabeth J. Wilson, *supra* note 10, at 404-405; Owen L. Anderson, *Subsurface "Trespass": A Man's Subsurface Is Not His Castle*, 49 WASHBURN L.J. 247, 251 (2010).

⁵¹⁹ See John G. Sprankling, *Owning the Center of the Earth*, 55 UCLA L. REV. 979, 1036 (2008).

criteria, such as limiting rights to five hundred feet or one thousand feet.⁵²⁰ Under this approach, the pore space ownership is granted to surface owners, ranging from the surface to a certain depth, and the ownership of the rest of the area below that certain depth is granted to the government. These standards have the merit of trying a balanced approach in order to determine whether or not the surface owners' property rights regarding pore space are granted.⁵²¹ However, these standards are not complete and also have criticisms. As for the qualitative standards, there is a lack of clarity, and the quantitative standard which applies uniform distance lacks consideration of specific circumstances.⁵²²

CHART 3. Options analysis on the pore space ownership issue

	Concept and type	Benefits	Drawbacks	Alternatives (to overcome the drawbacks)

⁵²⁰ This is called zone model. *See Id.*, at 1036-1038 (stating that one thousand feet seems appropriate as a specific depth for subsurface ownership, which draws on four standards that John has suggested: (1) expectations, (2) lack of possession, (3) enforcement difficulty, and (4) environmental concerns.)

⁵²¹ In other words, this opinion has both advantages of reducing too many transaction costs by limiting the scope to be negotiated and compensated and relieving the public's backlash by not directly granting the ownership to the government.

⁵²² As for qualitative standards, there is a critical view that it is difficult to decide the subsurface ownership with this standard. Additionally, under these standards, it is questionable that surface owners' property interest is to be protected and compensated. It is because pore space is likely to be considered as the area which is not substantially harmed or expected to be harmed. The qualitative standard of depth is also likely to be estimated that it is hard to be adopted since it does not consider specific circumstances.

Option 1	-surface owner's ownership	-protection of private owner's property right	<ul style="list-style-type: none"> -high transaction costs to negotiate with all the surface owners -hold-out problems -delay and inefficiency of processes 	<ul style="list-style-type: none"> -government's power of eminent domain -options to reduce transaction costs (e.g., proximity payment or compulsory unitization)
Option 2	-government ownership	-CCS facilitation without the necessity of CCS operator's negotiations with all associated private owners	<ul style="list-style-type: none"> -opposition from private owners (e.g., possibility of claim of violating Takings clause (Fifth Amendment of the U.S. Constitution)) -critique of administrative convenience 	-enhancement of public acceptance for the public value of CCS
Option 3	<ul style="list-style-type: none"> -compromising approach between the interests of surface owners and CCS operators -limiting surface owners' property rights with certain standards -two types: qualitative and quantitative criteria -balanced approach for finding middle ground 		<ul style="list-style-type: none"> -a lack of clarity, not easy to determine (in case of qualitative criteria) -may not consider specific circumstances, a flat result (in case of quantitative criteria) 	

Consequently, each country will be forced to choose an option among these suggested options. Since each option has both positive and negative characteristics, each

country will address this property right issue associated with CCS implementation according to its legal and regulatory foundations and circumstances. Therefore, a legal and regulatory system for CCS regarding the property right of pore space needs to be created in each country, not just focusing on one side's interest between the conflicting interests of surface owners and CCS operators, but also reflecting the legal background of its own country.⁵²³

CHART 4. Key legal issues and future reasonable directions for the issues

	Capture	Transportation	Sequestration	Long-term surveillance
permits	<ul style="list-style-type: none"> -Capture permit is required -Requirements (e.g., sufficient space, impurities and purities standards) 	<ul style="list-style-type: none"> -Transportation permit is required -Requirements (e.g., standards for pipeline components, diameter, length, and depth) -Operator's right needs to be guaranteed (e.g., rates and access to third parties) 	<ul style="list-style-type: none"> -Detailed and step-by-step permit system is required (e.g., exploration, injection and storage, and closure permit) -Exploration permit: requirements (e.g., technical equipment and skill, exploration time limitation) -Injection and storage permit: requirements (e.g., technical standards of injection wells, injection volume, temperature etc.) -Closure permit 	<ul style="list-style-type: none"> -Continuous and periodical monitoring is required -Operator's notification and government's supervision -Requirements (e.g., monitoring period, frequency, and techniques)

⁵²³ In case of a federal system, if each state shows a different attitude on the pore space ownership, it may also cause problems and the need for a uniform law may arise. For example, in the United States, it has been argued that an issue that is inevitably associated with various jurisdictions, such as aviation, requires the unification of relevant laws and regulations, and that interstate uniformity is particularly needed in a commercial area like aviation. *See* STUART BANNER, *supra* note 482, at 102-103, 110. This claim of uniform law in the area of aviation can also provide implications for the discipline of pore space ownership associated with CCS.

Environmental Impact Assessment (EIA)	<ul style="list-style-type: none"> -EIA is required -Requirements (e.g., risk assessment for amine based chemical materials) 	-EIA is required	<ul style="list-style-type: none"> -Strong risk assessment regime with detailed standards is required -Assessment items (e.g., effects on various fields, assessment on social and economic effects) -Assessment methods (e.g., utilizing both the quantitative and qualitative risk assessment, risk communication) 	<ul style="list-style-type: none"> -Risk management (e.g., monitoring, verification, and reporting) -Risk communication
Liability	<ul style="list-style-type: none"> -Operators are liable for leakage accidents 	<ul style="list-style-type: none"> -Operators are liable for leakage accidents -Operators can be liable to civil lawsuits (e.g., trespass, negligence, and nuisance cases) 	<ul style="list-style-type: none"> -Operators are liable for leakage accidents -Liability standards: Strict liability system and supportive system for strict liability (e.g., limitation of liability, creation of liability fund) -Operators are liable for monitoring 	<ul style="list-style-type: none"> -Liability transfer to the government -Setting up time period for the liability transfer -Long-term liability methods (e.g., liability fund raised from CCS industry operators, government liability funds and government indemnification)
Property Rights		-Eminent domain issue can be raised	<ul style="list-style-type: none"> -Pore space ownership issue (various options, such as surface owner's ownership, government ownership, and compromising approach) -Eminent domain issue can be raised according to the options regarding pore space ownership 	

B. Legislative and regulatory methods for CCS implementation

In addition to the importance of creating a CCS system which addresses

substantial issues on what kind of key legal issues the CCS has and how to treat them, the procedural issue of how to build such a system is equally significant. The forms of legislation or policy are important because they influence regulatory effectiveness as well. For instance, in federal countries, such as the US and Australia, it is necessary to analyze if a certain set of legislation or regulation is more effective between the federal and state level. Moreover, with regard to legislative form in the law-making process, it needs to be discussed whether the law should be a special act solely on CCS deployment or a comprehensive package including capture, transportation and sequestration. Furthermore, it is also necessary to carefully determine the type of legislation to analyze which details are regulated by law and which details are to be regulated by subordinate ordinances and so forth.

First, as in the federal countries, if a CCS-related law, regulation, or policy is set up at the federal level, it means that the CCS system is implemented uniformly. It is true that there is a need to establish a CCS legal and regulatory system which reflects each state's legal and economic situations. Additionally, in reality, the state governments will likely directly address key legal issues (e.g., license or authorization systems, environmental impact assessments, property right issues, and long-term liability).⁵²⁴ As discussed above, the US specifically shows difference in regulatory regimes among states concerning CCS-related legal issues. Such a patch-work of regulations can result in inefficient outcomes from the perspective of the country as a whole, no matter how well-

⁵²⁴ See *Key components of a state-level statutory & Regulatory framework to support deployment of carbon capture and storage (CCS) in the Midwest*, MIDWESTERN GOVERNORS ASSOCIATION, available at http://www.midwesterngovernors.org/CCS/MGA_CCSTF_Regulatory_Framework_Components_MAY_2011.pdf

established a system they have in their corresponding states.⁵²⁵ In this context, regarding the CCS implementation, if a CCS relevant law is legislated at the federal level, it will be useful to find out what kind of details can be incorporated preferentially.

For example, technical aspects such as the standard for carbon dioxide purity would require a considerable uniformity across the states.⁵²⁶ In other words, a federal law with a threshold may be necessary in order to prevent the states from ruling less stringently. For another example, during the transportation to a sequestration site after capture, it is highly likely for carbon dioxide transportation to pass through multiple states. Additionally, the location of sequestration itself may be in a place bordering multiple states. In such cases involving the crossing of many states' borders in the process of CCS-related facility installation, a federal-level regulation is all the more necessary.⁵²⁷ Specifically, for example, some claim that a federal-level system on siting

⁵²⁵ In federal countries, federal and state legislatures and governmental agencies have different functions and cooperate with each other by playing their own roles. Specifically, some areas need more uniformity and consistency between state legislation under a strong federal law. On the other hand, flexible and different legislation and policy is allowed or recommended on a state level in some areas. *See* Mark A. Latham, *supra* note 35, at 75-77. In case of CCS implementation, it is necessary to be addressed on a national level as a method responding to the climate change crisis, a national task. Additionally, CCS activities have a characteristic of not being limited to just a few states in a federal country. Additionally, it has a possibility of environmental harm across state boundaries. In creating a CCS legal and regulatory system, these aspects need to be considered, and a cooperative and well-allocated system between federal and state is required. *See* Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 31; Jenifer Skougard Horne, *supra* note 410, at 375-376.

⁵²⁶ *See* Jenifer Skougard Horne, *supra* note 410, at 378; GCCSI, PROJECT PIONEER – AN OVERVIEW OF FEDERAL AND PROVINCIAL REGULATORY FRAMEWORKS AND GAPS THAT GUIDE AND AFFECT IMPLEMENTATION OF CCS 37 (2011).

⁵²⁷ *See* GOVERNMENT ACCOUNTABILITY OFFICE [GAO], *supra* note 118, at 44.

and licensing should be necessary in selecting a location and issuing a license.⁵²⁸ This also relates to the argument that the exercising of the governmental eminent domain power needs to be performed at the federal level, as discussed in the above property rights issue.⁵²⁹ In such areas, federal-level rules can play a significant role, as they can clearly preempt any inconsistent characteristics among the states.⁵³⁰ On the other hand, in the areas where it is difficult to achieve uniformity among states, it may be questioned to what extent and to what scale must regulations be presented at the federal level.⁵³¹ Lastly, there could be factors requiring federal-level rules in a realistic and economic dimension. For example, there is a stance that views federal-level management as the appropriate mechanism for financial incentives for CCS implementation. Another example is that in areas requiring highly sophisticated technologies and high-quality

⁵²⁸ See PAUL W. PARFOMAK, *supra* note 511, at 25. From a perspective of regulatory efficiency, implementation consequences of states can be utilized as policy examples. In this context, there is an opinion that according to the analysis on whether or not state standards for siting are enough for regulating, a strong federal system needs to be considered. See PAUL W. PARFOMAK, *supra* note 511, at 26.

⁵²⁹ The different state level system may increase transaction costs. See Jonas J. Monast, Brooks R. Pearson & Lincoln F. Pratson, *A Cooperative Federalism Framework for CCS Regulation*, ENVIRONMENTAL & ENERGY LAW & POLICY J. 1, 13 (2012). For this reason, the federal eminent domain power can eliminate this problem of disputes and disparity due to the different state level standards. See WENDY B. JACOBS ET AL., ENERGY TECHNOLOGY INNOVATION POLICY, PROPOSED ROADMAP FOR OVERCOMING LEGAL AND FINANCIAL OBSTACLES TO CARBON CAPTURE AND SEQUESTRATION 15 (2009), also see Jonas J. Monast, Brooks R. Pearson & Lincoln F. Pratson, *A Cooperative Federalism Framework for CCS Regulation*, ENVIRONMENTAL & ENERGY LAW & POLICY J. 1, 33 (2012). Additionally, the federal system can help facilitate CCS implementation by resolving holdout problems which cause project cancellation or delay due to one country's objection. See Cyrus Zarraby, *supra* note 383, at 968.

⁵³⁰ See Mark A. Latham, *supra* note 35, at 75-77.

⁵³¹ For example, when the rationale of liability transfer to the government is strengthened, one opinion may be to have a provision of liability transfer and a minimum timeline of transfer in federal regulations and to leave details on specific timeline to state regulations. See Will Reisinger, Nolan Moser, Trent A. Dougherty & James D. Madeiros, *supra* note 32, at 29.

experts, federal-level assistance is necessary because states have difficulty in providing such experts.⁵³²

Additionally, each country also has to determine whether it is sufficient to modify or improve the existing environmental laws and regulations or whether it is necessary for a legislative special act solely created for CCS. It depends upon each country's existing legal regime, and those with a weaker base to apply CCS rules through inference needs to consider new legislation more positively.⁵³³ For example, for countries like South Korea, where oil or natural gas is not domestically produced but rather imported, their legal preparation for pore space ownership or acceptable legislation would be lower than other countries with those experiences.⁵³⁴

Furthermore, it also needs to be contemplated if a legislative form is appropriate to regulate the entire areas of capture, transportation, and sequestration or should target a single part of these areas. Of course, it is possible to mainly focus on the sequestration step, as with the EU CCS Directive or German CCS law. Such a form of legislation is based on the special CCS uniqueness of the sequestration phase. However, it would be

⁵³² See Mark A. Latham, *supra* note 35, at 77.

⁵³³ It can be more efficient to create a new CCS law including key issues which have been discussed so far in all phases of capture, transportation, and sequestration than to add or amend provisions of existing environmental laws associated with CCS implementation. This legislative method of separate CCS law would be recommended in a country where too much time and effort is predicted to be spent. For instance, Western Australia enacted legislation fitted onto a CCS project, the Gorgon project. This example, even though this type of CCS legislation is not general, implies that CCS legislation needs to be enacted and implemented in a timely manner.

⁵³⁴ Therefore, when legislative and regulatory gaps and insufficiency are also identified in other fields, such as environmental impact assessments, liability, and monitoring systems, it may be more necessary for these contents to be addressed in a general and comprehensive CCS law.

more desirable to cover all of the areas of capture, transportation, and sequestration within the framework of CCS law altogether, because the CCS itself is a technology which consists of a series of procedures where close connection is important. In other words, this can be an approach reflecting the characteristics of CCS. In the actual implementation stage, the comprehensive regulations can also be helpful for administrative convenience. When a certain country considers both onshore and offshore sequestration, a single comprehensive package will be more appropriate to ease the complications that can come from multiple pieces of legislation and implementation agencies.

Specifically, it is necessary to separately analyze the details to be dealt with in laws and other details to be included in administrative orders or rules. Some issues need to receive common, uniform regulatory application yet have much room to change in accordance with technological development.⁵³⁵ In any federal or non-federal country, the administration needs to be prepared for potential situations and determine which government agency is to take the lead for CCS implementation. Intervention of too many administrative bodies would complicate and decrease the effectiveness. Especially in the case of considering both onshore and offshore sequestration at the same time, it needs to be determined whether to concentrate all of the responsibilities on a single government agency or let multiple government agencies manage in a cooperative structure.

⁵³⁵ For example, carbon dioxide impurity can require a common standard for safe deployment of CCS both at a nation and state level, but at the same time requires room for amendments to reflect changed high criteria due to technical improvement. In this context, legislative and administrative thoroughness and details to respond to this characteristic of CCS are needed. *See* WENDY B. JACOBS ET AL., *supra* note 529, at 17.

C. Future international regulatory system

The essential and significant task is for each country to have a well-organized legal and regulatory system for CCS. However, in order to address climate change issues at a more fundamental level, such a domestic system for CCS would be insufficient. The CCS regime should work efficiently in the international dimension as well because CCS business can be implemented in close cooperation with bordering or transboundary countries through carbon dioxide export.⁵³⁶ Additionally, in a negative situation, even if a CCS regime is properly implemented in each country, leakage of carbon dioxide can occur to damage other countries unintentionally.⁵³⁷ In consideration of all of these aspects, a more effective and practical international system needs to be created.⁵³⁸

i. Regulatory systems for future transboundary CCS implementation

Transboundary CCS implementation means that the series of CCS activities in capture, transportation, and sequestration may not be limited by the boundary of any

⁵³⁶ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], TECHNICAL PAPER, TRANSBOUNDARY CARBON CAPTURE AND STORAGE PROJECT ACTIVITIES 1 (2012); Viviane Romeiro & Virginia Parente, *Carbon Capture and Storage and the UNFCCC: Recommendations to Address Trans-Boundary Issues*, LOW CARBON ECONOMY, 130, 131 (2012).

⁵³⁷ See Yvette Carr, *supra* note 67, at 140.

⁵³⁸ Even in a transboundary CCS implementation with cooperation between countries, carbon dioxide leakage accidents can happen, which can raise liability issues between countries. In such situations of CCS liability under transboundary CCS implementation, the allocation of liability between countries concerned will be an important issue, and it is differentiated from transboundary liability issue of unintentional transboundary harm to a neighboring country.

single country.⁵³⁹ As mentioned above, CCS implementation needs long-term sequestration in areas of appropriate storage sites. Therefore, countries without such a site domestically need to try to locate such a sequestration place in other countries.⁵⁴⁰ For example, actual capturing may be conducted in country A, transportation passes through countries A and B, and finally sequestration (possibly including onshore and offshore sequestration) is done in country B. Even though the possibility of actual performance between countries with regards to transboundary CCS implementation may not be high, diverse scenarios can exist. In this context, a more thoroughly-structured system for transboundary CCS implementation needs to be established by reviewing diverse

⁵³⁹ It is necessary to tell transboundary CCS implementation from CCS activities under the CDM which is explained in the part of incorporation of CCS within the CDM. The probable situation of CCS activities under the CDM is that the business entity is a CCS operator in a developed country, and all business operations of capture, transportation, and sequestration, are conducted in a developing country. However, it is also possible for the CCS project within the CDM to be performed as a type of transboundary implementation. *See* Viviane Romeiro & Virginia Parente, *supra* note 536, at 130. On the other hand, the discussion on transboundary implementation in this part is to create a legal system in which a series of CCS activities can be carried out in each different country. In other words, it means that multiple countries can participate in CCS deployment. While modalities and procedures of CCS within the CDM are established, international practice of transboundary CCS implementation is very limited, and international treaty or agreement addressing this transboundary CCS implementation does not exist yet. *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 17. Meanwhile, the IPCC has provided a guideline regarding transboundary implementation of CCS in 2006.

⁵⁴⁰ *See* CATO-2, TRANSBOUNDARY LEGAL ISSUES IN CCS – ECONOMICS, CROSS BORDER REGULATION AND FINANCIAL LIABILITY OF CO₂ TRANSPORT AND STORAGE INFRASTRUCTURE 22 (2011). Meanwhile, it is predicted that the EU has a greater possibility of associating with this type of transboundary CCS projects. *See* Andy Raine, *Transboundary Transportation of CO₂ Associated with Carbon Capture and Storage Projects: An Analysis of Issues under International Law*, CCLR 353, 355 (2008). Specifically, in the area of North Sea, a lot of CCS projects, which require cooperation between countries, have been conducted with reasons of technical and economic efficiency. *See* SCOTTISH CARBON CAPTURE & STORAGE, CARBON DIOXIDE TRANSPORT PLANS FOR CARBON CAPTURE AND STORAGE IN THE NORTH SEA REGION – A SUMMARY OF EXISTING STUDIES AND PROPOSALS APPLICABLE TO THE DEVELOPMENT OF PROJECTS OF COMMON INTEREST 2 (2015). However, a number of views in the EU show that the EU's CCS Directive does not provide practical regulations for transboundary CCS implementation. *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 8; David Langlet, *Transboundary Dimensions of CCS –EU Law Problems and Prospects*, CCLR 3, 198, 207 (2014).

scenarios associated with carbon dioxide capture, transportation, and sequestration between countries and by exploring necessary legal and regulatory schemes.

First of all, it is necessary to look for any limitation by international norms regarding the transboundary movement of carbon dioxide. One example to be reviewed is the Basel Convention. If the carbon dioxide stream of CCS is categorized as hazardous waste from an international environmental law perspective, transboundary CCS implementation can be limited by this convention.⁵⁴¹ However, considering current situations where domestic laws tend not to categorize carbon dioxide as hazardous waste, the general view is that the Basel Convention is unlikely to be applied to carbon dioxide movement under transboundary CCS implementation.⁵⁴²

Regarding offshore geological sequestration, the London Protocol needs to be reviewed for a possible restriction on carbon dioxide movement in the ocean. As shown above as the part of the current international system, the London Protocol's Annex included carbon dioxide stream in the materials permitted to be discharged to the ocean, allowing offshore geological sequestration. However, although still in controversy for interpretation, if the transboundary carbon dioxide movement is regarded as an export, it can be restricted by article 6 of the London Protocol.⁵⁴³ Therefore, in order to ensure the

⁵⁴¹ See IEA, *supra* note 115, at 32; UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 9.

⁵⁴² See Catherine Redgwell & Lavanya Rajamani, Energy Underground: What's International Law Got to Do With It? in *THE LAW OF ENERGY UNDERGROUND: UNDERSTANDING NEW DEVELOPMENTS IN SUBSURFACE PRODUCTION, TRANSMISSION, AND STORAGE* 103 (Donald N. Zillman eds., 2014).

⁵⁴³ See CATO-2, *supra* note 540, at 25.

transboundary movement of carbon dioxide at the sea, article 6 needs to be amended.⁵⁴⁴

The amendment of article was submitted by the International Marine Organization (IMO) in 2009 with this understanding. However, the dominant view is that it would take more time to be ratified and ready to be entered into force.⁵⁴⁵ This delay is because the amendment procedure under the London Protocol requires that an amendment should gain consent from two-thirds of the parties.⁵⁴⁶ Meanwhile, transboundary CCS implementation will be possible in the cases of non-marine international movement of carbon dioxide or cooperation among non-parties to the London Protocol.

If the transboundary CCS projects are to be implemented in the real world, diverse kinds of scenarios can be performed between countries.⁵⁴⁷ The first scenario is

⁵⁴⁴ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 7.

⁵⁴⁵ Currently, only two countries, Norway and the United Kingdom, have ratified this amendment of article 6 despite the need for ratification from around thirty countries. See Tim Dixon, Justine Garrett & Edward Kleverlaan, *Update on the London Protocol – Developments on Transboundary CCS and on Geoengineering*, ENERGY PROCEDIA 63, 6623, 6626, 6627 (2014). Further attention and efforts for the amendment are needed among parties of London Protocol since this article may be a major impediment to transboundary CCS implementation.

⁵⁴⁶ See IEA, *supra* note 115, at 33.

⁵⁴⁷ Meanwhile, in a case where country A and B are both the parties of Kyoto Protocol under the UNFCCC, the matter of whether or not country A and country B are Annex I or non-Annex I countries has a meaning. It is because a certain scenario depending on the results may be categorized as a form of CCS under the CDM, which requires following the rules of CDM, such as accounting or credit issuance system under the CDM. For example, with an emphasis on whether or not the capturing country is non-Annex I, there is an analysis that when capture of carbon dioxide is performed in a non-Annex I country, the CCS project falls on the CDM regardless of whether the sequestration is performed in Annex I or non-Annex I countries. See SVEN BODE & MARTINA JUNG, HAMBURGISCHES WELT-WIRTSCHAFT-ARCHIV [HWWA] DISCUSSION PAPER, CARBON DIOXIDE CAPTURE AND STORAGE (CCS) – LIABILITY FOR NON-PERMANENCE UNDER THE UNFCCC, 7 (2005). Therefore, more clear delineation of applicable scope between CCS activities under the CDM and transboundary CCS implementation is necessary. See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 5.

the case of capture in country A and sequestration in country B. In this case, country B is the importer and it may request country A to follow certain labeling or notice or tracking conditions.⁵⁴⁸ In this case, cross-border pipelines need to be constructed for carbon dioxide transportation. Therefore, as discussed in the domestic legal and regulatory issues regarding the transportation phase, both countries internationally need to agree upon legal issues, such as pipeline siting, installation, and third party access.⁵⁴⁹ Additionally, if any leakage occurs in the capture, transportation, and sequestration processes, it should be the responsibility of a country with jurisdiction over the corresponding area.⁵⁵⁰ According to the IPCC guidelines of 2006, a country of sequestering carbon dioxide is liable for the damage of leakage therefrom, an accounting of leaked carbon dioxide, and long-term monitoring.⁵⁵¹ However, some suggest that if characteristics or uniqueness of CCS are more thoroughly considered, this jurisdiction-based accountability may not be reasonable

⁵⁴⁸ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 19.

⁵⁴⁹ See CATO-2, *supra* note 540, at 12. In cases of different legal requirements regarding these issues and CCS operator's burden of meeting the requirements thereof, there would be significant hindrances for transboundary CCS implementation. See CATO-2, *supra* note 540, at 29.

⁵⁵⁰ It will be a general approach for the liability allocation between countries that a country with a jurisdiction or control over the process (e.g., capture, transportation, and sequestration) is liable for a leakage accident.

⁵⁵¹ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 21. When the captured carbon dioxide is calculated and regarded as an emission reduction in the capture country, the matter on how to clearly account carbon dioxide, which is leaked in a sequestration country, will be an important legal issue. See SVEN BODE & MARTINA JUNG, *supra* note 547, at 14. A precise system in calculating the leakage of carbon dioxide needs to be established, which brings trust between countries with equitable outcomes. Not only exclusion from calculating but also repetition of calculating must be avoided. For an exact system to account for the amount of leaked carbon dioxide, it will be a fundamental preparation for each country (for both carbon dioxide exporting and importing countries) to report the movement of carbon dioxide through inventories. The IPCC guideline of 2006 also provides these report obligations. See IEA, *supra* note 115, at 32.

enough. From the perspective of this argument, some claim that country A of capture needs to share the responsibility of leakage with country B of sequestration.⁵⁵² What matters is to make sure that liability between countries is allocated in preparation for any occurrence of leakage accidents. This clear liability distribution system of CCS can help give predictability to concerned countries under the high possibility of different liability systems in each country. Finally, as shown in the first scenario, both countries of carbon dioxide exporting and importing (countries A and B) need to cooperate in dealing with the transportation system construction or liability sharing, and other concerns. For this cooperation, an instrument to share necessary data and manage details collaboratively is needed.

The second scenario is the case of carbon dioxide capture in country A and transportation through country B to sequester in country C.⁵⁵³ The difference from the first scenario is the involvement of country B for transportation. In this scenario, setting the stance of country B will be an important issue. Without the permission of country B, the country to pass through, the procedure cannot progress, and the participation of country B will have to be guaranteed in transportation regulatory aspects.⁵⁵⁴ The

⁵⁵² In other words, from this perspective, a concern of unfairness is raised since the capture country enjoys the benefit of preventing carbon dioxide emission, and on the other hand the sequestration country has to take on the risk of leakage accidents and assume the burden of management for a long time. *See* Gustav Haver & Hans Christian Bugge, *Transboundary Chains for CCS: Allocation of rights and obligations between the state parties within the climate regime*, 4 J. EUR. ENVTL. & PLAN. L. 367, 374 (2007).

⁵⁵³ *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 26.

⁵⁵⁴ *See Id.* The transit country B can be a coastal country and pipelines for transportation of carbon dioxide can cross the country B's Exclusive Economic Zone. In this situation, the consent of transit country B with jurisdiction on the area is required. *See* CATO-2, *supra* note 540, at 27.

involved countries, countries A, B, and C, will also have to reach an agreement on the liability of country B and the extent thereof in the event of leakage during transportation. For example, it also needs to be discussed whether to make country B liable or if there is any room to distribute liability to country A and C so that country B can indemnify damages to country A or C.⁵⁵⁵

The third scenario is for country A and B to share the sequestration area. This case can be divided into two types. One is the case of capture solely in country A and sequestration in a place shared by both countries. The other is the case of capture in country A and country B separately and sequestration in a shared place. Unlike the first and second scenarios, this scenario does not show transboundary carbon dioxide transportation.⁵⁵⁶ In this scenario, as the sequestration site is shared, countries A and B especially need to build a cooperative system for a series of procedures from sequestration site selection, license issuance, environment impact assessment, and long-term monitoring.⁵⁵⁷ On the other hand, regarding the distribution of responsibility, in the first case of this scenario, country A is likely to have more responsibilities of accounting

⁵⁵⁵ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 27.

⁵⁵⁶ See *Id.*, at 21, 24.

⁵⁵⁷ See *Id.*, at 22. Specifically, as for the transboundary environmental impact assessment on the storage area, the Espoo Convention, which requires cooperation between countries, offers implications. See *Id.*, at 12. Additionally, the aspects from social elements of CCS, such as public acceptance or public participation, have to be also applied to the transboundary CCS implementation. In this context, the Aarhus Convention needs to be looked into, as it addresses access to information and public participation in decision-making regarding actions which have influential effects on the environment. See *Id.*, at 12-13. Additionally, in this scenario, cooperation among countries is required in many areas, such as access to the sequestration sites, periodic monitoring, and notification and information sharing in case of finding any unusual movement of carbon dioxide.

and compensation due to a leakage after a long time as all processes of capture, injection, and sequestration are conducted in country A alone.⁵⁵⁸ In the second case, it would be more appropriate that both country A and country B have a duty to report the amount of leakage, and responsibilities regarding leakage accidents are shared by countries A and B equally.⁵⁵⁹

The fourth scenario is the case of separate capture by country A and B and sequestration in country C, even though this scenario is less likely and less discussed.⁵⁶⁰ If the relationship between country A and C is separate from the relationship between country B and C, this scenario is not much different from the first scenario. In this scenario, the carbon dioxide stream from country A and B is mixed and sequestered together like the second type of the third scenario. Therefore, the capture countries A and B will need to cooperate and share the information associated with carbon dioxide stream purity, as well as to give notification of this information to country C.

As discussed above, transboundary CCS implementation requires cross-border cooperation for the duties of mutual notice and report, environmental impact assessments and monitoring, etc.⁵⁶¹ Such structures can work as practical ways of actively executing preventative measures under the precautionary principle, the environmental principle of

⁵⁵⁸ *See Id.*, at 22.

⁵⁵⁹ *See Id.*, at 24; *See IEA, supra* note 115, at 32.

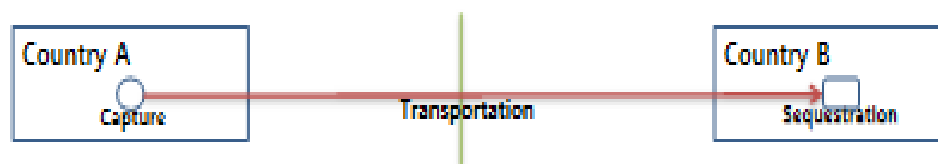
⁵⁶⁰ Unlike other scenarios that have been analyzed in previous studies, Scenario 4 has not been discussed much in research outcomes yet. Although the feasibility is somewhat low, this paper also includes this form in the analysis, considering the possibility.

⁵⁶¹ These factors are considered as key methods to realize the precautionary principle, which are emphasized under the precautionary principle.

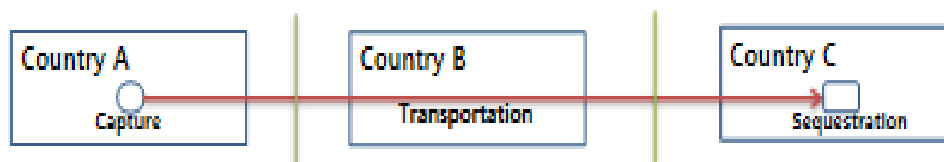
international law as looked at above.

DIAGRAM 1. Scenarios regarding transboundary CCS projects

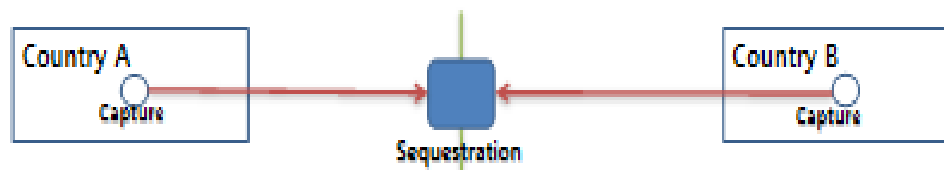
Scenario 1



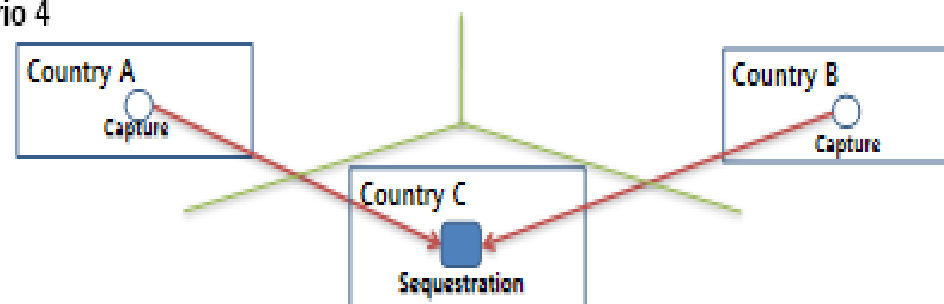
Scenario 2



Scenario 3



Scenario 4



The procedural issue for such a cooperative structure from an international level equally matters as analyzed in a domestic legal and regulatory system. Regulating this transboundary CCS within a form of multilateral framework, such as inclusion in the UNFCCC and Kyoto Protocol or an independent CCS treaty, is desirable in that CCS implementation can be controlled and managed with a global range.⁵⁶² However, practically, concluding such an agreement is not easy, and bilateral agreements between several countries involved in each CCS project are more likely.⁵⁶³ One important aspect in creating an international regime regarding transboundary CCS implementation is to make an effective and timely form of agreement and sufficiently reflect the discussion of various scenarios above.

ii. Regulatory systems for transboundary environmental liability

With such a CCS-related domestic and international legal and regulatory system in place, CCS safety will be guaranteed to the maximum extent possible. Nevertheless, however, the possibility of leakage accidents cannot be ruled out, and it means that CCS

⁵⁶² Under the system, the establishment of a CCS clearinghouse, which enables integrated management of CCS internationally, deserves consideration. *See* Mark A. Latham, *supra* note 35, at 75. This clearing house can not only function for coordinated sound policy approaches of each country but also contribute to sharing scientific research results and expertise between countries. *See* Mark A. Latham, *supra* note 35, at 73.

⁵⁶³ *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 28. This prediction is based on the experience that there have been many bilateral agreements regarding transboundary projects which are associated with oil and gas reservoir sharing. *See* UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 15-16.

implementation in one country can harm the environment of another country.⁵⁶⁴ More likely, though, leakage affects every country, because it adds to the global carbon load. Carbon dioxide is not locally, directly harmful in the way one usually thinks of transboundary pollution. Any transboundary liability scheme for CCS has yet to be set up.⁵⁶⁵ Additionally, the existing system is unclear about the possibility that a country with environmental damage by such an unexpected leakage accident can claim damage to another country. In this situation, it is important to look at the present international legal norms and customary laws and establish a clearer transboundary responsibility scheme for CCS.⁵⁶⁶ Such a system should be appropriate in making full and prompt compensation in the event of damage and be consistent with existing international environmental principles. Only in that case would the CCS liability and compensation scheme be internationally persuasive and fair, and it helps CCS technology to be well implemented in the global arena as a technology against climate change.

Examples of damage to another country in the process of CCS implementation in one country include cases where the carbon dioxide in sequestration leaks into the territory of a neighboring country after a long time to contaminate underground water or where a leakage accident occurs in an offshore geological sequestration in one country to

⁵⁶⁴ The prevailing scientific view is that the likelihood of leakage accidents and transboundary harm is low. However, without a CCS liability system regarding transboundary harm, it may discourage CCS implementation at a global level. *See* CATO-2, *supra* note 540, at 38. Therefore, international liability and compensation system for CCS is necessary and will help to increase international acceptance of CCS.

⁵⁶⁵ The transboundary liability means any liability issue that may affect more than one country. *See* DOE/NETL, *supra* note 224, at 13.

⁵⁶⁶ *See* Yvette Carr, *supra* note 67, at 148.

harm the marine environment of another country. The present international conventions, practices, and judicial precedents will be significant standards to assess if a damaged country (or its entity) can claim damages from a damaging country in the event of CCS-related transboundary environmental accidents. Although international conventions have recognized state liability for transboundary environmental pollution as a key issue, it is not very common to provide state liability in any direct manner. In the current international law, the state responsibility associated with international wrongful acts has been regulated by an International Law Commission (ILC) convention. However, an accountability structure has yet to be clearly established regarding environmental damage caused by non-illegal behaviors.⁵⁶⁷ Meanwhile, the major international precedent is the *Trail Smelter arbitration* case, which is based on the *Sic utere tuo ut alienum non laedas* principle.⁵⁶⁸ This case stated that no country has a right to cause damage to another country by the use of own territory.⁵⁶⁹ However, the concept of this principle is too broad and ambiguous to present any specific detail. Consequentially, under the present international norms, a damaged country or individual citizen of a damaged country is limited in holding a damaging country liable for CCS-related environmental damage. Therefore, this can be connected to the need to introduce a liability and compensation regime solely for CCS activities in the international law. In this sense, it is necessary to

⁵⁶⁷ With regard to the area of international liability arising from acts not prohibited by international law, the International Law Commission (ILC) has established two drafts: draft articles on prevention of transboundary harm from hazardous activities of 2001 and draft principles on the allocation of loss in the case of transboundary harm arising out of hazardous activities of 2006. *See Id.*, at 150.

⁵⁶⁸ *See* Abbas Ahdal Sharif, State Responsibility and Liability for Long Term Carbon Capture and Storage in the Event of Leakage from the Sub Seabed 25 (2014) (unpublished thesis, UiT The Arctic University of Norway).

⁵⁶⁹ *See* Yvette Carr, *supra* note 67, at 149.

look at what kind of details are to be incorporated in adopting such a liability and compensation regime.

First of all, it should be demonstrated why a state liability is necessary in the CCS accountability regime at an international level.⁵⁷⁰ Furthermore, looking at what kind of characteristics and scope the liability system would have is important. It is true that the international community has progressed toward creating a civil liability regime in preparation for international environmental damages by hazardous behaviors.⁵⁷¹ However, some conventions have adopted international liability and provided strict liability.⁵⁷² It would be reasonable to view the liability for CCS activity-caused damages as falling under the area requiring state liability.⁵⁷³ Each country has a duty to carefully supervise CCS implementation from licensing to monitoring management as a regulator, since the CCS technology still has the risk of leakage (though it is still regarded as a significant measure to overcome the climate change crisis). This perspective can be related to the point that a country's behavior should be in line with the precautionary principle, the important principle of international environmental laws.⁵⁷⁴ In this regard, countries themselves are deemed to have independent responsibility from the

⁵⁷⁰ The term “state liability” will be used in this part in order to distinguish it from the term “state responsibility,” which addresses damages and compensation associated with internationally wrongful acts.

⁵⁷¹ See Yvette Carr, *supra* note 67, at 153.

⁵⁷² For example, state liability systems are adopted with regard to damages caused by space objects or oil pollution.

⁵⁷³ See Yvette Carr, *supra* note 67, at 155.

⁵⁷⁴ See Abbas Ahdal Sharif, *supra* note 568, at 31.

responsibility that CCS operators have, which is also consistent with the polluter pays principle.⁵⁷⁵

Additionally, state liability is necessary for ensuring prompt and sufficient compensation for a damaged country suffering CCS-related damages. Given the nature of CCS, which requires long-term sequestration, state liability is all the more necessary.⁵⁷⁶ If state liability is not recognized, unfair situations may take place where compensations are made insufficiently. For instance, CCS operators may have a poor financial situation or become nonexistent after a long time.⁵⁷⁷ Another basis for the argument for state liability is the view that state interference becomes more justified in areas implying a huge possibility of damage, even though its likelihood is deemed very low, such as the risk of CCS leakage.⁵⁷⁸

Furthermore, if the state liability is recognized, it can pose another problem in setting specific standards to determine whether to include the requirements of intentionality or fault of the corresponding state agencies or officers. Though it should be more discussed, given the fact that presenting scientific proof is difficult in environmental damage lawsuits and could be more difficult in inter-country lawsuits, it would be more

⁵⁷⁵ There is an argument that a state liability may not be consistent with the polluter pays principle. However, it would be reasonable that the polluter pays principle should not be interpreted as a direction for exempting a state from its own liability. *See* Yvette Carr, *supra* note 67, at 155. In other words, a state has a liability for its unique obligations and its violations as a regulator against operators, which is independent from operators' obligation and its violations. *See Id.*, at 35.

⁵⁷⁶ *See* Yvette Carr, *supra* note 67, at 155.

⁵⁷⁷ *See* Abbas Ahdal Sharif, *supra* note 568, at 39.

⁵⁷⁸ *See* CATO-2, *supra* note 540, at 45.

persuasive to make the damaging state liable for the results regardless of intentionality or fault. Additionally, with regard to compensation scope, more specific standards are needed. For example, there needs to be regulation which includes the relevant cost of cleanup and recovery of damaged environmental resources in addition to the direct damage amount.

Such a CCS state liability scheme does not rule out the civil liability of CCS operators. Based on the polluter pays principle, CCS operators should be made liable for transboundary damages as they are the direct and major cause thereof.⁵⁷⁹ Then, the next discussion would be about how to set up the relationship between operators' liability and state liability. In this regard, there are two different stances. One approach is that a country and operator should be jointly responsible. The other approach is that the operator should take liability primarily and, if this compensation is less than enough, the state should become liable secondarily.⁵⁸⁰ Of these two approaches, the latter is more in line with the polluter pays principle, as it holds the operator liable first since the operator's liability is more direct and fundamental.⁵⁸¹ Additionally, to motivate operators

⁵⁷⁹ It is possible to provide both systems of state liability and civil liability and that this kind of CCS liability regime will be consistent with polluter pays principle and precautionary principle. With regard to a CCS operator's liability under a civil liability system, this issue on which option between fault and strict liability standard is applied will be discussed, similar to a domestic liability system. *See* Yvette Carr, *supra* note 67, at 156. The reasons supporting strict liability will still be valid in a transboundary liability system.

⁵⁸⁰ The EU's CCS Directive provides that when a member country's territorial sovereignty is violated by another member country, the offending country's competent administrative agency and CCS operator have a joint liability for the violation. This attitude is analyzed as a method to activate CCS activities.

⁵⁸¹ *See* Yvette Carr, *supra* note 67, at 155. With regard to state and operator's liability, some measures can be taken by state, such as insurance requirements for the operator for guaranteeing the operator's financial security as well as government-led fund raising for preparing state liability. *See* Yvette Carr, *supra* note 67, at 157.

not to slow their efforts to prevent environmental damages, holding CCS operators primarily liable will be fairer and more persuasive rather than holding state and CCS operators jointly responsible from the outset.⁵⁸² As seen from this, in the transboundary liability regime, there are multiple parties who bear obligations to compensate damages, such as private operators and states.⁵⁸³ Additionally, transboundary liability system which includes industry-wide funds or insurance companies as a subject of liability has been shown in international environmental treaty regime.⁵⁸⁴ Thus, the transboundary liability system including funds or insurance companies can be considered in CCS international regime, which can make CCS transboundary liability system more robust.

Which form of liability regime needs to be accepted will also be a significant issue. If a comprehensive convention on the transboundary CCS implementation is to be concluded as discussed above, building a protocol to a main convention will be another good way to set up the liability regime.⁵⁸⁵ Meanwhile, if the international CCS implementation is to be progressed in bilateral agreements and conclusion of multilateral agreements is delayed, it is reasonable to take the approach for types of soft law for this issue of liability. Although the dispute settlement process has been hardly discussed so far regarding disputes over CCS-caused transboundary liabilities that CCS may bring out, it

⁵⁸² This reason will be consistent with the reasons which were suggested for the support of liability transfer to the government.

⁵⁸³ See Ilias Plakocefalos, THE PRACTICE OF SHARED RESPONSIBILITY IN RELATION TO LIABILITY FOR TRANSBOUNDARY HARM, SHARES RESEARCH PAPER 95, 1 (2016).

⁵⁸⁴ For example, there is the Convention on Civil Liability for Oil Pollution Damage. See *Id.*, at 6.

⁵⁸⁵ Current practice with regard to the conclusion of international environmental conventions shows this trend toward a combination of a general convention with a specific protocol.

needs to be addressed whether to include dispute settlement provisions to establish a more effective liability scheme.⁵⁸⁶

D. Summary

The issues of permits, environmental impact assessments, liability, and property rights are important legal issues that should be addressed in any country implementing CCS in the future. With regard to permits, it is necessary to have a detailed permit system for each stage of the CCS life cycle. The environmental impact assessment also needs to be strengthened to allow detailed and multidimensional risk assessment. Additionally, monitoring movements of carbon dioxide stream and associated conditions is particularly significant in CCS, which needs to be meticulously addressed using both laws and enforcement decrees. This direction is intended to prevent the possibility of physical leaks in advance as thoroughly as possible. It is also a reflection of the precautionary principle in the CCS legal and regulatory system, considering the characteristics and potential risks of CCS. In the area of liability, it is necessary to provide clearer standards regarding liability bodies, scope, and period. The initial and primary liability of CCS operators and a liability transfer to the government after a certain period of time are needed, which is not in conflict with the polluter pays principle and will be a balanced approach within the interpretation of that principle. The pore space ownership issue has various options to take depending on the property law of each country. The government ownership option can help to facilitate CCS implementation and surface landowners'

⁵⁸⁶ See UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE [UNFCCC], *supra* note 536, at 31.

ownership option needs to be supported by effective eminent domain procedures with a unified agency. In the end, it is analyzed that the government can play an important and diverse role in solving these four legal issues.

A finding from an international level analysis shows the need for consensus on the fundamental technical standards among countries. The attempt to reach agreement can be done through various channels as well as treaties. It is also necessary to create an international liability system for CCS in case of liability issues between countries due to transboundary leakage. Additionally, transboundary CCS projects can be presented in various forms depending on how the CCS processes are distributed among countries. By standardizing requirements according to various scenarios, it will be helpful for smooth transboundary CCS projects, and it will be also help CCS to expend internationally.

Finally, through these international norms regarding CCS, administrative leakage (or market leakage) problems due to the different regulatory systems across countries may be reduced as well-designed domestic legal and regulatory systems can prevent the physical leakage.

VI. South Korea's legal and regulatory system for CCS

The most important and urgent task in South Korea is to create CCS legislation, a single, comprehensive law that deals only with CCS and covers the entire process of CCS. To this end, this paper provides a roadmap for South Korea's CCS legal and regulatory framework. Therefore, rather than presenting specific provisions of the CCS law, this

paper takes a more outline approach that suggests overall desirable directions of CCS system to be made, including a legislative form and government agency form. Meanwhile, in the case of the four issues that have been the subject of analysis, this paper intends to give more concrete legislative options and contents. Since each country has different situations in terms of domestic industrial structure, energy supply and demand situation, and basic legal system, the analysis on these matters will be necessary background knowledge in setting up CCS legislation and regulations. Therefore, before presenting recommendations for South Korea's domestic CCS system, these backgrounds will be briefly explained. Additionally, as both the domestic and international analysis are conducted in previous sections (Section IV and V), this section suggests recommendations on not only a domestic legal framework but also how to prepare and respond to the international aspects of a CCS system in South Korea.

A. Actual conditions and importance of CCS in South Korean industries, energy sector, and legal and administrative structures

i. South Korean industries, energy sector, and legal and administrative structure

In the 21st Conference of the Parties (COP) of the UN Framework Convention on Climate Change (UNFCCC), which was held in December 2015 in Paris, the Paris Agreement that became the foundation of a new climate system created for the participation of all countries was adopted.⁵⁸⁷ The South Korean government set the goal

⁵⁸⁷ The signing of the Paris Agreement was held in April 2016, and 175 countries participated in it. This shows a global will to resolve the climate change problem and also enables a positive outlook for an early entry into force of the Paris Agreement. This Paris Agreement will be open for signature for one year from April 22, 2016. According to article 21 of the Paris Agreement, it will enter into force when fifty-five or

of a reduction in greenhouse gas emissions to 37 % for Business As Usual (BAU) by 2030.⁵⁸⁸ To achieve the carbon dioxide reduction goal in South Korea, CCS technology is essential and is expected to play a critical role.⁵⁸⁹ This paper reviews the meaning and potential impact of CCS technology for South Korea. The necessity of CCS technology and establishing legal and regulatory systems for CCS in South Korea is more persuasive upon understanding South Korea's industrial structure and energy sector.

The main industries of South Korea, such as automobiles, shipbuilding, semiconductor, and steel, require the installation of heavy equipment that highly relies on fossil fuel energy. Of the energy sources for the South Korean power supply, oil (37.8%), coal (29.3%), and liquefied natural gas (18.7%) account for high proportions.⁵⁹⁰ Nuclear

more countries ratify and the amount of greenhouse gas emissions of the countries accounts for at least fifty-five percent of total global emissions. Additionally, under article 4 of the Paris Agreement, each party should suggest nationally determined contributions (NDCs) every five years and have it communicated. *See* MoonHyun Koh & TaeYoung Ahn, *Legal Issues of CCS*, SOONGSIL L.R. VOL. 35(1) , 31, 34 (2016), *also see The Paris Agreement Summary*, CLIMATEFOCUS, *available at* <http://www.climatefocus.com/sites/default/files/20151228%20COP%2021%20briefing%20FIN.pdf> Recently, the United States and China, the world's two biggest carbon emitters, formally joined the Paris Agreement, *available at* http://www.nytimes.com/aponline/2016/09/03/world/asia/ap-as-obama-china.html?_r=0

⁵⁸⁸ This reduction aim is higher than the initial goal of 30% reduction for BAU by 2030. It is evaluated that South Korea set up a strengthened target when compared with other countries' reduction targets. *See* DongKyun Seo & WonSoon Kwon, *Economical and Environmental Study on SNG Combined Cycle Integrated with CCS for Large-Scale Reduction of CO₂ (Based on NETL Report)*, KOREAN HYDROGEN AND NEW ENERGY SOCIETY VOL. 26(5), 499, 500 (2015).

⁵⁸⁹ In 2014, South Korea's government established strategies for core technology development in order to respond to climate change and selected the top six technologies, which included CCS: solar cell, fuel cell, bio-energy, secondary cell, power information technology, and CCS. *See* KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *STUDY ON THE INVESTMENT EFFICIENCY OF CLIMATE CHANGE RESPONDING TECHNOLOGIES THROUGH CURRENT CIRCUMSTANCES ANALYSIS –FOCUSED ON RENEWABLE ENERGY, NUCLEAR POWER, AND GREENHOUSE GAS TREATMENT TECHNOLOGIES* , 5 (2016).

⁵⁹⁰ In South Korea, thermal power generation accounts for over 85% of energy generation. Therefore, it is

energy amounts only to 10.4%, and renewable energy (solar power, wind power, tidal power, etc.) amounts to 3.2% or so.⁵⁹¹ The industrial structure and makeup of the energy sector lead to a massive amount of greenhouse gas emissions. Among OECD member countries, South Korea had the highest increased rate of greenhouse gas emissions.⁵⁹² Therefore, the ultimate energy system goal is to develop low carbon energy sources. The South Korean government also economically supports research and development in the renewable energy field and has prepared legislative system for distributing and developing new renewable energy.⁵⁹³ However, South Korea has yet to develop renewable energy on a significant level and faces economic and geographical restrictions

more likely that CCS implementation can have positive effects on South Korea under this industrial structure. *See* MoonHyun Koh & TaeYoung Ahn, *supra* note 587, at 38. Meanwhile, the synthetic natural gas which is obtained from coal can be connected to CCS technology, and there is an analysis that this connection can be a competitive alternative by using the pre-combustion capture technology for carbon dioxide. *See* DongKyun Seo & WonSoon Kwon, *supra* note 588, at 500. Additionally, with regard to energy resources, South Korea's energy resources system is characterized by a substantial dependence on imports from other countries, and the dependence on imports of energy resources accounts for about 95% of the energy sector. This situation shows that the energy security of South Korea is vulnerable. *See* YounSang Lee, *Nuclear Power Dilemma*, KukminIlbo, February 16, 2015, *available at* <http://news.kmib.co.kr/article/view.asp?arcid=0922962840&code=11151400&cp=nv>. As for a characteristic with regard to the electricity industry structure of South Korea, Korea Electric Power Corporation (KEPCO), which is not a private enterprise but a public enterprise, exclusively produces and supplies electric power of South Korea. The government of South Korea owns 51% of all shares and, the KEPCO is comprised of five affiliated branches: Korea South-East Power, Midland Power, Western Power, Southern Power, and East-West Power Co., Ltd.

⁵⁹¹ *See* YounSang Lee, *supra* note 590.

⁵⁹² *See infra* Section IV. A. iv. 1.

⁵⁹³ As of 2015, the investment scale in the field of research and development for greenhouse gas treatment amounts to ninety-one billion KRW (Korean Won). On the other hand, the investment in the field of renewable energy reaches four hundred and forty billion KRW. *See* KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *supra* note 589, at 44-45.

to the switch to renewable energy system.⁵⁹⁴ More interest has been drawn in CCS technology that helps to maintain the conventional fossil fuel energy- centered system and treat a massive amount of carbon dioxide.⁵⁹⁵

In addition, a basic understanding of the South Korea's legal and administrative structure is required for any preparation of a law relating to CCS, which is the ultimate purpose of this paper, and makes it possible to prepare a more systematic and efficient law. With regard to the basic legislative system in South Korea, there is the Constitution (the supreme law), Acts, Presidential decrees, and Ministerial ordinances. The legislative system is based on a strict hierarchical order, and lower laws should not violate upper laws.⁵⁹⁶ In terms of lower laws, there are administrative rules and the ordinances and rules of local governments.⁵⁹⁷ To come up with a systematic and comprehensive legal

⁵⁹⁴ Taking into account geographical conditions in South Korea, there are difficult aspects for renewable energy development. For example, in South Korea, continuous electricity production and supply can be limited due to the monsoon climate as well as the small and overpopulated territory. This is called the intermittence problem of renewable energy resources. See YounSang Lee, *supra* note 590.

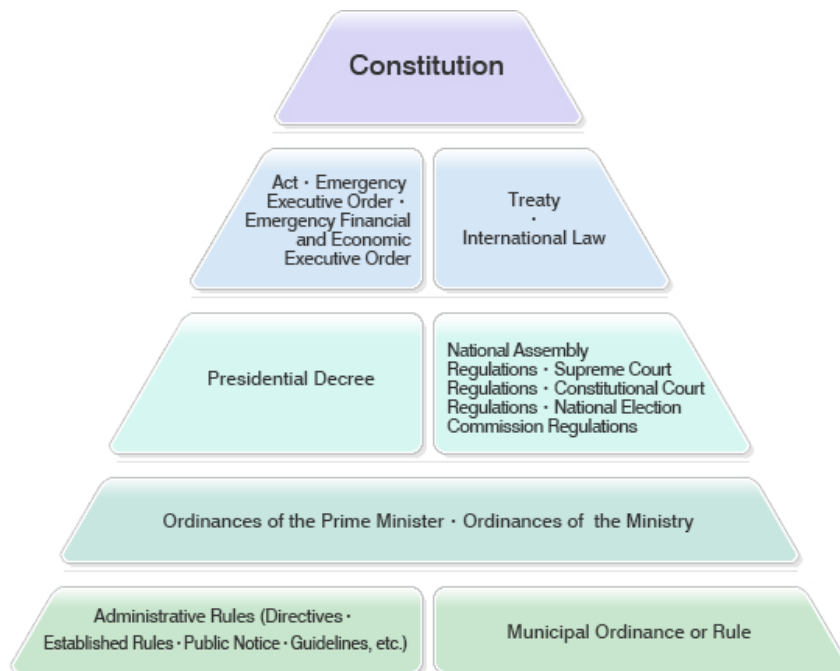
⁵⁹⁵ See JooSuk Lee & EunChul Choi, *The Economic Impacts of CCS Marine Geological Storage Demonstration Project on the National Economy using Input-output Analysis*, OCEAN AND POLAR RESEARCH VOL. 38(1), 71, 72 (2016).

⁵⁹⁶ Both presidential orders issued by the President and ministerial orders issued by the ministers of each department have the same effect. None of these executive orders violate laws, the higher-level legislation above these executive orders. According to article 26 of the Government Organization Act of South Korea, there are currently seventeen executive ministries. See NATIONAL LAW INFORMATION CENTER, <http://www.law.go.kr/lsSc.do?menuId=0&subMenu=1&query=government%20organization#undefined>

⁵⁹⁷ The current administrative structure of South Korea is comprised of seventeen provincial level divisions: eight provinces (Gyeonggi, Gangwon, North Chungcheong, South Chungcheong, North Jeolla, South Jeolla, North Gyeongsang, South Gyeongsang), one special autonomous province (Jeju), one special city (Seoul), six metropolitan cities (Incheon, Busan, Daegu, Gwangju, Daejeon, Ulsan), and recently designated metropolitan autonomous city (Sejong). Each provincial-level division has its own local council and heads of local government in which ordinances and rules can be created. These ordinances and rules, which address local matters, play an important role for each local government to function well.

and institutional framework for CCS, it is necessary to take into account not only acts, but enforcement decrees and ordinances. Aside from the legislative system in the National Assembly and the government dimension, it is necessary to set forth guidelines and rules for CCS businesses in the industry dimension.

DIAGRAM 2. Hierarchy of Acts & Subordinate Statutes



Source. KOREA LEGISLATION RESEARCH INSTITUTE, Statutes of the Republic of Korea

(http://elaw.klri.re.kr/eng_service/struct.do)

ii. Actual conditions and meaning of CCS in South Korea

To narrow the gap with developed countries, South Korea has made an effort to develop and commercialize the source technology of CCS and has seen some outcomes. Nevertheless, some outcomes fail to realize research and development plans suggested by

the government, and there are concerns over delayed development of CCS technology and commercialization. More specifically, the South Korean government intended to determine a storage place by the mid-2010s, and tried to complete integrated verification of capture and storage of a large 100 MW (megawatt) plant and commercialize it by 2020.⁵⁹⁸ As of now, a 10 MW-carbon dioxide capture plant (treatment amount: 200 tons/day) that is in the step right before the commercialization step is installed in the Boryeong thermal power plant site division of Korea Midland Power Co., Ltd, and in the Hadong thermal power plant site division of Korea Southern Power Co., Ltd., and their performance is being tested.⁵⁹⁹

The core task of CCS execution is where to secure a geological storage system for injected carbon dioxide. Because of the lack of suitability for storage in the onshore geology, South Korea has focused its explorations efforts in the offshore environment. To find such an offshore site, the Ministry of Oceans and Fisheries has researched candidate storage sites since 2010. As a result, a candidate site near the continental shelf of Ulleng Basin has been found that could support a large scale one million ton test.⁶⁰⁰ However, to

⁵⁹⁸ See DaeHyun Im, *Carbon Capture and Storage – current conditions and future tasks*, KISTI MARKET REPORT VOL. 3(4), 12, 15 (2013).

⁵⁹⁹ See JiHyun Lee et al., *supra* note 88, at 111. These small- and medium-sized CCS projects' implementation can be contributable to future CCS commercialization by providing experiences and track records necessary for large-scale CCS projects with construction of capture facilities over 100MW or 300MW. See Arom Kim & HyungMok Kim, *Scenario Analysis of Injection Temperature and Injection Rate for Assessing the Geomechanical Stability of CCS (Carbon Capture and Sequestration) System*, TUNNEL AND UNDERGROUND SPACE VOL. 26(1), 12, 13 (2016).

⁶⁰⁰ The Ulleng Basin, which is 60-90 kilometers away from the metropolitan city of Ulsan, is located in the sedimentary layers of the continental shelf of the East Sea, 800-3000 meters below sea level. Currently, it is estimated that this storage site can store about 5.1 billion tons of carbon dioxide. When calculated with the criterion of sequestering 32 million tons of carbon dioxide annually, which is the target to reduce

determine if the Ulleng Basin is a suitable place, an evaluation of the subsurface geology of the site using seismic surveys and a drilling survey is required. In April 2015, the Ministry of Oceans and Fisheries applied for a preliminary feasibility survey, and a relevant survey is in progress. If the site is found to be satisfactory, it is estimated for the South Korean government to invest 722.5 billion KRW (Korean won) from 2016 to 2025 and establish the first CCS offshore geological sequestration site in the country capable of storing one million tons of carbon dioxide annually.⁶⁰¹ An additional advantage of offshore geological sequestration is that onshore geological storage requires additional social expenses caused by pore space ownership issues and compensation costs.⁶⁰² Nevertheless, there is a lack of research on systematic systems for integrating and connecting capture, transport, and storage. There can be various transport scenarios

through CCS by 2030, this scale is such that South Korea can sequester carbon dioxide for more 150 years. See YeonGeun Jung, *Finding for CO₂ storage site responding to new climate systems*, NAEIL TIMES, December 8, 2015.

Besides this storage site, South Korea's government has searched western and southern oceans as well. In 2014, the *Ministry of Marine Affairs and Fisheries* and *Korea Maritime Institute of Science and Technology Laying Vessels Offshore Plants* published a carbon dioxide storage map containing potential distribution of the promising subsea structures of South Korea and possible storage capacity associated with each structure. For example, this map includes carbon dioxide storage structure of Gunsan Basin in the West Sea and Jeju Basin in South Sea, as well as Ulleng Basin in the East Sea. See JooSuk Lee & EunChul Choi, *supra* note 595, at 73.

⁶⁰¹ See YeonGeun Jung, *supra* note 600.

⁶⁰² *Id.* However, South Korea has possibilities to find onshore storage sites and is looking into a few possible sites on land, such as Gyeongsang Basin, Bukpyeong Basin, and Pohang Basin. See NATIONAL INSTITUTE OF ENVIRONMENTAL RESEARCH [NIER], INTERNATIONAL EXCHANGE SOURCEBOOK FOR CCS ENVIRONMENTAL MANAGEMENT 45 (2013).

including land pipeline transport, ocean pipeline transport, and ship transport, and research on how to use them is still being conducted.⁶⁰³

Given the actual conditions of the South Korean industry and energy systems, CCS is essential as a promising technology and important plan for accomplishing the goals of limiting global temperature rise, responding to climate change, and achieving South Korea's goal of aggressive reductions in carbon dioxide emissions.⁶⁰⁴ In the meantime, the CCS market is predicted to keep expanding and grow larger globally.⁶⁰⁵ Therefore, it is time to secure the competitiveness of CCS in South Korea. For example, carbon dioxide capture technology development and its export, as well as the construction of CCS plants and CCS plant exports can contribute to economic development in South Korea.⁶⁰⁶ A lot of developed countries use onshore geological storage, whereas South Korea takes into account offshore geological sequestration of

⁶⁰³ See ByeongYong Yoo et al., *A feasibility study of CO₂ marine transport in South Korea*, ENERGY PROCEDIA 37 (2013); JongHoon Han, *Study on CCS infrastructure through the analysis of CCS industry and actual conditions*, GREEN TECHNOLOGY TREND REPORT VOL. 2011(1), 131, 141 (2011). Transportation through ships (with the application of carbon dioxide transport vessels) could be a leading example of a CCS project where South Korea has a competitive position. Additionally, there is a positive view that offshore technology associated with carbon dioxide transportation will be in favor of South Korea, given South Korea's competitiveness in the shipbuilding industry, which will be helpful for CCS implementation in South Korea. See JooSuk Lee & EunChul Choi, *supra* note 595, at 73; Yosep Kim, *Elimination of CCS uncertainty for commercialization*, <http://www.hellodd.com/?mt=view&pid=56818>

⁶⁰⁴ See MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 38.

⁶⁰⁵ See Kyongho Kim, *Carbon Capture Storage and Unitization technology*, KISTI MARKET REPORT VOL. 2(12), 4 (2011).

⁶⁰⁶ See JooSuk Lee & EunChul Choi, *supra* note 595, at 71-78.

carbon dioxide captured by power plants.⁶⁰⁷ If CCS is successfully executed in South Korea, that success can offer good technological and legal suggestions to developing Asian countries that need the establishment of new CO₂ emitting power plants and have the high possibility of offshore geological sequestration. In South Korea, the noticeable effort to respond to climate change and greenhouse gas emissions also includes executing a carbon emission trading system and attracting the Green Climate Fund (GCF), which shows not only the South Korean government's will and effort to resolve climate change issues, but the gradually increasing role of South Korea in international society.⁶⁰⁸ Accordingly, it is more important to execute CCS successfully and prepare CCS legal and regulatory systems thoroughly in South Korea. Such actions will contribute to the active participation of the South Korean government in the global activities for addressing climate change issue.

B. Current state of CCS legislation in South Korea and future desirable directions to consider in preparing CCS legislation

The South Korean government established the comprehensive framework to respond to national climate change in 2008, launched the *Presidential Committee on Green*

⁶⁰⁷ See *Promoting offshore CCS for greenhouse gas reductions*, THE MINISTRY OF OCEANS AND FISHERIES, available at <http://www.mof.go.kr/article/list.do?menuKey=376&boardKey=10>

⁶⁰⁸ Therefore, South Korea is faced with some new tasks of settling down a carbon emission trading system and interlocking it with a CCS legal and regulatory system for efficient implementation of CCS. Additionally, when taking into account the necessity of international financial support to developing countries for reducing carbon dioxide emissions and the possibility of financing through Green Development Fund (GDF), South Korea's role may be more important as a host country of the GDF. See GLOBAL CCS INSTITUTE [GCCSI], *THE GLOBAL STATUS OF CCS 2015, SUMMARY REPORT*, 12-13 (2015).

Growth in 2009, and announced the national climate change adaptation plan in 2010.⁶⁰⁹ In addition, the government established the *National CCS Comprehensive Plan* in 2010 as an effort to deal with CCS directly.⁶¹⁰ According to the *National CCS Comprehensive Plan*, the *Presidential Committee on Green Growth* operates the general consultative group of CCS technology development, and the *Ministry of Strategy and Finance* supports the budget and financing. The *Ministry of Education, Science, and Technology*, the *Ministry of Knowledge Economy*, the *Ministry of Land, Transport, and Maritime Affairs*, and the *Ministry of Environment* perform CCS technology development in each field.⁶¹¹ Five years after the establishment of the *National CCS Comprehensive Plan*, each policy task was analyzed for finding outcomes and assessing the current state accurately to determine if the plan is well implemented.⁶¹² In the analysis, it is necessary to understand the possibility of changing an original goal and design the 2nd CCS comprehensive plan for more realistic and achievable execution. One noticeable point of

⁶⁰⁹ See KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *supra* note 589, at 15.

⁶¹⁰ See DaeHyun Im, *supra* note 598, at 15. The roadmap for reduction targets of greenhouse gas, which is produced by the *Ministry of Environment*, also considers CCS technology as one of the core reduction methods.

⁶¹¹ See KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *supra* note 589, at 52. For example, the Ministry of the Environment seeks to develop techniques for detecting and managing possible CCS risks and techniques for evaluating environmental effects when carbon dioxide is sequestered in deep underground. For doing this, the *Ministry of the Environment* started Korea- CO2 Storage Environmental Management (K-COSEM) Research Center in April of 2014, and the research resulting from this center is supposed to be reflected in law or policies relevant to CCS. In particular, this kind of research by the *Ministry of Environment* is even more necessary to be linked with technical developments, which are conducted under other ministries. See MoonHyun Koh & TaeYong Ahn, *supra* note 587, at 66.

⁶¹² This analysis covers overall areas regarding not only technical development of capture, transportation, and sequestration but also legal system improvement, interdepartmental cooperation, and international cooperation.

the execution analysis was that relevant laws and systems failed to be established sufficiently in terms of CSS implementation.⁶¹³

The absence of laws pertinent to CCS causes more uncertainty in CCS implementation.⁶¹⁴ An improvement in the CCS legislative system is meaningful as it would suggest the regulatory direction of the government, and such a suggestion of direction to industrial circles and enterprises would enable greater certainty and motivation.⁶¹⁵ When it comes to the South Korean CCS legal conditions, the *Ministry of Oceans and Fisheries*, the *Ministry of Trade, Industry and Energy*, and the *Ministry of Environment* drew up multiple legislative bills.⁶¹⁶ The critical and urgent issue in South Korea is to integrate and improve the bills, make a CCS legislative system, and elicit the public's agreement for implementation.

The basic direction to provide recommendations for South Korea's CCS legal and regulatory systems is that finding resulting from all previous sections needs to be applied to the South Korea's CCS system: It is clear that any recommendations for South Korea's CCS legal and regulatory systems must include an application of all of this paper's previous sections' considerations and findings. As seen from Section II, this paper supports a system that takes into account two conflicting aspects: the CCS

⁶¹³ See KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *supra* note 589, at 71.

⁶¹⁴ See MoonHyun Koh & TaeYong Ahn, *supra* note 587, at 39.

⁶¹⁵ See Yosep Kim, *supra* note 603.

⁶¹⁶ See KyungShin Kim & SungSoon Yoon, *An analysis of Japan CCS and Implication on Large Scale demo Project in Korea*, THE KOREAN SOCIETY OF MARINE ENVIRONMENT & SAFETY, 30, 31 (2015).

facilitation for good execution of CCS and regulation that thoroughly prepares for the potential risks of CCS.⁶¹⁷ As for key legal issues regarding CCS implementation, this paper addressed four issues, including permission, environmental risk assessments, liability, and property rights in Section V, which will important issues with a priority in South Korea as well.⁶¹⁸ As mentioned earlier, the precautionary principle is important in preparing an environmental legislative system.⁶¹⁹ It will also become the underlying principle in preparing South Korean CCS legal and regulatory systems. Therefore, the finding that a thorough and strong regulatory system needs to be established in accordance with the precautionary principle also applies to South Korea. However, it is also found that if all of the four key legal issues focus only on strict regulations, it would lead to undesirable results in terms of CCS facilitation. Accordingly, if the legal system is created with the consideration of which aspect or aspects are emphasized when addressing each legal issue, this will establish a more flexible and efficient CCS system. In this regard, the precautionary principle should be applied flexibly to the preparation of the CCS legal and regulatory system of South Korea.

In developing a more specified system, it is necessary to refer to the relevant systems of the US and Australia which have been explored in Section IV, and apply them to the South Korean CCS legislative system. Furthermore, it is also important to set forth a law that requires the consideration of the special conditions and weak points in South

⁶¹⁷ See *infra* Section II. B. ii. 1.

⁶¹⁸ See *infra* Section V. A.

⁶¹⁹ See *infra* Section III. C. iii.

Korea, which can make the CCS law useful and efficient. For example, in dealing with environmental impact assessments associated with CCS, it is necessary to make legislative efforts to improve the existing problems of environmental impact assessment in South Korea. The weaknesses of communication between government ministries and relatively low social perception of environmental protection and climate change issues can be a particularly vulnerable part of South Korea, which needs to be considered for the CCS legal and regulatory framework. Additionally, if the South Korean CCS legislative system reflects technological, economic, and social factors as described in Section III⁶²⁰, it will be able to become more thorough and complete.

In the end, this paper provides recommendations with the intention of recalling findings of these previous sections and applying them appropriately in South Korea's CCS framework.

C. Recommendations for South Korea's domestic CCS legal and regulatory system

Under these desirable directions to consider, some recommendations are suggested for the establishment of the South Korean CCS legislative and institutional system. First, it is necessary to make a flexible approach to the main legal issues of CCS and to judge which one should be emphasized between the two conflicting purposes of CCS—regulation and facilitation—and apply that judgment to the resulting legislative system. In other words, it is important to avoid preparing a legislative system

⁶²⁰ See *infra* Section III. A-B.

emphasizing only one purpose and rather to find a plan realizing the two purposes. For instance, of the aforementioned four issues (permission, environmental risk assessments, liability, and property rights), permission and environmental risk assessments require a thorough regulation system and emphasize the precautionary principle. Developed countries make preparations with strict and specific permission criteria, whereas South Korea has vulnerable points. Additionally, given that environmental risk assessment continues to show its problems domestically, it is necessary to come up with a strict regulation system for the potential risks of CCS. Regarding property rights, it is necessary to focus on something that makes it possible to implement CCS smoothly.⁶²¹ That is because CCS should be introduced and applied in a timely manner as the intermediate technology acting as a bridge between existing fossil-fuel and future renewable energy sources.⁶²² With regard to liability, a balanced approach is specially required. As mentioned earlier, various and specified solutions to carbon dioxide leakage

⁶²¹ It is true that the protection of the property rights that are relevant to CCS implementation is important. However, if the property right issues fail to be fixed early, it can cause disruption to CCS implementation because the property right issues are problems that can be raised in the early stage associated with facilities installation, rather than long-term operation or stewardship.

⁶²² It is likely that South Korea can avoid complex and challenging pore space ownership issues which are associated with vast storage sites because South Korea is currently considering the type of offshore sequestration. However, even in the case of offshore sequestration, property right issues can be raised for the transportation linked from the onshore capturing facilities, as CCS is a connected technology between a series of processes.

are suggested.⁶²³ It means that the issue of liability requires fair and balanced solutions.⁶²⁴

Second, the most important aspect in dealing with the four issues is to find what is needed for the legislative system. With regard to permission, the position that business permissions for capture, transport, and capture should be given separately is also valid in South Korea.⁶²⁵ To set forth specific criteria, it is necessary to check if the matters prescribed in the legislative systems of developed countries, including the US, Australia, and EU nations are neglected in South Korea. For example, with respect to the permission of capture facility installation, it is necessary to have the criterion of carbon dioxide concentration included in the legislative system.⁶²⁶ South Korea has no experience with carbon dioxide transport, and therefore, for safety, it is necessary to set criteria for pipeline parts and design for the future permission of any transport facility. In

⁶²³ See *infra* Section V. A. iii.

⁶²⁴ In other words, a compromising approach is needed between two opposing stances: one is the CCS operator's stance arguing for a somewhat limited liability system and the other one is the CCS regulator's stance claiming a robust liability system for a safer CCS deployment.

⁶²⁵ The EU CCS Directive also provides that each permit of capture, transportation, and sequestration, can be obtained respectively. See Hyeok Jeong, *The EU's Efforts into achieving the goal of "2030 framework for Climate and Energy Policies": with focus on the EU ETS and CCS*, INSTITUTE FOR EU STUDIES VOL. 33(2), 377, 395 (2015).

⁶²⁶ See MoonHyun Koh & TaeYoung Ahn, *supra* note 587, at 42. In South Korea, a carbon dioxide purity standard of 98% has been suggested in a CCS legislative draft. See NATIONAL INSTITUTE OF ENVIRONMENTAL RESEARCH [NIER], A ENVIRONMENTAL FIELD STUDY ON THE LEGAL FOUNDATION OF CARBON CAPTURE AND SEQUESTRATION [I], 161-163 (2012). On the other hand, Japan requires 99% purity of carbon dioxide. See Kazuya Goto et al., *Effect of CO₂ purity on energy requirement of CO₂ capture processes*, ENERGY PROCEDIA 37 (2013). The purity standard of carbon dioxide needs to be determined carefully in South Korea, referring to other countries' criteria because this standard can affect CCS costs and CCS safety as mentioned before.

terms of storage fields, it is necessary to limit an injection amount, an injection temperature, and an injection pressure, and prepare relevant criteria.⁶²⁷

With regard to environmental risk assessments, it is necessary to make sure that CCS facility installations get involved in the environmental impact evaluation explicitly.⁶²⁸ There are a lot of potential areas that can be affected by CCS implementation. Therefore, it is essential to draw evaluation items thoroughly under the environmental risk assessment system of CCS. For instance, by analyzing all possible paths of leakage, it is possible to predict a range of damage.⁶²⁹ Additionally, through alternative evaluation, it is necessary to find specific and actual risks and apply the methods of alternative evaluation that are used in the US or EU countries to the South Korean environmental risk assessment system.⁶³⁰ In South Korea, the private sector

⁶²⁷ See Arom Kim & HyungMok Kim, *supra* note 599, at 13. These conditions are necessary to be established appropriately to maximize injection capability as well as to ensure safe implementation. For these reasons, it is reasonable for those conditions to be set up thoroughly and be described in detail. For example, standards regarding conditions within storage sites as well as conditions within injection wells need to be established. Moreover, even in the standards within injection wells, specified standards between single injection wells and several injection wells need to be included. See Arom Kim & HyungMok Kim, *supra* note 599, at 21.

⁶²⁸ See NATIONAL INSTITUTE OF ENVIRONMENTAL RESEARCH [NIER], *supra* note 626, at 183-184.

⁶²⁹ With regard to offshore sequestration, techniques for risk evaluation on the marine environmental and ecosystem have been developed in South Korea. See NATIONAL INSTITUTE OF ENVIRONMENTAL RESEARCH [NIER], *supra* note 626, at 180. As the techniques and methods improve more and more, South Korea needs to strengthen evaluation items and standards in order to create a robust risk assessment system for CCS.

⁶³⁰ For example, the alternative analysis between risk mitigation options under South Korea's risk assessment system is just simply prescribed in the Environmental Impact Assessment Act. Additionally, the enforcement decree or rule of this act has no detailed provisions regarding procedures or methods to select alternatives. For these reasons, there is a concern that the alternative evaluation method lacks effectiveness. Therefore, more specific provisions about alternative evaluation need to be included in the enforcement decree or rule under the Environmental Impact Assessment Act. (e.g., in the United States, the standard of reasonableness is provided and specified through the NEPA and CEQA.) See Vian Rhee, *Needs to Include*

performs environmental influence evaluations, so that there is a lack of objectivity.⁶³¹ It is necessary to overcome these disadvantages institutionally. The development of an environmental risk assessment system will be able to affect CCS environmental influence evaluation positively.⁶³² The risk management for preparing long-term storage, or long-term stewardship including monitoring, verification, and reporting, is the most important aspects, but it is very vulnerable in South Korea. Accordingly, the obligatory monitoring, monitoring method, monitoring period, and monitoring frequency of execution businesses should be incorporated into a legislative system. Furthermore, it is necessary to review the provisions about the punishment for violations and about additional requirements under the government's authority, if necessary.

In South Korea, offshore geological storage is taken into account. As a result, the issue of property rights associated with long-term sequestration may not arise. Nevertheless, there is a possibility of land geological storage, and a land pipeline to

Alternatives in EIAs of Korea: "Reasonable" & "No-Action" Alternatives, ENVIRONMENTAL LAW REVIEW VOL. 32(1), 375-376, 382, 392 (2010).

⁶³¹ See ByungGil Jung, *A Note on the Problems and Alternative improvement of Environmental Impact Assessment in Korea –Evaluation in an Engineer's Viewpoint*, PUBLIC LAW JOURNAL, VOL 10(2), 327, 337 (2009).

⁶³² In South Korea, business operator should write environmental impact assessment report. This approach is different from other countries' environmental impact assessment system, which requires government agencies to make assessment reports, such as the United States or Canada. The attitude of business operator's conducting of risk assessment like South Korea has an advantage that the report can be created by a person who is well aware of the business. On the other hand, it also has disadvantage of lacking objectiveness and fairness. *See Id.* The Environmental Impact Assessment Act of South Korea allows business operator to engage an agent for conducting the risk assessment. However, conducting risk assessment by agency also has critics who argue that the agency is not independent from business operators, and the requirements of the agency are not strict. *See Id.*, at 341. In case of maintaining this attitude of making environmental impact assessment reports by operators, continuous efforts to improve objectiveness and fairness are needed in South Korea.

transport from the capture source on land to the offshore storage site is needed under offshore sequestration.⁶³³ Therefore, it is necessary to make preparations for the property right issues. Regarding the issue of property rights in South Korea, the ownership of underground pore spaces needs to be placed in the dimension of public ownership or government ownership, rather than in the dimension of private ownership.⁶³⁴ Given the judicial cases and jurists' theories of underground space, it is highly likely that the argument that the underground pore space for CCS is owned by the South Korean government will be accepted. If so, CCS implementation is free from complicated problems such as expropriation and compensation, and CCS activities can be done smoothly. In order to draw the decision that underground pore spaces are owned by the government, it is necessary for the public to understand CCS positively and recognize

⁶³³ Property rights issue appears to be limited in the processes of capture and transportation. There is no eminent domain issues in a capture process because the land within the power plant facilities will be used. Additionally, in case of transportation through vehicle or ship, no eminent domain issues occur because no private land is utilized. On the other hand, property rights issue can be the most problematic during the sequestration process. Therefore, the issues of eminent domain and pore space ownership will be raised in the sequestration process with the type of onshore sequestration. (The storage site in offshore sequestration is a deep layer of the ocean, so pore space ownership issues will not be raised.) See DongRyun Kim, *Korean CCS Policy and Legislative Direction –Focused on the Land Expropriation and Public Acceptance*, PUBLIC LAND LAW REVIEW VOL. 74, 259 (2016).

⁶³⁴ For example, according to the Carbon Capture and Storage Statutes Amendment Act 2010 of Alberta in Canada, which amended the Mines and Minerals Act, the pore space ownership of all land, except land owned by federal Crown, falls on the ownership of the provincial Crown, Alberta. Moreover, Alberta also has provisions that deem the statutory vesting of pore space is not an expropriation of the land and that prohibit anyone from claiming compensation or damages from the provincial Crown. See *Canadian property rights relating to CCS*, GLOBAL CCS INSTITUTE [GCCSI], available at <https://hub.globalccsinstitute.com/publications/property-rights-relation-ccs/canadian-property-rights-relating-ccs>

CCS as a key technology to resolve the climate change crisis. Therefore, the effort to increase public acceptability should be made.⁶³⁵

When it comes to CCS liability in South Korea, it is valid to impose strict liability on businesses as strong regulation is required for preparing for the risks of CCS.⁶³⁶ Aside from that, it is necessary to draw up plans of compensation to businesses institutionally at the same time. For example, South Korea needs to adopt an appropriate method to support CCS businesses associated with CCS liability among various options (e.g., fund, insurance, bond, and threshold of liability). Like the CCS legislative system in other countries, the South Korean CCS legislative system needs to specify a provision that liability is transferred to the government after a certain period. In fact, the legislative systems of developed countries have an uncertain scope of liability and a different time of liability transfer to the government.⁶³⁷ Accordingly, the South Korean CCS legislative system for liability should prescribe an accurate time of liability transfer and fair solutions once the main subjects of liability, a scope of liability, and liability transfer are accepted. For instance, if there is a single government agency that manages and regulates CCS, the agency will be able to become the main body that has the responsibility for

⁶³⁵ See MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 57.

⁶³⁶ In South Korea, the Act on Liability for Environmental Damage and Relief Thereof entered into force from January 1, 2016, which provides strict liability for compensation of environmental damages. If a strict liability standard is provided under CCS liability system, it can be consistent with the existing environmental law. See SoonJa Lee, *Legislative Assessment for the Introduction of carbon dioxide capture and sequestration legislation*, KOREA LEGISLATION RESEARCH INSTITUTE [KLRI] LEGISLATIVE EVALUATION RESEARCH VOL. 9, 407-409 (2015).

⁶³⁷ See MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 58.

liability transfer to the government. In a scope of liability, the transfer of compensations for damage and of monitoring to the government needs to be prescribed accurately.⁶³⁸

Third, for the South Korean CCS legislative system, it is more efficient to prepare a single CCS law for regulating CCS capture, transport, and storage comprehensively. The amendment and revision of existing environmental acts (e.g., the High-Pressure Gas Safety Control Act, Wastes Control Act, Groundwater Act, and Marine Environment Management Act) are considered for preparing CCS legislative systems that cover the regulation of CCS. However, in terms of the concepts and purposes, the acts have some difficulties that may affect CCS. For example, in the case of the High-Pressure Gas Safety Control Act, the carbon dioxide compressed for storage is in a supercritical state, so CCS may be interpreted to not involve high-pressure gas.⁶³⁹ Some can argue that carbon dioxide for CCS is considered to be a waste and some provisions relating to CCS need to be added in the Wastes Control Act. However, this argument also faces a refutation. In other words, in the circumstances where carbon dioxide needs to be recycled biologically and chemically, it is possible to bring up a

⁶³⁸ A timing of the liability transfer to the government of fifteen years or twenty years can be potentially considered, as adopted in Australia and the EU's CCS directive. Meanwhile, in the EU, there is an opinion that this period of twenty years is too much to CCS operators. *See* Hyeok Jeong, *supra* note 625, at 400. South Korea needs to determine an appropriate timing of liability transfer, taking into account other countries' provisions and influences from the provisions.

⁶³⁹ There is a view that it is difficult for the Groundwater Act to be applied to CCS implementation because the Groundwater Act's purpose is to deal with development and use of groundwater. *See* JongYeong Lee, *Legal Issues of Carbon Capture and Sequestration*, JOURNAL OF LEGISLATION RESEARCH VOL. 42, 327, 345 (2012). Additionally, just amending or adding to the Groundwater Act is not enough for CCS implementation if South Korea is considering offshore sequestration.

question if it is valid to see the captured carbon dioxide as a waste.⁶⁴⁰ Moreover, the Wastes Control Act has provisions that are inappropriate to CCS regulation. For example, according to the article 18 of the Waste Control Act, the waste has to be treated by the operator him/herself or by a disposal business operator who has a license for a waste treatment business. Therefore, there is an opinion that the Waste Control Act is not appropriate to apply for CCS implementation because current disposal business operators may find it difficult to handle CCS transportation or sequestration due to the high cost burden.⁶⁴¹ In the case of the Marine Environment Management Act, there is an argument that the act is applied only to the sea, not to the underground of the sea.⁶⁴² In addition, the Marine Environment Management Act may have an improper legislative aspect if many regulations for storage of CCS were attempted to be included in the act.⁶⁴³

⁶⁴⁰ The problem of categorizing the legal character of carbon dioxide needs to be approached carefully, since applicable laws can become different and economic and social ripple effects can be brought from the categorization. *See* MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 40. For example, if the definition of carbon dioxide is limited to one characterization, such as contaminants or industrial wastes, there is a possibility of conflict with a future situation where carbon dioxide has a value as a useful resource.

⁶⁴¹ *See Id.*, at 44.

⁶⁴² *See* JongYeong Lee, *supra* note 639, at 350-351.

⁶⁴³ Meanwhile, article 19 of the Marine Environment Management Act of South Korea has a provision regarding marine environmental improvement charges. In case that this Act is applied to CCS implementation, clear interpretation is required about whether or not CCS operators are obligated to pay these charges. *See Id.*, at 349. As explained before, in South Korea there was an amendment of the enforcement decree of the Marine Environment Management Act in which carbon dioxide stream is exceptionally allowed to be discharged to the ocean even though carbon dioxide stream is a waste generated from the land. *See* MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 43. This amendment intended to enable offshore sequestration of CCS in South Korea. However, just with this amendment, it is not necessary to interpret that the carbon dioxide stream is (or should be) regarded as a waste in South Korea's CCS legal and regulatory system.

Given all of these considerations, it is more proper to establish a new comprehensive act that is specific to CCS rather than to add or amend provisions in existing environmental acts simply because of the organic connection of CCS technology. In other words, many laws referred to as applicable laws are not in line with CCS implementation from the perspective of the laws' legislative intent and system. Additionally, if CCS implementation is regulated by existing laws, amendments in a variety of environmental laws and ordinances are inevitable, which leads to a considerably high legislative burden.⁶⁴⁴ On the other hand, the establishment of a single law that governs only CCS may not only deal with CCS-related activities systematically and coherently, but may also play a role in promoting social acceptance through policy attention and concentration.⁶⁴⁵ The comprehensive and general legislative system of CCS is able to include all processes of capture, transport, and storage and prescribe permission matters in each step manifestly.⁶⁴⁶

Other detailed matters should be included in enforcement decrees and enforcement regulations as well. Since CCS is an advanced scientific technology, it is

⁶⁴⁴ For these reasons, the argument that amendments of existing environmental laws are justified because of legislative costs and efforts to create a new CCS law can be refuted. *See* SoonJa Lee, *supra* note 636.

⁶⁴⁵ *See* JongYeong Lee, *supra* note 399, at 26.

⁶⁴⁶ *See* InSung Cho, *Highlights and Implications of the EU Directive and the German law on the licensing law for the capture, transport and storage of CO₂*, CHONBUK LAW REVIEW VOL. 43, 299 (2014). Furthermore, creating a CCS law, which directly addresses only to CCS relevant activities and regulations, can be reasonable in that it can create a consistent and effective legal and regulatory system by avoiding the possibility of duplicated regulation that can be brought from multiple applications of existing environmental laws. For example, even though an environmental impact assessment is an important factor in a CCS legal and regulatory system, overlapping enforcement obligation provisions under more than one existing environmental law can cause confusion.

difficult for a CCS law to prescribe all detailed matters. For this reason, specific provisions need to be included in lower laws, such as enforcement decrees and regulations.⁶⁴⁷ Additionally, along with the development of capture and monitoring technologies, relevant laws need to be amended. In this case, amending enforcement decrees is more desirable than amending an act.⁶⁴⁸ Although it is expected that CCS will be managed by the central government under a national project, it is necessary to check if there are any relevant roles and ordinances of local governments.⁶⁴⁹ To increase the possibility of legal enforcement and make the legislative system more efficient and thorough, it is essential to prepare guidelines for private enterprises which participate in CCS project as an operator.⁶⁵⁰

⁶⁴⁷ See MoonJi Rhee, *supra* note 312, at 715.

⁶⁴⁸ As explained, one example can be a specific purity standard of carbon dioxide. It can be regulated under an enforcement decree, which is easy to amend and can respond to technical advancements. Another example can be a regulation of monitoring of long-term management of CCS risks. While important factors, such as the monitoring obligation and monitoring period, can be provided at a law level, the specific factors, such as monitoring techniques applicable to a sequestration site, can be regulated under an enforcement decree.

⁶⁴⁹ For example, CDM businesses associated with reducing greenhouse gas emissions has been primarily conducted and regulated at a local government level in South Korea. Therefore, with regard to the incorporation of CCS within the CDM and specific enforcement of relevant activities with the incorporation, ordinances or regulations at the local autonomy government level need to be utilized. Specifically, given the situation that CCS activities are expanded to various industrial fields in each local government and the need for reflection of local affairs and circumstances, the CCS legal and regulatory system of South Korea needs to cover local government-level ordinances and rules.

⁶⁵⁰ It is encouraging that corporations are getting more interested in businesses relevant to greenhouse gas emissions reduction. In the 6th Korea CCS Conference which was held in 2016, corporations' participation was remarkable, while previous conferences were focused on scientists and researchers.
<http://www.hellodd.com/?md=news&mt=view&pid=56810>

Fourth, it is necessary to establish an independent government agency that takes charge of CCS and requires cooperation between departments. Since CCS features the organic operations of capture, transport, and storage businesses, administrative procedures and relevant works can be complicated.⁶⁵¹ In particular, in South Korea, which has offshore geological storage type CCS, land work and offshore work can be processed in different departments. In this sense, more cooperation between the departments is needed.⁶⁵² In reality, governmental divisions' roles for technology development and research are not allocated properly to the departments.⁶⁵³ Accordingly, it is necessary to determine an independent department that processes all required permission procedures.⁶⁵⁴ The existence of an independent competent department will make it possible to perform consistent and efficient work by functioning as a general coordination of CCS-related administrative tasks, such as issuance of permits. It will also have a positive impact on corporate participation in CCS.⁶⁵⁵

⁶⁵¹ See Hyeok Jeong, *supra* note 625, at 399.

⁶⁵² See SunYoung Chae & SukJae Kwon, *A Study on Domestic Policy Framework for Application of Carbon Dioxide Capture and Storage (CCS)*, JOURNAL OF THE KOREAN SOCIETY OF MARINE ENVIRONMENT & SAFETY VOL. 18(6), 617, 622 (2012).

⁶⁵³ The performance evaluation report of the National Comprehensive CCS Strategic Plan also indicated this problem of failure of role allocation and cooperation between governmental divisions. See KOREA INSTITUTE OF S&T EVALUATION AND PLANNING [KISTEP], *supra* note 589, at 67-68.

⁶⁵⁴ The EU's CCS directive also provides that having an independent primary agency is required, and it is necessary for integrated management of permit issuance procedures through this single main channel. See Hyeok Jeong, *supra* note 625, at 395.

⁶⁵⁵ Meanwhile, it is judged that this independent department does not necessarily to be a new ministry, and it would be efficient to designate the most appropriate ministry that can be involved with CCS regulations. For example, since South Korea considers the type of offshore sequestration as a priority, the Ministry of

Aside from the single government agency for CCS regulation, the possibility that CCS development activities are led by the government and CCS activities are conducted by a government organization is taken into account. With regard to the question of who will be an entity to conduct CCS activities, various options can be provided in South Korea (e.g., private sector operating option, government or public institutions operating option, and an option of early government-led and thereafter private sector-led operation.)⁶⁵⁶ In this case, it is careful not to make a regulator an operator of CCS. It is because proper control system will not work if a governmental agency performing CCS activities and a governmental agency regulating the activities are not properly distinguished. For example, in case of government-led businesses, it is likely that control is loosened, which lead to reckless business operation or corruption of government officials.⁶⁵⁷ Therefore, in order to avoid the negative consequences, CCS regulation and operation should be performed by different government organizations. A government

Maritime Affairs and Fisheries can be considered, and the Ministry of Commerce, Industry, and Energy can be considered with an emphasis on the industrial aspect of CCS. However, it is persuasive that the Ministry of Environment will be the most appropriate agency, considering that CCS should be implemented in an environmentally safe manner and given the overall nature of administrative work regarding CCS.

⁶⁵⁶ See KyungShin Kim & SungSoon Yoon, *A Study on Operational Organization of CCS offshore Geological Storage*, KOREAN SOCIETY FOR MARINE ENVIRONMENT & ENERGY, 125 (2015). When it comes to the situation that government or public institutions can be a subject of CCS operation, a few options can be also suggested: one of the existing government agencies can be designated as a CCS operator or a new and special national entity can be created for the stable operation of CCS activities. See InSung Cho, *supra* note 646, at 322.

⁶⁵⁷ In this regard, it is also necessary to examine the governance structure of public enterprises and the problems of public enterprise operations in South Korea. As mentioned above, the KEPCO is a public enterprise in which the South Korean government owns a 51 percent stake, and the KEPCO owns a 100 percent stake in its six branches. Recently, in the Korea Hydro & Nuclear Power Co., one of the six branches, there was a corruption case that employees received money from suppliers of parts for nuclear power plants. From this case, it can be seen that more thorough supervision is needed in case CCS is implemented as a government-led project.

organization for CCS regulation should serve objectively and fairly. Additionally, the transparency of the government agency performing the business and morality of the government agency's officials should be guaranteed.⁶⁵⁸

Fifth, a relationship between CCS implementation and carbon trading system needs to be set up under the enforcement of a greenhouse gas emission trading system of South Korea.⁶⁵⁹ It is encouraging that the South Korean government gave an economic value to a reduction in greenhouse gas emissions so as to create the efficiently functioning market under the market-based system.⁶⁶⁰ However, in circumstances where a carbon price is not high and thereby purchase of an emission allowance, rather than CCS technology based reduction, is selected, CCS implementation and expansion can be impeded.⁶⁶¹ Therefore, it is necessary to operate a carbon trading system appropriately so

⁶⁵⁸ Meanwhile, an issue of whether or not it is reasonable for this primary single agency, which is in charge of a series of permit regulations and overall regulatory matters, to address financial support matters together can arise. Since these two aspects have opposite characteristics, it would be more appropriate for funding CCS or providing financial support to be addressed by another government agency, not the same agency with the primary single responsibility suggested.

⁶⁵⁹ The Paris Agreement also supports a market-based mechanism for emissions trading and encourages countries to cooperate on carbon pricing. *See* THE ENVIRONMENTAL DEFENSE FUND (EDF) & INTERNATIONAL EMISSIONS TRADING ASSOCIATION (IETA), CARBON PRICING—THE PARIS AGREEMENT'S KEY INGREDIENT (April 2016).

⁶⁶⁰ Currently, the carbon emission trading market is largely concentrated in the EU's carbon market, but carbon trading markets are expected to increasingly expand to other countries' carbon trading markets, such as the United States, China, New Zealand, Japan, and South Korea. *See* ECOI, A STUDY ON THE IMPROVEMENT OF CDM BUSINESSES UNDER POST-2012 SYSTEMS, 16-17 (2012).

⁶⁶¹ *See* GCCSI, SUBMISSION TO THE UNITED NATIONS FRAMEWORK CONVENTION TO CLIMATE CHANGE (UNFCCC) SUBSIDIARY BODY FOR SCIENTIFIC AND TECHNICAL ADVICE (SBSTA) (FCCC/AWGLCA/2011/CP.17 [PARAGRAPHS 79 TO 86]) – ELABORATION OF THE MODALITIES AND PROCEDURES FOR NEW MARKET BASED MECHANISMS, 3 (2012). Meanwhile, the EU also has this problem and it reveals that purchase of credits through the EU emission trading system is more inexpensive rather

as to keep a carbon price in a proper level. In addition, by taking into consideration support strategies for operators of CCS technology, such as financial support and incentives, it is necessary to lay the foundation for complementary functions of CCS technology and a carbon trading system.⁶⁶²

Sixth, the important task in South Korea is to increase public acceptability of CCS.⁶⁶³ South Korean people are still less aware of CCS and have low acceptability of CCS. That can be an obstacle to CCS implementation.⁶⁶⁴ In developed countries like the

than the cost of reducing carbon dioxide emission through the use of CCS technology. *See* Hyeok Jeong, *supra* note 625, at 402. Currently, under the first period (2015-2017) of South Korea's carbon trading system, 100% free allocation has been enforced. However, in the second period after 2018, capital allocation will be introduced even though the ratio of capital allocation will be small. *See* GREENHOUSE GAS INVENTORY & RESEARCH CENTER OF KOREA, *available at* <http://www.gir.go.kr/home/board/read.do?menuId=19&boardId=49&boardMasterId=8>. Under the initial step of emission trading system with the type of free allocation, the carbon trading price is low, but it can be predicted that the carbon trading price is getting higher as the carbon trading system is getting stabilized. Therefore, in this future situation, CCS implementation can be more competitive and economic under South Korea's carbon emission trading system. *See* JongYeong Lee, *supra* note 399, at 10.

⁶⁶² South Korea also recognizes the problem of cost burden in implementing CCS and the necessity of financial assistance for CCS implementation to overcome this challenge. The CCS drafts mentioned above also have provisions regarding a CCS management fund. Additionally, there is an opinion that in order to bring CCS businesses' participation to develop CCS markets and to provide CCS operators with financial aid, legal grounds and incentives associated with them need to be established. *See* Yosep Kim, *supra* note 603. For example, CCS legislation of Texas in the United States provides that Enhanced Oil Recovery (EOR) operators can get tax exemption benefits. *See* MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 45-46.

⁶⁶³ *See* KyungShin Kim, *Direction on Social Acceptance for Marine Geological Storage Project of Captured Carbon Dioxide*, KOREAN SOCIETY FOR MARINE ENVIRONMENT & ENERGY, 109 (2016). Since CCS technology is a new and little-known technology, the role of media, such as newspaper and online discussions, is important. *See* Sarah Mander et al., *New energy technologies in the media –A case study of carbon capture and storage in LOW-CARBON ENERGY CONTROVERSIES* 227 (Thomas Roberts eds., 2013).

⁶⁶⁴ Since the social phenomenon of NIMBY (Not In My Backyard) is shown in South Korea, it can be predicted that a problem of backlash from residents who are living close to CCS-relevant facilities will arise. *See* MoonHyun Koh & TaeYoug Ahn, *supra* note 587, at 65.

United States, the government communicates with the public in performing a CCS project.⁶⁶⁵ The South Korean government also needs such communication with the public. To improve the public's understanding of CCS, it is necessary to provide promotion and education to citizens and corporations, let local residents participate in environmental impact assessments, communicate with local residents when a project is performed, enable the public to access information, and find other plans for more public acceptability.⁶⁶⁶ As such, preparing CCS laws and policies that reflect economic and social factors will allow the laying of a foundation for successful CCS implementation in South Korea.

D. South Korea's preparation and responses to CCS implementation from an international perspective

i. Circumstances and meaning of international CCS implementation in South Korea

⁶⁶⁵ For example, the Decatur Project by Illinois State Geological Survey shows a strong effort to communicate with the public by creating a group associated with public communication. This kind of effort can enhance field efficiency with regard to CCS operation and prevent delay or cancellation of a CCS project in advance. *See Id.*, at 48. It is noteworthy that Japan shows an attitude of actively communicating with the public while conducting CCS projects through various measures (e.g., showing construction field in real time and hosting periodic fora regarding CCS.) *See Id.*, at 60.

⁶⁶⁶ Specifically, the environmental impact assessment system of South Korea has a critique that citizen participation does not work properly, and there are drawbacks with the notification procedure for public hearings. Therefore, South Korea's environmental impact assessment system needs to be improved toward reflecting views and opinions from citizens who can be affected by CCS activities. *See ByungGil Jung, supra* note 631, at 339.

It is important to prepare the legal system to respond to the main issues of CCS domestically and research how to analyze and apply the internationally executed CCS system in South Korea. South Korea has been exempted from international reduction obligations even though South Korea emits a large amount of carbon dioxide.⁶⁶⁷ In the new climate system under the Paris Agreement, it is expected for all countries to participate and to be asked to achieve their reduction goal. It means that South Korea should engage in international cooperation for CCS that is accepted as a means to significant greenhouse gas reduction and should assume responsibilities and obligations in preparation for an international commercialization of CCS.

Meanwhile, since CCS is involved in the Clean Development Mechanism (CDM), South Korea can have diverse scenarios and opportunities. Accordingly, the country needs to take a strategic approach. To prepare for various types of international cooperation for CCS projects, it is necessary to take into account geological, technical, and diplomatic conditions to find possible cooperative nations, and to set up a plan based on more specific scenarios. For example, given the economic efficiency based on carbon dioxide transportation distance, countries that are geographically close to South Korea can be considered as a priority. Additionally, considering the technological aspects, it can be assumed that the developed countries with advanced techniques associated with CCS conduct CCS-related CDM projects in South Korea. On the other hand, South Korea, which has comparatively superior technological capabilities compared to other developing countries, can also implement such CCS-related CDM projects in other

⁶⁶⁷ See *infra* Section IV. A. iv. 1.

developing countries. In selecting those countries with potential for cooperation, it is necessary to judge whether they can cooperate well and benefit each other in diplomatic aspects with the country.

As of now, there are no international treaties or protocols for CCS.⁶⁶⁸ However, it is necessary to research relevant areas to prepare for their eventual establishment. To prepare the domestic CCS legislative system, it is essential to find the critical areas for international responses. In this way, it is possible to execute domestic CCS laws that meet the international CCS criteria and increase the possibility of implementing international agreements. On balance, in order for South Korea to execute CCS properly, it is necessary to cooperate with international CCS implementation in this helpful and efficient direction.

ii. Recommendations for South Korea regarding international CCS implementation

Based on the response goal and direction, some recommendations for international CCS activities of South Korea are suggested as follows. First, it is important to prepare the process of getting CCS incorporated in the CDM. Since South Korea performs a carbon trading system, it is necessary to analyze accurately how CERs issued by a CDM project connect with the carbon market for trading.⁶⁶⁹ Currently, most

⁶⁶⁸ See *infra* Section IV. B.

⁶⁶⁹ As explained earlier, the CERs which are issued under the CDM can be traded in carbon trading markets. The project-based carbon emission trading market, such as CDM, plays an important role in

investors of CDM are European countries including the United Kingdom, and the main host countries of CDM are China, India, Brazil, and South Korea.⁶⁷⁰ If developed countries perform CDM-typed CCS projects in South Korea and CERs are generated, or if CERs are generated as part of South Korea's unilateral CDM projects, it is necessary to set forth more detailed rules about trading of the generated CERs.⁶⁷¹ It is important to analyze clearly that the CERs generated by CDM- typed CCS projects conducted in South Korea are used to achieve the emission goal of South Korea and to trade in the South Korean carbon market.⁶⁷² A restriction of CERs trading can weaken CCS business execution. Therefore, it is necessary to review if there are any restrictions in trading the CERs generated by the domestic CDM project execution in the carbon markets of other countries that enforce carbon emission trading systems like EU ETS.⁶⁷³ Moreover, it will

carbon trading markets, and it accounts for 20% of the carbon trading market. Meanwhile, 80% of the carbon trading market is based on an allowance trading system. *See* ECOI, *supra* note 660, at 16-17.

⁶⁷⁰ *See Id.*, at 21-22.

⁶⁷¹ The Act on the Allocation and Trading of Greenhouse Gas Emission Permits of South Korea has a provision in article 36, which requires the government to endeavor for linkage of domestic carbon market with the international carbon market. However, no detailed contents and regulations associated with the connection have been provided yet. *See Id.*, at 68-69.

⁶⁷² In other words, a mechanism that allows internationally approved credits in accordance with UNFCCC, such as CERs under the CDM, to be traded in domestic carbon market needs to be established. Additionally, in preparation for the link between the domestic and international carbon trading market, a domestic allowance registry is also necessary in order to manage and calculate these internationally approved credits. Therefore, with regard to management and settling of the credits issued by CDM projects, more details and procedures need to be created at a domestic level. *See Id.*, at 70, 76. As an alternative, there is an opinion that holding accounts under the Designated National Authorities (DNA) can be utilized for the link of domestic and international carbon markets. *See Id.*, at 81.

⁶⁷³ For example, under the EU ETS, there was a limitation on CERs trading in 2013, which only allows CERs generated through CDM projects conducted in Least Developing Countries (LDCs) to be traded in the EU ETS. When this kind of restriction on CERs is created in other countries' carbon trading markets,

be possible for South Korea to export CCS related technologies to developing countries and conduct CCS projects in the developing countries as mentioned above. Considering these circumstances, it is necessary to judge strategically whether CCS execution in other countries is more advantageous than in South Korea.⁶⁷⁴ There is a critical view that South Korea lacks a CDM strategy for utilizing CCS, whereas developed countries, such as the United States, European countries, and Japan, are already contemplating CDM strategies using CCS in contact with developing countries (China, Indian, Southeast Asian countries, etc.).⁶⁷⁵ As demonstrated before, CCS can have a positive impact on economic development from the domestic implementation. Therefore, while continuing CCS implementation domestically, it is necessary to carry out a more detailed analysis of the extent to which CCS projects can be implemented in developing countries and what are the economic benefits resulting from the implementation in other countries. To find if there are any international restrictions for such activities, it is necessary to keep watching

there is a concern that CERs which are issued through CDM projects in South Korea cannot be traded in those countries internationally. *See THE EUROPEAN UNION AND SOUTH KOREA: THE LEGAL FRAMEWORK FOR STRENGTHENING TRADE, ECONOMIC AND POLITICAL RELATIONS* 220 (James Harrison ed., 2013). Therefore, looking into whether these restrictions exist or not is necessary for efficient and strategic enforcement of CDM projects in South Korea.

⁶⁷⁴ South Korea imports most of its energy resources from other countries and promotes foreign resources development to ensure energy security. In this regard, there is a positive opinion that CCS projects under the CDM carried on in other developing countries in connection with foreign resources development would be helpful for South Korea by realizing two goals of reducing greenhouse gas emissions and overseas resources development. *See* Cheol Huh et al., *Consideration of Carbon dioxide Capture and Geological Storage (CCS) as Clean Development Mechanism (CDM) Project Activities: Key Issues Related with Geological Storage and Response Strategies*, JOURNAL OF THE KOREAN SOCIETY FOR MARINE ENVIRONMENTAL ENGINEERING Vol. 14(1), 51, 62 (2011).

⁶⁷⁵ *See* JongHyeop Lee, *Analysis of international trends on technical, methodological, legal and environmental issues related to CDM commercialization of CCS technology*, GREEN TECHNOLOGY TREND REPORT VOL. 2010(3), 196 (2010).

rule systems in the UN Framework Convention on Climate Change (UNFCCC) or the trading system in the international carbon trading market.

Secondly, in terms of permission, environmental impact assessments, liability, and property rights, it is necessary to find any matters to consider in the international aspect and analyze any international agreement types. For instance, a permission system is controlled in accordance with a domestic permission act.⁶⁷⁶ Nevertheless, in order to ensure CCS safety, the minimal criteria for technological and scientific requirements need to be unified internationally.⁶⁷⁷ The technological matters will be able to be suggested favorably in guidelines as a soft law.⁶⁷⁸ Meanwhile, the liability legislative system will also be able to be defined in the framework of a convention or protocol, and substantial factors can be defined differently in each country depending on their conditions. The issue of property rights is related to civil law, so it may be addressed differently depending on each country's domestic conditions. On the contrary, there is more room that the environmental influence evaluation is handled in the framework of an international agreement or local treaty. Therefore, for environmental influence evaluations of CCS execution, it is necessary to require an inter-national cooperative

⁶⁷⁶ See discussion *infra* Section IV. A. i-ii, also see *infra* Section V. A. i.

⁶⁷⁷ When the strict CCS legal and regulatory system at a domestic level can reduce possible risks of physical leakage, internationally uniformed standards and criteria regarding CCS regulations can be a method to reduce possible risk of administrative leakage between countries.

⁶⁷⁸ For example, there exist international standards from the International Organization for Standardization (ISO), and it is expected that more standardization regarding technical and scientific requirements will be created. South Korea has to make an effort to grasp current situations when developing international norms and meeting international standards.

execution or agreed international criteria. In these circumstances, South Korea needs to prepare.

Thirdly, CCS projects requiring international cooperation need close cooperation between adjacent countries on the basis of realistic feasibility. As mentioned earlier, there are various scenarios of capture, transport, and storage in transboundary CCS cooperation projects.⁶⁷⁹ It is necessary to analyze the countries that South Korea is able to cooperate with and the types of transboundary CCS execution in order to satisfy the different conditions under these scenarios.⁶⁸⁰ In particular, since South Korea is highly likely to cooperate with China and Japan in terms of CCS execution and mutual influence, it is worthwhile to make a more thorough attempt at a cooperation of legislation and policy.⁶⁸¹

Fourthly, what is most needed in order to realize these recommendations is the exchange of relevant information. CCS is an advanced organic system-based technology and a new technology. Additionally, it is the area where there is not much accumulated

⁶⁷⁹ See *infra* Section V. C. i.

⁶⁸⁰ For example, when South Korea carries on transboundary CCS projects with other countries, possible scenarios that can be applied to the CCS projects can differ country by country. For example, among possible scenarios explored before in Section V. C., the first scenario can be applied to South Korea and China CCS projects. On the other hand, as for the cooperative CCS project between South Korea and Australia, the second scenario can be considered, and the third scenario can be reviewed as an applicable scenario between South Korea and Japan. Therefore, preparation for transboundary CCS projects needs to be prepared by country, recognizing each requirement by scenario.

⁶⁸¹ There is a critical view that the collaborative level for environmental protection between East Asian countries has not been too high, particularly compared to European countries. See Ickpyo Hong, *A Critical Assessment of the Environmental Cooperation in Northeast Asia: Focusing on the Constraints of the Cooperation*, KOREAN JOURNAL OF INTERNATIONAL STUDIES VOL. 52(3), 171, 173 (2012). Therefore, various channels for international or regional agreements to resolve environmental issues need to be explored through legal, political, and diplomatic means.

information on possible risks of CCS implementation in countries. Therefore, it is critical to share information between countries. If an international agreement of CCS is created, a procedure for analyzing data through information sharing channels and of sharing knowledge and experience will be needed.⁶⁸² Although South Korea participates in the projects led by developed countries including the United States and Australia, there is still a lack of international cooperation.⁶⁸³ Therefore, South Korea needs to acquire the experiences and information of developed countries through international cooperation such as the participation of the developed countries-led projects until a channel of information exchange is created under an international convention. Given the point that CCS implementation and commercialization are important in developing countries, it is more essential to exchange information to quickly deliver the technological and legal experiences of developed countries to developing countries.

VII. Conclusion

As countries increasingly consider CCS technology to be one of the key means of reducing greenhouse gas emissions, there is a need for a more strong and thorough legal system to cope with the various risk factors, by recognizing precisely the

⁶⁸² In this regard, it is recommendable to have a clearinghouse for exchanging a lot of information relevant to CCS implementation between countries.

⁶⁸³ It is noteworthy that China shows strengths in collaborative CCS projects with many developed countries. South Korea also needs to endeavor to share information regarding technical development, projects experiences, and risk assessment results through cooperative works with China as well as with developed countries.

characteristics and uniqueness of CCS, such as complexity, organic connectivity, and long-term storage. Additionally, it is necessary to construct a legal system through a multi-faceted approach considering economic and social factors as well as scientific and technological contents to establish an efficient legal system for implementing CCS.

Scientific results provide a basis for judging thresholds to be incorporated in legal standards and for identifying areas of risk. From an economic point of view, in addition to a direct approach, such as financial support for CCS operators, it is also necessary for an approach to reduce transaction costs incurred in CCS implementation. Moreover, in relation to the carbon trading system, it is necessary to ensure that CCS can function efficiently and competitively, and that the two systems work well together. Regarding social elements, a legal system that can raise public acceptance of CCS and further reflect public opinion is needed. In order to create an effective system that can include these various factors, multiple legislative forms, such as laws, executive rules, guidelines, etc., need to be utilized.

By looking at the direct and indirect legislation related to CCS, it is clear that there are different levels of legislation and regulation in the four countries. In the United States, there is no comprehensive CCS law at the federal level, but the EPA's UIC program provides detailed criteria for injection and monitoring after injection. It appears that the existing federal and state environmental legislation can be put in place so that CCS can be implemented overall. However, with regard to pore space ownership and liability issues, while state legislation has been created, it is problematic in that it is incomplete and inconsistent. In Australia, federal and state laws have been in place in

response to the implementation of offshore and onshore CCS, but there is again the issue of inconsistency as in the United States. On the other hand, in South Korea and China, compared with the legal system of the United States and Australia, there is no CCS-specific legislative and regulatory system in which major legal issues have yet been addressed. Finally, in all four countries, legislative gaps and inconsistencies take place and it is a future task to find important common issues and to find a certain degree of desirable and consistent direction.

Specifically, permits, environmental impact assessments, liability, and property rights issues are of common importance, which are priority areas to establish well. In resolving each of these key legal issues, the precautionary principle and the polluter pays principle should be realized. Furthermore, a flexible approach to these principles' interpretation and application is also needed in order for the implementation of CCS to be carried out safely and smoothly through all the processes.

First, in the case of a permit system, it is important to ensure that each step (site exploration, capture, transport, storage, post-closure management) requires a permit system with detailed standards in order for the government agency to be able to judge whether an authorization is appropriate. Second, it is necessary for the government to enforce environmental impact assessments while making evaluation items and evaluation methods as detailed and diverse as possible. It is also significant to emphasize the enforcement of monitoring, especially in the long term, to ensure that the potential risks of carbon leakage are managed on a continuous basis. In this regard, clear criteria for monitoring are needed. Third, with regard to the liability issue, different opinions can be

raised as to who will be liable for damages by carbon leakage accidents, what standard to take, and the extent of liability. It is desirable to clearly provide the relevant standards for enhancing clarity and to have a liability system that effectively balances between the CCS operators and the government. Specifically, it is reasonable for the CCS operator to assume compensation liability for leakage accidents. Regarding the standard for judging liability, strict liability is necessary because the damage will be considerably high in case of an actual leakage occurrence. On the other hand, a system for transferring liability to the government after a certain period of time needs to also be adopted because it can contribute to the duty of securing safety for both the CCS operators and the government and at the same time distribute the liability burden (e.g., a liability transfer after 30 years can be presented as a preferred example). Finally, in resolving the property rights issue, it is reasonable that the government's power of eminent domain is exercised more at a federal-level so that unified institution can promote the smoothness of CCS implementation. In addition, if it can be tolerated in accordance with the relevant property laws and social awareness, it may be considered that the ownership of the pore space is given to the government.

As shown from approaching and addressing these four key issues, the government plays a crucial role in many aspects, such as thorough regulatory surveillance, as well as sometimes facilitating CCS implementation and sharing liability associated with CCS.

On an international level, international treaties and norms that can be related to CCS have been reviewed to see if they are consistent with CCS technology. As a result of

the analysis, it was shown that CCS technology is not against many ocean-related laws in case of offshore sequestration, and rather can be supported under climate change-related laws. Additionally, CCS is incorporated in the CDM under the current Kyoto Protocol, which expects that CCS projects are more likely to be applied to developing countries. However, regarding the issuance of CERs due to the implementation of CCS projects, problems, such as over-issuance, lack of relevant legislation and regulation, and its ambiguity, are also exposed. Therefore, there is a need to continually supplement the rules so that CERs can be issued by accurate and fair methodologies, and that issued CERs can be traded well in the market.

Currently, no international treaty that deals with CCS exists, but there are areas where there is a need for international legal and regulatory framework in the future. First, it is necessary to draw an agreement on the minimal technical standards required for safe implementation of CCS at the international level so as to be able to function as a standard in the drafting of domestic laws. In this case, various forms, from treaties to voluntary soft laws, can be considered. Second, the international legal system is required for transboundary cooperative CCS projects. Transboundary CCS projects need to be implemented by prepared standards and procedures that will be applied, such as notification, risk impact assessment, and monitoring. In this case, it was analyzed that requirements and procedures for various types of scenario due to the combination of capture, transport, and storage among countries can be different. Third, it is likely that an international liability system is not yet sufficiently constructed for when the CCS implementation of one country causes unexpected damage to another country, while there is a high possibility that the liability issues are discussed in advance in the terms of

transboundary CCS projects. With regard to the transboundary CCS liability framework, it is desirable to introduce a state liability system, and adopt a primary liability system for CCS operators in which it is reasonable to consider a strict liability standard for domestic liability. In relation to the form of international agreement regarding transboundary CCS operation and liability, a multilateral framework is desirable, but it is necessary to increase the possibility of agreement by taking into account the forms of bilateral treaties or guidelines if necessary.

In South Korea, CCS technology is a necessary and viable option, given the country's energy industry structure and technological and geographical possibilities, and CCS implementation becomes more meaningful in South Korea considering the urgent need to reduce carbon dioxide and the achievement of attracting the Green Climate Fund (GCF). The important thing in South Korea is to build a clear roadmap for CCS legislation and regulation, and to do so, it would be reasonable to reflect the positive implications from previous sections and to complement the existing weaknesses of environmental law in South Korea. Essentially, South Korea's CCS legal and regulatory systems need to be strong, set up under the principle of the precautionary principle, and in particular, it is necessary to elaborate and strengthen the standards for permit systems, environmental impact assessments, and monitoring. It is also necessary to put liability of CCS operators under the strict liability so that the strong regulatory regime can be well maintained, and that credibility on CCS investment from the private sectors can be enhanced. At the same time, South Korea needs to adopt a transfer of liability to the government after a certain period of time. Finally, if onshore sequestration becomes a reality and the issue of ownership of the pore space, which is a possible sequestration

areas, is raised, it is recommended to adopt the option of government ownership so that the government reduces the transaction costs and enables CCS projects to proceed quickly.

Taking into account the complexity of CCS's technological linkage, organicity, and also considering the problems of the government's responsibility avoidance between agencies that have been continuously raised in South Korea, the CCS law of South Korea needs to be aimed at a single law that covers capture, transportation, and sequestration together. In the same vein, it is judged that the existence of a single government department that manages this is also efficient. Additionally, it is necessary to focus more on preventing the relaxation of regulations or loosening of oversight rather than the problem of a CCS project being cancelled due to a lack of financial aid from the government, given the particular situation of government-led CCS implementation in the early stages.

In terms of preparation for an international CCS framework, South Korea needs to contemplate CCS strategies that are appropriate to the situation in South Korea so as to assert them in international legal negotiations. Particularly, it is necessary to preemptively review and addresses the transboundary issues on CCS projects with China and Japan, and the legal issues arising from CCS-related CDM projects in developing countries in Asia where there is much room for CCS to be executed. Moreover, South Korea needs to cooperate with other countries in creating an international legal framework for CCS. For example, it is necessary to actively participate in the establishment of international standards for the technical elements of CCS, for the establishment of international

standards for CCS-related environment impact assessment, and information exchange between countries.

Creating a legal and regulatory framework for CCS means that legal issues and answers to the issues will be predictable and clear by having some agreed standards. With this predictability and certainty, there can be synergies that can lead to CCS development activities. The most important thing for CCS implementation is to prepare for the risk of physical leakage through creating legal and regulatory systems which cover important legal questions that may arise in the entire process of CCS. In addition, by drawing an agreement on the basic requirements at an international level for ensuring the safe implementation of CCS, unreasonable results of market leakage can be prevented as well. If CCS technology is implemented safely and efficiently on this legal basis, it can contribute to meeting the ultimate goal of reducing carbon dioxide emissions. By implementing CCS through a legal and regulatory framework both domestically and internationally in a timely manner, CCS technology will be able to play a significant role as a bridge technology, and will also function to protect the environment for future generations.

Additional research in this area will be necessary. As mentioned above, CCS technology has a possibility of combining with bioenergy, which is called BECCS, and also has a useful ability to convert and recycle captured carbon dioxide into other materials, which is called Carbon Capture and Utilization (CCU). Therefore, legal systems dealing with these areas will be a future research topic. Another area where there is a need for further legislative research is legislation on measures to reduce carbon

dioxide by sustainably managing forests and preventing forest degradation, as the Paris Agreement emphasizes. Finally, if legislative research on renewable energy systems and energy efficiency enhancement has been actively conducted and developed, the transition to a successful future energy era will be accelerated.

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