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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.[1] 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).[2] 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. Additionally, CCS technology has been considered as a feasible and necessary strategy in developing countries as well.[3] Under these circumstances, the essential and significant task for each

1 *See* Int'l Energy Agency [IEA], *CO_2 Emissions from Fuel Combustion 2018 Highlights*, http://www.indiaenvironmentportal.org.in/files/file/CO2_Emissions_from_Fuel_Combustion_2018_Highlights.pdf (detailing specific data associated with carbon dioxide emission from fuel combustion including national, regional, and global analyses).

2 *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); *see* Peter Folger, Congressional Research Service [CRS], Carbon Capture and Sequestration (CCS) 2 (Jan. 25, 2010) (meanwhile, carbon sequestration could happen as a natural process. Forests, agricultural lands, and oceans exchange huge amounts of CO_2 and store it. However, the CCS that this paper covers is not this type of natural process but rather the artificial activity of carbon capture and sequestration as a new technology); *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 paper uses the term "Carbon Capture and Sequestration (CCS)" since it includes an emphasis on the long-term.

3 *See* Brad Page, *The Global Status of CCS: 100 days after the COP21 Paris Agreement,* Decarboni.se, Mar. 21, 2016, http://www.decarboni.se/insights/global-status-ccs-100-days-after-cop21-paris-agreement (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. Addi-

country is to have a well-organized legal and regulatory system for CCS and a number of countries have put legislative efforts on fixing existing legal systems and preparing a new legal system for CCS implementation.

In order to address climate change issues at a more fundamental level, however, a domestic system for CCS would be insufficient. It is imperative that the CCS regime should work efficiently in the international dimension because CCS business can be implemented in close cooperation with bordering or transboundary countries through carbon dioxide export.[4] 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.[5] In other words, there is the problem of transboundary CCS projects due to limitations of appropriate storage sites and potential transboundary CCS damages, which are not adequately covered under existing international law. Fundamentally more, 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 all countries in resolving the current climate change crisis is a desirable and an efficient measure, global scale CCS implementation and internationally collaborated CCS projects are expected with necessary legal CCS system research.

In consideration of all of these aspects, a more effective and practical international system needs to be created.[6] With this aim in mind, this paper examines the necessity of preparing international norms and proposed contents to be included in these areas. Section II mainly explained basic and technical features of CCS first. After that, Section III addresses regulatory systems for future transboundary CCS implementation, and Section IV covers regulatory systems for transboundary environmental liability. In addressing a future CCS legal framework on an international level, this paper has taken a scenario-based approach to analyze cases that have not yet been realized.

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tionally, 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 also* Milagros Miranda, *The New Climate Deal Shows the Importance of CCS*, WORLD COAL ASSOCIATION [WCA], Feb. 4, 2016, https://www.worldcoal.org/new-climate-deal-shows-importance-ccs. For more discussion about the important role of CCS under the Paris Agreement, *see* GLOBAL CCS INSTITUTE [GCCSI], THE GLOBAL STATUS OF CCS 2016, SUMMARY REPORT, 2-7 (2016).

4 *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*, 3 LOW CARBON ECONOMY 130, 131 (2012).

5 *See* Yvette Carr, *The International Legal Issues Relating to the Facilitation of Sub-Seabed CO_2 Sequestration Projects in Australia*, 14 AUSTRALIAN INT'L L.J. 137, 140 (2007).

6 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.

II. Basic explanation of CCS and CCS from an international perspective

a. The concept and characteristics of CCS

Carbon Capture and Sequestration (CCS) is a technology comprised of a series of processes, in which CO_2 is captured from large-scale emitting sources, transported to a determined storage site and then sequestered deep below the surface into pore space. The primary potential site where the capture of CO_2 might be carried out would be electric power plants, which are based on the use of fossil fuel energy sources.[7] Installing capturing facilities to power plants could be considered both for new power plants and for existing power plants by retrofitting them.[8] As for other emitting point sources of CO_2, there are oil refineries, manufacturing units (such as chemical plants cement manufacturers and steel works), and pulp mills.[9] There are three main types of technologies which are available to capture carbon dioxide from emitting point sources: pre-combustion capture, post-combustion capture, and oxy-fuel with post-combustion capture technology.[10]

The CO_2 captured through these processes would be transported through pipelines or other transport methods such as trains, trucks, and ships.[11] The state of CO_2 under this process of capture and transport is called "supercritical fluid," which makes the movement of CO_2 in pipelines easy and enables the CO_2 to be stored efficiently in sequestration sites that are geologically stable.[12] There are three types of reservoirs that are being considered as possible geological seques-

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7 *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) (the amount of CO_2 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 CO_2 emissions in the United States.); INT'L ENERGY AGENCY [IEA], IEA GREENHOUSE GAS R&D PROGRAMME, PUTTING CARBON BACK INTO THE GROUND 4 (2001) [hereinafter "IEA GREENHOUSE GAS R&D PROGRAMME"] (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.).

8 *See* Rao, *supra* note 7, at 13.

9 *See id.*; IEA GREENHOUSE GAS R&D PROGRAMME, *supra* note 7, at 4.

10 *See* Intergovernmental Panel on Climate Change [IPCC], *IPCC Special Report on Carbon Capture and Storage* 5 (2005), *see also* FOLGER, *supra* note 2, at 10-11 (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.).

11 *See* Haszeldine, *supra* note 2, at 7; IPCC, *supra* note 10, at 5.

12 *See* IPCC, *supra* note 10, at 386; *CO_2 Transport for Storage: Regulatory Regimes –European and Regional: The CCS Directive*, UCL CARBON CAPTURE LEGAL PROGRAMME, http://www.ucl.ac.uk/cclp/ccstransport-europe-CCS.php; *see also* STEVE WHITTAKER & ERNIE PERKINS, TECHNICAL ASPECTS OF CO_2 ENHANCED OIL RECOVERY AND ASSOCIATED CARBON STORAGE, GLOBAL CCS INSTITUTE [GCCSI] 3-5 (2013) (precisely speaking, the supercritical fluid indicates that it exists above its critical temperature and pressure of 31.1 degree Celsius as an equilibrium between a gas, which is a general state of CO_2

tration repositories: (1) saline aquifers, (2) depleted oil and gas reservoirs, and (3) unmineable coal seams.[13] These places will have CO_2 sequestered at least one kilometer below the surface because these three layers would be located deep below the ground.[14] 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.[15] 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.[16]

The distinctive characteristic that distinguishes CCS from other storage technologies is that it is designed to store CO_2 for a very long time, amounting to hundreds or thousands of years in the future.[17] 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.[18] While the EOR technology utilizes temporary storage of CO_2 to increase oil production by injecting carbon dioxide into oil fields, CCS technology features a permanent sequestration and requires a more expansive pipeline system than that which serves the current EOR network.[19] 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.[20]

under normal temperature and pressure, and liquid.); Alexandra B. Klass & Elizabeth J. Wilson, *Climate Change, Carbon Sequestration, and Property Rights*, 2010 U. Ill. L. Rev. 363, 373 (2010).

13 *See* Haszeldine, *supra* note 2, at 7; Stephen A. Rackley, Carbon Capture and Storage 24 (2010); IEA Greenhouse Gas R&D Programme, *supra* note 7, at 15.

14 *See* Midwest Geological Sequestration Consortium [MGSC], http://www.sequestration.org/

15 The offshore geological storage scheme sequesters CO_2 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 CO_2 into the ocean is strictly prohibited under international norms.

16 *See* Leonardo Cipolla, Center Sviluppo Materiali [CSM], Carbon Capture and Storage at Power Plants – A Perspective Towards a Successful Zero Emission Strategy 28 (2007) (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.).

17 *See* Haszeldine, *supra* note 2, at 8.

18 *See* Arnold W. Reitze Jr., *Carbon Capture and Storage (Sequestration)*, 43 Envtl. L. Rep. 10414, 10414 (2013).

19 *See* Folger, *supra* note 2, at 13 (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 of pipeline network will be necessary for the commercialization of CCS, which is similar in scale to the natural gas pipeline network.). For more analysis on CO_2 transportation infrastructure for EOR and CCS technology considering carbon price, *see* Matthew Tanner, *Projecting the Scale of the Pipeline Network for CO_2-EOR and Its Implications for CCS Infrastructure Development*, U.S. Energy Info. Admin. (Oct. 25, 2010), http://www.eia.gov/workingpapers/co2pipeline.pdf.

20 *See* Chris Mooney, *This Iceland plant just turned carbon dioxide into solid rock-and they did it super fast*, Wash. Post (June 9, 2016), https://www.washingtonpost.com/news/energy-environment/wp/2016/06/09/scientists-in-iceland-have-a-solution-to-our-carbon-dioxide-problem-turn-it-into-stone/?noredirect=ON&utm_term=.90fef2b28424 (recently in Iceland, a new technique called carbon mineralization consisting of injecting carbon dioxide into basaltic rocks to convert gaseous carbon dioxide into rocks,

b. 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.[21] 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.[22] 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 trapping.[23] 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.[24] Therefore, it will be very important to explore geologically appropriate sites for sequestering carbon dioxide.[25] 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

has been researched and achieved positive outcomes.); *see also* Henry Fountain, *Iceland Carbon Dioxide Storage Project Locks Away Gas, and Fast*, N.Y. TIMES (June 9, 2016), https://www.nytimes.com/2016/06/10/science/carbon-capture-and-sequestration-iceland.html (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. 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.).

21 *See* Jon Gibbins & Hannah Chalmers, *Carbon Capture and Storage*, 36 ENERGY POL'Y 4317, 4320 (2008).

22 *See* CIPOLLA, *supra* note 16, at 28 (the reason why carbon dioxide is transported and sequestered in a supercritical state is because it is cost effective as well as technically safe.).

23 *See* Chen Zhu et al., *Benchmark modeling of the Sleipner CO_2 plume: Calibration to seismic data for the uppermost layer and model sensitivity analysis*, INT'L. J. GREENHOUSE GAS CONTROL (2015) (cap rock trapping, which is also called structural trapping, makes up the majority of trapping. Mineral trapping dramatically increases permanent safety sequestration.).

24 *See* IPCC, *supra* note 10, at 31; *See* Seyed M. Shariatipour et al., *The Effect of Aquifer/Caprock Interface on Geological Storage of CO_2*, 63 ENERGY PROCEDIA 5544, 5544 (2014) (further studies on the interface between aquifer and cap rock are needed.).

25 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.

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.[26]

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 capturing technique have been developed.[27] 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.[28] Therefore, there is a need for establishing acceptable criteria regarding carbon dioxide purity and impurity.[29] 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).[30] 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.[31] This type of earthquake, which takes place because of human or anthropogenic activities, is called induced seismicity or an induced earthquake.[32] 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.

As seen from the technical and scientific perspectives, CCS is a new technology that has a complex and highly integrated process and requires numerous

26 *See* INTRODUCING THE CO_2 STORAGE DATA CONSORTIUM, CO_2 STORAGE DATA CONSORTIUM [CSDC], https://www.sintef.no/globalassets/sintef-petroleum/brosjyre/csdc_sintef.pdf.

27 *See generally* CARBON SEQUESTRATION LEADERSHIP FORUM [CSLF], 2013 TECHNOLOGY ROADMAP (2013).

28 *See* INT'L ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE –MODEL REGULATORY FRAMEWORK 52 (2010).

29 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.

30 *See* CIPOLLA, *supra* note 16, at 28; Zhu et al., *supra* note 23, at 1.

31 *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/.

32 *See* INT'L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, INDUCED SEISMICITY AND ITS IMPLICATION FOR CO_2 STORAGE RISK 4 (2013).

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.

c. Status of CCS on the international level

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.[33] Since activities by developing countries might make the global climate change crisis worse, developing countries' cooperation is imperative in reducing CO_2 emissions.[34]

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 fuel energy sources for the time being.[35] 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 fuels[36] and ensuring time for a gradual shift from fossil fuel to renewable energy sources.[37] 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.[38] In this context, CCS could play an important role as a bridge between developed and developing countries.

33 *See* Matthias Finkenrath, Julian Smith & Dennis Volk, Int'l Energy Agency [IEA] CCS Retrofit: Analysis of the Globally Installed Coal-Fired Power Plant Fleet 22 (2012); 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).

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

35 *See* Haszeldine, *supra* note 2, at 8.

36 *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).

37 *See* Francisco Almendra, Logan West, Li Zheng & Sarah Forbes, CCS Demonstration in Developing Countries: Priorities for a Financing Mechanism for Carbon Dioxide Capture and Storage 1 (World Resources Institute, Working Paper, April 2011).

38 *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.).

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 a few years. 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.[39] 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.[40] In regards to future CCS prospects in developing countries, the IEA reports also say that it is reasonable that in 2050, 70 percent of capture and storage of CO_2 will be performed in developing countries.[41] 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.

On an international level analysis, 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-related laws.[42] However, this international level analytical effort falls short as it only addresses the initial step for making the new CCS technology acceptable. As CCS technology expands internationally, it is necessary to look for possible relevant treaties and norms. Meanwhile, the adoption of CCS in the Clean Development Mechanism (CDM) is positively evaluated in that the adoption makes it possible for developed countries to implement CCS in developing countries.[43] However, regarding the issuance of Certified

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39 *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 29 (Nils Markusson, Simon Shackley & Benjamin Eva eds., 2012).

40 *See id.* at 18; FINANCING CCS – OVERVIEW, GLOBAL CCS INSTITUTE [GCCSI], https://hub.globalccsinstitute.com/publications/financing-ccs/financing-ccs-overview.

41 *See* CCS IN DEVELOPING COUNTRIES – FACT SHEET, GLOBAL CCS INSTITUTE [GCCSI], http://decarboni.se/sites/default/files/publications/191093/fact-sheet-ccs-developing-countries.pdf.

42 *See* Ray Purdy, *The Legal Implications of Carbon Capture and Storage Under the Sea*, 7 SUSTAINABLE DEV. L. POL'Y 22, 24-26 (2006) (CCS implementation is not prohibited by relevant articles of the UNCLOS, and CCS activities are clearly allowed by the London Protocol. Additionally, 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.).

43 *See* Ray Purdy & Ian Havercroft, *Carbon Capture and Storage: Developments under European Union and International Law*, 4 J. EUR. ENVTL. & PLAN. L. 353, 360-361 (2007) (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. 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

Emission Reductions (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.[44]

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.[45] 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.[46] 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.[47] Finally, the international legal regime needs to look into and cope with the areas that have legal and regulatory gaps and ambiguities beyond the current initial step. 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.[48] As for these areas, transboundary movement of carbon dioxide and transboundary liability from leakage occurrences need to be explored first.

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be performed through additional efforts. This concept is called additionality, which is an important requirement in the CDM. Along with the benefits of CDM, positive effects can be brought and expanded by incorporating CCS within the CDM.); *see* ANDREI MARCU, CEPS SPECIAL REPORT NO. 128, CARBON MARKET PROVISIONS IN THE PARIS AGREEMENT (ARTICLE 6) 13 (2016) (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 also* INT'L ENERGY AGENCY [IEA], CARBON CAPTURE AND STORAGE - PROGRESS AND NEXT STEPS, IEA/CSLF REPORT TO THE MUSKOKA 2010 G8 SUMMIT 16 (2010).

44 *See* INT'L ENERGY AGENCY [IEA] GREENHOUSE GAS R&D PROGRAMME, USE OF THE CLEAN DEVELOPMENT MECHANISM FOR CO_2 CAPTURE AND STORAGE (2004); Anatole Boute, *Carbon Capture and Storage Under the Clean Development Mechanism – An Overview of Regulatory Challenges*, 2008 CARBON & CLIMATE L. REV. 339 (2008); 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).

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

46 *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). *See also* David Langlet, *Safe Return to the Underground? The Role of International Law in Subsurface Storage of Carbon Dioxide*, 18 REV. EUR. CMTY. & INT'L ENVTL. L. 303, 303 (2009).

47 *See* Daniel H. Cole, *Advantages of a polycentric approach to climate change policy*, 5:2 NATURE CLIMATE CHANGE 114, 114-117 (2015) (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.).

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

III. Regulatory systems for future transboundary CCS implementation

a. Backgrounds

Transboundary CCS implementation means that the series of CCS activities in capture, transportation, and sequestration may not be limited by the boundary of any single country.[49] Additionally, 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.[50] 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 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.[51] If the carbon dioxide stream of CCS is cate-

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49 *See* Viviane Romeiro & Virginia Parente, *supra* note 4, at 130 (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* UNFCCC, *supra* note 4, at 17 (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.). Meanwhile, the IPCC has provided a guideline regarding transboundary implementation of CCS in 2006. *See* Intergovernmental Panel on Climate Change [IPCC], 2006 IPCC Guidelines for National Greenhouse Gas Inventories Volume 2 Energy: Chapter 5 Carbon Dioxide Transport, Injection, and Geological Storage (2006), https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol2.html.

50 For more discussion on the international cooperation for CCS demonstration, *see* Heleen de Coninck, Jennie Stephens & Bert Metz, *Global Learning on Carbon Capture and Storage: A Call for Strong International Cooperation on CCS Demonstration*, 37:6 Energy Pol'y 2161-2165 (2009). 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* Peter Brownsort, Vivian Scott, & Gordon Sim, 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* UNFCCC, *supra* note 4, at 8; David Langlet, *Transboundary Dimensions of CCS –EU Law Problems and Prospects*, CCLR 3, 198, 207 (2014).

51 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal, Mar. 22, 1989, 1673 U.N.T.S. 126.

gorized as hazardous waste from an international environmental law perspective, transboundary CCS implementation can be limited by this convention.[52] 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.[53]

Regarding offshore geological sequestration, the London Protocol needs to be reviewed for a possible restriction on carbon dioxide movement in the ocean. As a part of the current international system regarding CCS, the London Protocol's Annex included carbon dioxide stream in the materials permitted to be discharged to the ocean, allowing offshore geological sequestration.[54] 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.[55] Therefore, in order to ensure the transboundary movement of carbon dioxide at the sea, article 6 needs to be amended.[56] The amendment of article was submitted by the International Marine Organization (IMO) in 2009 with this understanding.[57] However, the dominant view is that it would take more time to be ratified and ready to be entered into force.[58] This delay is because the amendment procedure under the London Protocol requires that an amendment should gain consent from two-thirds of the parties.[59] 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.

b. Possible scenarios and required elements in each scenario

If the transboundary CCS projects are to be implemented in the real world, diverse kinds of scenarios can be performed between countries.[60] The first scena-

52 *See* IEA, *supra* note 28, at 9.

53 *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).

54 *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*, INT'L MARITIME ORGANIZATION [IMO], http://www.imo.org/en/OurWork/Environment/LCLP/Pages/default.aspx.

55 1996 Protocol to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter, art. VI. (Export of Wastes or Other Matter) (contracting Parties shall not allow the export of wastes or other matter to other countries for dumping or incineration at sea.).

56 *See* UNFCCC, *supra* note 4, at 7.

57 *Carbon Capture and Sequestration*, INT'L MARITIME ORGANIZATION [IMO], http://www.imo.org/en/OurWork/Environment/LCLP/EmergingIssues/CCS/Pages/default.aspx.

58 *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) (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. 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.).

59 *See* IEA, *supra* note 28, at 33.

60 *See* SVEN BODE & MARTINA JUNG, HAMBURGISCHES WELT-WIRTSCHAFT-ARCHIV [HWWA] DISCUSSION PAPER, CARBON DIOXIDE CAPTURE AND STORAGE (CCS) – LIABILITY FOR NON-PERMANENCE

rio is 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.[61] 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.[62] 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.[63] 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.[64] However, some suggest that if characteristics or uniqueness of CCS are more thoroughly considered, this jurisdiction-based accountability may not be reasonable 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.[65] 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

UNDER THE UNFCCC at 7 (2005) (meanwhile, in a case where country A and B are both the parties of Kyoto Protocol under the UNFCC, 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* UNFCCC, *supra* note 4, at 5 (therefore, more clear delineation of applicable scope between CCS activities under the CDM and transboundary CCS implementation is necessary.).

[61] *See* UNFCCC, *supra* note 4, at 19.

[62] *See* CATO-2, TRANSBOUNDARY LEGAL ISSUES IN CCS – ECONOMICS, CROSS BORDER REGULATION AND FINANCIAL LIABILITY OF CO2 TRANSPORT AND STORAGE INFRASTRUCTURE 12, 29 (2011) (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.).

[63] 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.

[64] *See* UNFCCC, *supra* note 4, at 21; *see* SVEN BODE & MARTINA JUNG, *supra* note 60, at 14 (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* IEA, *supra* note 28, at 32 (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.).

[65] *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) (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.).

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.[66] 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.[67] The 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.[68]

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 shows transboundary carbon dioxide transportation.[69] 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.[70] 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 and compensation due to a leakage after a long time as all processes of capture, injection, and sequestration are conducted in country A alone.[71] In the second case, it would be more appropriate that both country A and country B have a duty to report the amount of

66 *See* UNFCCC, *supra* note 4, at 26.

67 *See id.*; *See* CATO-2, *supra* note 62, at 27 (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.).

68 *See* UNFCCC, *supra* note 4, at 27.

69 *See id.* at 21, 24.

70 *See id.* at 12-13, 22 (specifically, as for the transboundary environmental impact assessment on the storage area, the Espoo Convention, which requires cooperation between countries, offers implications. 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. 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.).

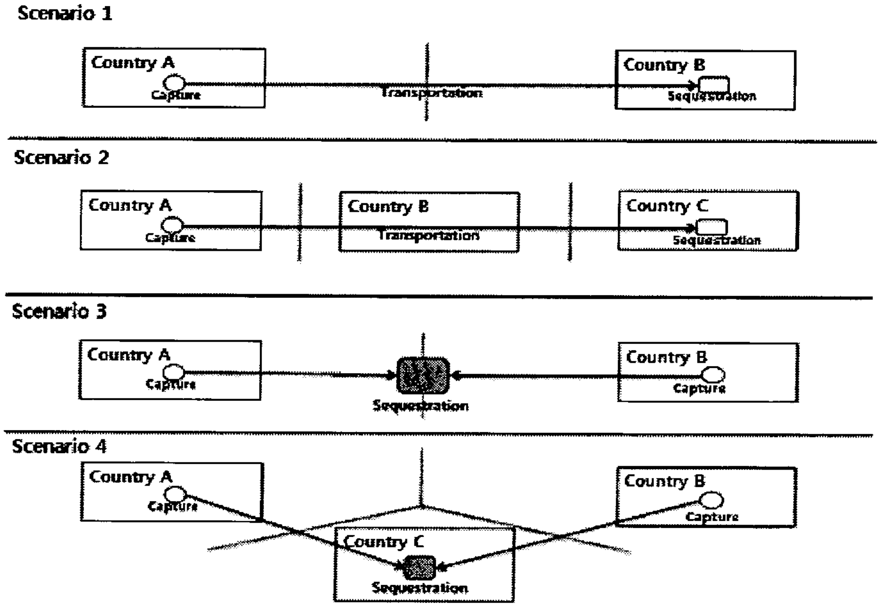
71 *See id.* at 22.

leakage, and responsibilities regarding leakage accidents are shared by countries A and B equally.[72]

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.[73] 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.[74] Such structures can work as practical ways of actively executing preventative measures under the precautionary principle, the environmental principle of international law as looked at above.

Diagram 1. Scenarios regarding transboundary CCS projects.[75]



[72] *See id.* at 24; *see also* IEA, *supra* note 28, at 32.

[73] 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.

[74] These factors are considered as key methods to realize the precautionary principle, which are emphasized under the precautionary principle.

[75] *See generally* UNFCCC, *supra* note 4; *see also* Romeiro & Parente, *supra* note 4, at 130 (detailing the Author's factual basis' in creating this diagram).

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.[76] However, practically, concluding such an agreement is not easy, and bilateral agreements between several countries involved in each CCS project are more likely.[77] 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.

IV. Regulatory systems for transboundary environmental liability

a. Backgrounds

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 implementation in one country can harm the environment of another country.[78] 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.[79] 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.[80] 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

76 *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, 73, 75 (2011) (Under the system, the establishment of a CCS clearinghouse, which enables integrated management of CCS internationally, deserves consideration. 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.).

77 *See* UNFCCC, *supra* note 4, at 28; *Id.* at 15-16 (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.).

78 *See* CATO-2, *supra* note 62, at 38 (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. Therefore, international liability and compensation system for CCS is necessary and will help to increase international acceptance of CCS.).

79 *See* DOE/NETL, International Carbon Capture and Storage Projects Overcoming Legal Barriers 13 (2006) (The transboundary liability means any liability issue that may affect more than one country.).

80 *See* Carr, *supra* note 5, at 148.

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 harm the marine environment of another country.[81] 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.[82] However, an accountability structure has yet to be clearly established regarding environmental damage caused by non-illegal behaviors.[83] Meanwhile, the major international precedent is the *Trail Smelter arbitration* case, which is based on the *Sic utere tuo ut alienum non laedas* principle.[84] This case stated that no country has a right to cause damage to another country by the use of own territory.[85] 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 look at what kind of details are to be incorporated in adopting such a liability and compensation regime.

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[81] *See* Global CCS Institute [GCCSI], Strategic Analysis of the Global Status of Carbon Capture and Storage Report 3: Country Studies, International Policy and Legislation 14-16 (2009).

[82] Draft Articles on the Responsibility of States for Internationally Wrongful Acts, U.N. Doc. A/56/10 (2001).

[83] *See id.* at 150 (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.).

[84] *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) (Arctic University of Norway, Working Paper, 2014).

[85] *See* Carr, *supra* note 5, at 149.

b. The need for state liability adoption for CCS

First of all, it should be demonstrated why a state liability is necessary in the CCS accountability regime at an international level.[86] 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.[87] However, some conventions have adopted international liability and provided strict liability.[88] It would be reasonable to view the liability for CCS activity-caused damages as falling under the area requiring state liability.[89] 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 county's behavior should be in line with the precautionary principle, the important principle of international environmental laws.[90] In this regard, countries themselves are deemed to have independent responsibility from the responsibility that CCS operators have, which is also consistent with the polluter pays principle.[91]

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.[92] 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.[93] Another basis for the argument for state liability is the view that state interfer-

[86] 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.

[87] *See* Carr, *supra* note 5, at 153.

[88] For example, state liability systems are adopted with regard to damages caused by space objects or oil pollution.

[89] *See* Carr, *supra* note 5, at 155 ("Even if a State fully complies with its prevention obligations, accidents may nonetheless occur and have transboundary consequences that cause harm and serious loss to other States. A liability regime for sub-seabed sequestration, while imposing primary liability on the operator, should be without prejudice to the rules of State responsibility for internationally wrongful acts. In other words, ideally a liability regime for sub-seabed sequestration would be a 'residual State liability' regime.").

[90] *See* Sharif, *supra* note 84, at 31.

[91] *See* Carr, *supra* note 5, at 155 (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* Sharif, *supra* note 84, at 35 (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.).

[92] *See* Carr, *supra* note 5, at 155.

[93] *See* Sharif, *supra* note 84, at 39.

ence 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.[94]

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 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.

c. Balanced approach for transboundary CCS liability

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.[95] 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.[96] 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.[97] Additionally, to motivate operators 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.[98] As seen from this, in the transboundary liability regime, there are multiple parties who bear obligations to compensate

[94] *See* CATO-2, *supra* note 62, at 45.

[95] *See* Carr, *supra* note 5, at 156 (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. The reasons supporting strict liability will still be valid in a transboundary liability system.).

[96] 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.

[97] *See* Yvette Carr, *supra* note 5, at 155; Yvette Carr, *supra* note 5, at 157 (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.).

[98] This reason will be consistent with the reasons which were suggested for the support of liability transfer to the government.

damages, such as private operators and states.[99] 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.[100] 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.[101] 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 needs to be addressed whether to include dispute settlement provisions to establish a more effective liability scheme.[102]

V. Conclusion

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. Considering the characteristics and uniqueness of CCS, it is necessary to draw an agreement on the fundamental technical standards required for safe implementation of CCS at the international level so it can function as a standard in the drafting of domestic laws. The attempt to reach an agreement can be done through various channels from treaties to voluntary soft laws.

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. By standardizing requirements according to various scenarios, it will be helpful for smooth transboundary CCS projects, and it will also help CCS implementation to expend internationally. Additionally, 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

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99 *See* Ilias Plakokefalos, The Practice of Shared Responsibility in Relation to Liability for Transboundary Harm 1 (Research Project on Shared Responsibility in International Law, Working Paper No. 95, 2016).

100 For example, there is the Convention on Civil Liability for Oil Pollution Damage. *See id.* at 6.

101 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.

102 *See* UNFCCC, *supra* note 4, at 31.

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.