The Potential of CCUS in Japan

and Japan's Role in Initiating Further Implementation of CCUS in Asia

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Abstract

Global Warming and Climate Change is an urgent issue which needs to be addressed by all countries. There are various technologies which allow for decarbonisation of the energy sector. A relatively new technology which may have high potential is “Carbon Capture, Utilisation and Storage (CCUS).” This paper discusses upon the potential of CCUS in order to address the pressing issue of global warming and climate change. CCUS includes two different phases which is “Carbon Capture Storage (CCS)” which includes of the capturing, transporting, and the storing of carbon dioxide, and “Carbon Capture and Utilisation (CCU)” which refers to the utilisation process of the captured and stored carbon dioxide (Global CCS Institute 2022b). This paper will first discuss upon the concepts of CCS and CCU, while raising the beneficial aspects and current challenges regarding the implementation of the technologies. For example, there are challenges involving the interpretation of existing international regulations when considering cross border transporting of carbon dioxide via shipping, for the purpose of storing carbon dioxide (CCS) in another country (cross-border CCS). Then, the situation regarding CCUS in Japan will be discussed. Japan has been initiating leadership for implementing CCS across the Asian Region. This section will be followed by several suggestions on how Japan could initiate implementation of CCUS projects (mainly CCS as of the current state) across the Asian Region. In this paper, the Asian Region would mainly be addressing Japan and the ASEAN member states, based on the

participating countries of the “Asia CCUS Network” which had been established with the initiatives of the Government of Japan and the Economic Research Institute for ASEAN and East Asia (ERIA) (Asia CCUS Network, 2021). Japan has also initiated the establishment of a platform to enhance cooperation among Asian Countries toward reaching carbon neutrality, called the “Asia Zero Emissions Community (AZEC)” which had been established in 2023 (The Government of Japan, 2024).

In this paper, suggestions are given toward Japan’s role in Asia to accelerate implementation of CCUS technology from three aspects which are “Continuous Knowledge and Experience Sharing,” “Cross-Border CCS,” “Establishing a Carbon Market in Asia,” and “Establishing Rules to Ensure CCUS Contributes to Emission Reduction.” The third section which is to establish a carbon market in Asia, includes two sub-sections which discuss upon “carbon credits” and “carbon pricing.” The first three suggestions focus mainly on CCS in which the demonstrations very much need to be completed first, and the fourth suggestion addresses CCU. Although the fourth suggestion addresses CCU, it is an important aspect which should be worked toward, from the current state.

Keywords: Global warming, climate change, carbon neutrality, “Carbon Capture, Utilisation and Storage (CCUS)”, Carbon Capture Storage (CCS), Carbon Capture and Utilisation (CCU), cross-border CCS, Joint Carbon Crediting (JCM), carbon credits, carbon pricing

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1. Introduction

Global warming and climate change is an urgent issue in which all countries need to be addressing in order to be effectively mitigated. The transformation of the energy sector is crucial, and many countries are focusing on changing their energy sources from fossil fuels to renewable energy sources. There are many issues related to implementation of renewable energy as well to be addressed; such as to ensure every process associated with the production of electricity by renewable energy sources would not be emitting carbon dioxide. Yet, renewable energy is already widely implemented and continuous technological advancements and development is already being made in order to address such issues.

While efforts toward increasing the capacity of renewable energy and further advancing its technology is being made, a different approach to reducing emissions is gradually being brought to more attention, which is the potential of "Carbon (dioxide) Capture, Utilisation, and Storage (CCUS)." The term CCUS mainly includes two phases which is referred to as "Carbon (dioxide) Capture and Storage (CCS)" and "Carbon (dioxide) Capture and Utilisation (CCU)." These technological terms are often misunderstood, however these refer to different technologies with CCS being the phase of capturing carbon dioxide emitted from such as power plants and chemical factories storing it deep underground, and CCU refers to utilising the captured and stored carbon dioxide (The Agency for Natural Resources and Energy, the Ministry of Economy, Trade and Industry, the Government of

Japan [ANRE], 2017). Therefore, CCU would be the utilisation phase which is based on the completion of the successful procedure of CCS.

CCS is a technology which holds high potential of reducing emissions. This is, as CCS would capture CO2 before it is released into the atmosphere and would be stored underground. Moreover, with the technology of CCU, the captured carbon dioxide would be utilised for other purposes. As it could be assumed, this is a relatively new concept and therefore requires development of technology for this to be brought to practice with safe and stable operations secured. According to the International Energy Agency (IEA), despite efforts of implementing CCUS projects, the current capacity of capturing and storing carbon dioxide is far behind what is required for the Net Zero Scenario (IEA, 2024a). Although not being deployed yet to the level expected in the Net Zero Scenario, in the recent years, the number of CCUS projects has been growing with over 500 projects as of April 2024.

There are various concerns raised regarding CCUS, including technological stability; as it is a relatively new concept. However regarding this, technological advancement is continued to be made in order to ensure its safety and stability. Apart from the concerns regarding technological aspects, there is the concern regarding potential storage sites. For a site to be suitable for carbon dioxide to be stored, it would have to meet certain criteria. Research suggests that there is a substantial amount of potential storage which far exceeds the amount of carbon dioxide to be stored in the “Sustainable Development Scenario (Malischek

& McCulloch, 2021).” Estimates show that there are plenty of potentially suitable storage sites. However, even if the site itself would be geological suited for carbon dioxide storage, it may not always be commercially available (Malischek & McCulloch, 2021). Another major issue is that the availability of the potential storage sites differs by geographical location (Malischek & McCulloch, 2021). This means that not all countries have the suitable storage site for storing carbon dioxide. Cooperation among countries would be needed for the substantial deployment of CCUS enough for it to be able to show effectiveness toward the issue of global warming and climate change.

Japan has been making effort toward deploying CCS technology. In 2012, Japan launched a large scale CCS demonstration project in Tomakomai of Hokkaido, Japan (ANRE, 2017). Japan has also been encouraging cooperation and knowledge sharing regarding CCUS in the Asia Region. In 2020, Japan and the Economic Research Institute for ASEAN and East Asia (ERIA) initiated the establishment of the “Asia CCUS Network” as a hub for knowledge-sharing and cooperation regarding CCUS (Asia CCUS Network, 2021). As Japan has initiated a network for cooperation, cooperation between countries; whether through knowledge sharing, technology, funding, or even storage sites, would be crucial in mitigating global warming and climate change through the effective implementation of CCUS technology. In 2023 another platform with the aim to “promote decarbonisation in Asia (The Government of Japan, 2024),” the “Asia Zero Emission Community (AZEC)” was

established with the proposal by Prime Minister Fumio Kishida. Therefore, Japan has initiated two platforms in order to accelerate the cooperation among Asian Countries in order to reach the common goal of reaching carbon neutrality.

This paper will be discussing upon the potential of CCUS in Japan, and Japan's role in initiating the implementation of CCUS in Asia.

2. About the Carbon Capture, Utilisation, and Storage (CCUS) Technology

The term CCUS actually includes mainly two different phases which is "Carbon Capture Storage (CCS)" and "Carbon Capture and Utilisation (CCU)." CCS itself actually involves three phases despite the term including only two which are capture and storage (Global CCS Institute, n.d.).

The overview of the procedures included in CCUS is shown in the figure below developed by the IEA (2024a).

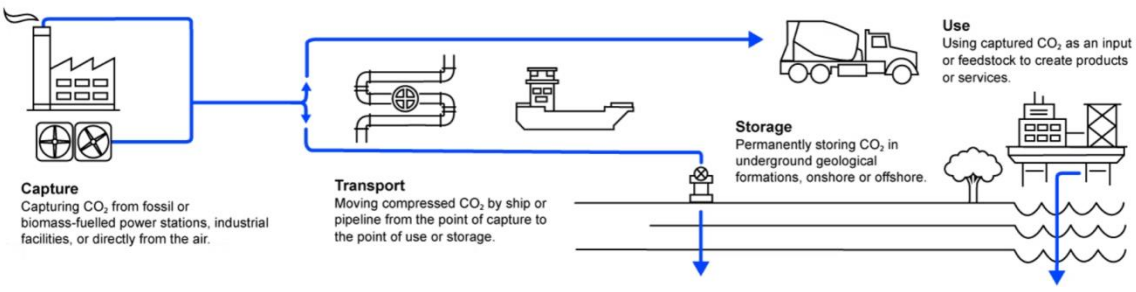

Figure 1: Procedure of CCUS

Source: IEA (2024a). *Carbon Capture, Utilisation and Storage*. IEA.

2.1. Carbon Capture Storage (CCS)

CCS comprises of three different stages involved which is to “capture,” “transport,” and “store (storage)” the carbon dioxide (Global CS Institute, 2022b).

The figure below developed by the Global CCS Institute (2022b) shows the procedures included in “CCS.”

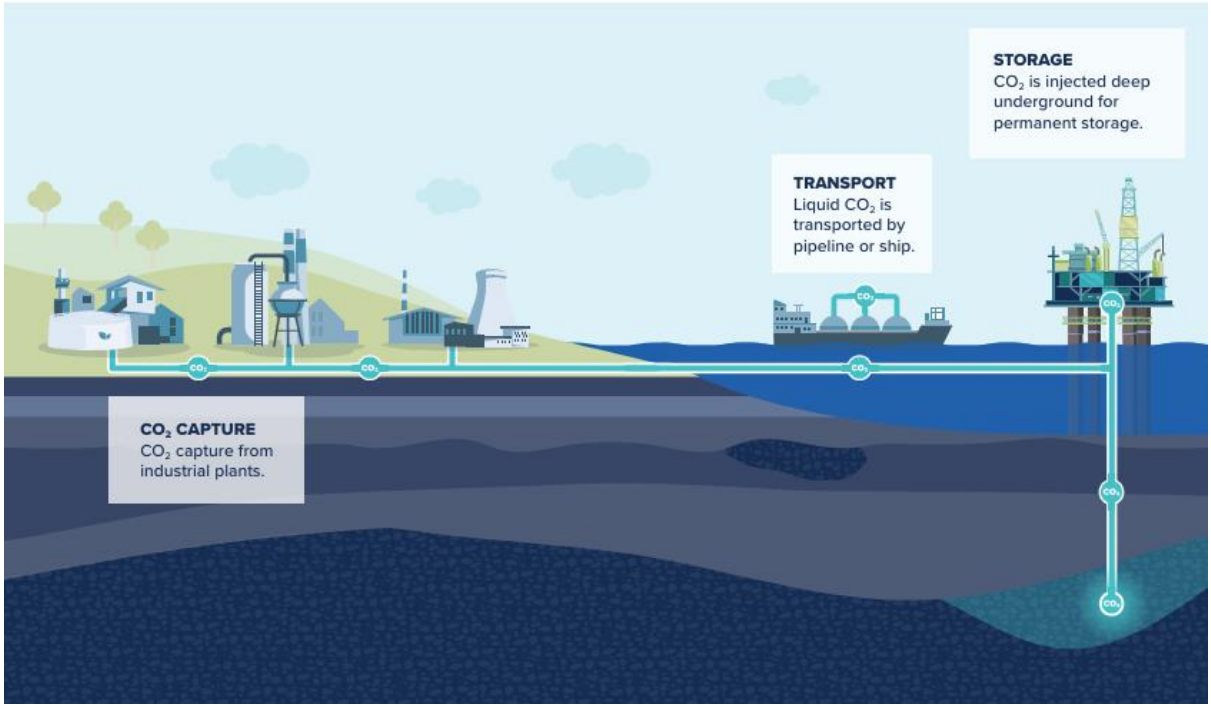

Figure 2: Procedure of CCS

Source: Global CCS Institute (2022b). *Understanding CCS, Transport*. Global CCS Institute.

a) Capturing

The capturing phase refers to the procedure of separating carbon dioxide from the other gases which are produced (Global CCS Institute, n.d.). The gases are mainly emitted from “large industrial process facilities such as coal and natural-gas-fired power plants, steel

mills, cement plants and refineries (Global CCS Institute, n.d.).”

According to the Global CCS Institute (2022b), CCS technology can, not only capture emissions before being emitted to the atmosphere; as explained above, but can also remove “historical emissions from the atmosphere (Global CCS Institute, 2022b).” This would be a key technology for mitigating global warming and climate change, as it not only prevents further emissions reaching the atmosphere but could be removing the already released carbon dioxide from the atmosphere. Preventing further releasing of emissions is crucial but the removal of carbon dioxide from the atmosphere could potentially improve the current situation; which would be a different approach from other technologies such as producing energy from renewable energy sources; which is also crucial but a different approach to the issue from CCS. Renewable energy is also crucial for mitigating the climate issue and with demonstrated practices and more technological stability compared to CCS due to the wide implementation, it should be continued to be increased. However this would yet not directly be addressing the emissions being emitted from industrial factories. Together with shifting energy production sources to renewables as much as possible, it would be effective to implement technology to capture the carbon dioxide from currently operating industrial factories to prevent further releasing of carbon dioxide to the atmosphere.

The available technologies regarding the capturing of carbon dioxide will not be discussed upon in detail in this paper. However innovation is continued to be made, including

the option of installing facilities which could directly capture emitted carbon dioxide in the air called “direct air capture (IEA, 2024b).”

b) Transporting

The processed carbon dioxide then needs to be “transported” which is the next procedure (Global CCS Institute, n.d.). The carbon dioxide is compressed in order to be transported to suitable sites where it could be stored (Global CCS Institute, n.d.). There are various modes of transportation which could be by trucks or ships, or via pipelines dedicated for the transporting of carbon dioxide. As carbon dioxide takes less space when it is in liquefied form compared to gas, in most cases it is compressed to the liquid form in order for it to be transported (Global CCS Institute, 2022b).

Pipelines

According to Leinum and Davison (n.d.), currently pipelines are mainly used for the transporting of carbon dioxide. They also raise that the repurposing of existing pipelines to be suitable for transporting carbon dioxide could reduce the risks associated to launching a new project and commercial aspects compared to constructing new pipelines for the specific purpose (Leinum & Davison, n.d.). However Leinum and Davison (n.d.) also suggest that for deployment of CCS projects at large scale and in order to effectively transport carbon dioxide

to distant locations, new pipelines would also need to be constructed for these purposes.

Shipping

Pipelines may be feasible when existing pipelines could be repurposed for the transporting of carbon dioxide for storage. However, according to the Oil and Gas Division of the Agency for Natural Resources and Energy, the Ministry of Economy, Trade and Industry (METI) of the Government of Japan (2022a), cost calculations show that pipelines are of low cost only for short distances, and shipping would result in lower cost for distances longer than 200 kilometres. The issue with shipping had been that the shipping technology for transporting large volumes of carbon dioxide in the liquefied form is still under development (The Oil and Gas Division, ANRE, 2022a). However this information was as of a report in 2022, and Japan has made significant progress in development of large scale ships suitable for transporting liquefied carbon dioxide (The Japan News, by the Yomiuri Shimbun2024). According to a news article by the Japan News (by the Yomiuri Shimbun) in February 2024, a large scale ship for transporting liquefied carbon dioxide to be stored in a distant geological storage site called “Excool” had been unveiled. According to the Ministry of Economy, Trade and Industry (METI), the demonstrational transporting of carbon dioxide in the liquefied form would be conducted from around October 2024 from a power station to a potential CCS storage site (The Japan News, by the Yomiuri Shimbun, 2024). According to METI, this

would be “the world’s first attempt to transport the liquid gas at a low temperature of about minus 50 C (The Japan News, by the Yomiuri Shimbun, 2024).” Therefore Japan has been making rapid substantial progress in developing the technology needed for the deployment of CCS. The Oil and Gas Division of ANRE (2022a) has pointed-out that the potential storage sites and emitting areas are concentrated on opposite sides of Japan, therefore transporting of carbon dioxide for long distances would be needed for CCS projects in Japan. The completion of construction of the large-scale ship for liquefied carbon dioxide transportation and the start of demonstrative shipping from October this year would be the key to further progress of CCS projects in Japan. With successful shipping of carbon dioxide, this would enable possibility of shipping to other countries which are located geographically close to Japan. In order to ship carbon dioxide to other countries, there will be international laws, conventions and protocols which need to be considered.

Challenges Regarding the Cross-Border Shipping of Carbon Dioxide

The issue with the shipping of carbon dioxide to other countries is that many of the regulations applicable to shipping of carbon dioxide do not specifically mention CCS, as it is a relatively new technology. For example, the London Convention and London Protocol which regulate marine waste in order to prevent pollution of the marine environment are often brought to discussion. Article 6 under the London Protocol is especially raised in consideration regarding the shipping of carbon dioxide. The content of Article 6 of the

London Protocol is that “Contracting Parties shall not allow the export of wastes or other matters to other countries for dumping or incineration at sea (Article 6 of the London Protocol; James-Olsen, Magnussen, & Voraa, 2022).” There are two main issues which may prohibit the transporting of carbon dioxide for the purpose of storage (CCS) via ships, according to the London Protocol. The first issue is that the captured carbon dioxide may be considered as “waste.” The carbon dioxide would have been a part of emissions from factories or industrial facilities, therefore being excess substances. The emissions would have been separated and the carbon dioxide would have been compressed in order to be shipped. The purpose of shipping would be for storing the carbon dioxide. Therefore from these aspects, the carbon dioxide intended to be shipped could possibly be considered to be “waste.” If the carbon dioxide is considered as “waste,” the shipping of it would go against Article 6 of the London Protocol. There may be a possibility that the carbon dioxide being shipped would not be considered as “waste” taking into account the planned utilisation process of the stored carbon dioxide. However even in this case, as the London Protocol specifies “other matters” as well, it would yet prohibit the act of shipping substances which would be subject to “dumping or incineration at sea (Article 6 of the London Protocol; James-Olsen, Magnussen, & Voraa, 2022).” This is, as not all potential storage sites are in-land and some are offshore. Regarding the London Protocol, an amendment to the considered Article had been proposed in 2009, in order to allow carbon dioxide as an exception (James-Olsen, Magnussen, & Voraa,

2022). The amendment proposed was to allow the exporting of carbon dioxide for the purpose of storage (CCS) as long as it is agreed upon; through bilateral agreements or understandings, between the parties (countries) considering the cross border shipping and storing of carbon dioxide (James-Olsen, Magnussen, & Voraa, 2022). However, this amendment has not been ratified as it would need to have a vote of two-thirds majority in order for it to be ratified. Japan is one of the countries which has been pushing-forth for the ratification of the amendment to the London Protocol to allow cross-border collaboration for CCS projects, as the IEA highlights in their report regarding CCUS (IEA, 2024a).

There are many challenges for the shipping of carbon dioxide from one country to another, as even in the case of intending to store the carbon dioxide in-land, the shipping of carbon dioxide which may be considered “waste” or a “pollutant” to the marine environment, may be considered to be against marine protection and shipping regulations.

Another issue regarding shipping are the emissions being released from the mobilising of the ships. Moreover, the process of constructing the large-scale ships dedicated for delivering liquefied carbon dioxide would also require energy in its construction process. These aspects also need to be considered. However although this is not regarding ships for delivering liquefied carbon dioxide for the purpose of storage (CCS), Japan has been developing technology to implement CCS systems on-board ships so that emissions emitted from the running ship could be captured by the ship itself (Mitsui O.S.K. Lines, 2024). In

2024, Mitsui O.S.K. Lines Announced that they will be installing a CCS system on-board a ship which would be commercially available (Mitsui O.S.K. Lines, 2024). According to Mitsui O.S.K. Lines (2024), this is the first example of a CCS system installed on-board a ship to be commercially available via a domestic shipping company.

Project Utilising Both Transportation Methods: The Northern Lights Project

The Northern Lights Project is an example of a project which utilises both of the main modes of transporting carbon dioxide, which are via pipelines and via shipping (IEA, 2021c). This project is a cross-border CCS project intending to safely store captured carbon dioxide deeply under the seabed of the Northern Sea, Norway (IEA, 2021c). The feature of the Northern Lights Project is not only of the mode of transportation. The project is a cross-border CCS project in which the IEA (2021c) highlights that with the start of its operations in 2024, “Northern Lights will be the first ever cross-border, open-source CO2 transport and storage infrastructure network (IEA, 2021c).” There are two phases currently planned for the project (Northern Lights, 2021). The first phase is to be conducted by mid-2024, which is planned to be storing up to 1.5 million tonnes of carbon dioxide a year (Northern Lights, 2021). The first phase of the project is conducted as part of the Longship Project which is a project led by the Government of Norway to establish a “full-scale CCS value chain in Norway (Northern Lights, n.d.).” The second phase of the project is aimed to

be expanding the storing capacity of carbon dioxide to 5 million tonnes annually (Northern Lights, 2021). As this is a cross-border CCS project, this project required permission to be granted under regulations in Europe (Northern Lights, 2021). This Northern Lights Project was "awarded status as a Project of Common Interest (PCI) under the Trans-European Network for Energy (TEN-E) Regulation (Northern Lights, 2021, p. 5)" in 2021.

c) Storing (Storage)

The final procedure included in CCS is the "storing" of carbon dioxide. The carbon dioxide is finally injected and stored in a site suitable for it to be stored deep underground (Global CCS Institute, n.d.). There are mainly two techniques for injecting and storing the carbon dioxide underground, which is storing the carbon dioxide in "Aquifers," and what is called "Enhanced Oil Recovery (The United Nations Economic Commission for Europe, 2021)."

Storing in Aquifers

"Aquifers" is defined as "geological formations containing brine (salt water) in porous rocks (The United Nations Economic Commission for Europe, 2021, p. 8)." According to the United Nations Economic Commission for Europe (2021) aquifers could be "found all over the world at depths over 1km (The United Nations Economic Commission for Europe, 2021,

p. 8)" which makes storing carbon dioxide to these types of formations an accessible option for regions all over the world.

Enhanced Oil Recovery

"Enhanced Oil Recovery" refers to the technique of injecting and storing carbon dioxide while allowing the carbon dioxide to function toward pushing-out oil and gas from rocks (The United Nations Economic Commission for Europe, 2021). To be more specific, the carbon dioxide is injected to oil fields which already exist, which increases the pressure of the oil reservoir, resulting in oil to be pushed-out of the oil fields (McGlade, 2019). According to McGlade's[1] article as of 2019, the majority of carbon dioxide used for enhanced oil recovery had been from carbon dioxide of natural sources, and not those in which had been emitted (McGlade, 2019). McGlade (2019) raises that emitted carbon dioxide should be utilised for enhanced oil recovery, however the challenge would be that the current situation reliant on utilising naturally sourced carbon dioxide is due to emitted carbon dioxide not being accessible near the oil fields. Nevertheless, McGlade (2019) suggests that CCUS projects which include Enhanced Oil Recovery; or in other words the utilising of emitted carbon dioxide for Enhanced Oil Recovery Projects, should be deployed. McGlade (2019) raises that as there is economic value for oil, the revenue which could be expected from the collected oil could be reducing the overall cost for the deployment of the CCUS project. McGlade (2019)

[1] Head of Energy Supply Unit of the International Energy Agency in 2019

indeed raises an important aspect, as although Enhanced Oil Recovery in this paper is categorised under “storage,” it also indirectly functions as or contributes to the utilisation of the stored carbon dioxide. Therefore, although CCS projects are generally considered to be costly, and CCUS is currently not focused on as much with the urgent need to first ensure the first step which is to successfully and safely store the captured carbon dioxide, the option of Enhanced Oil recovery could bring economic benefits which as McGlade (2019) suggests, could contribute to the funding of the CCS or CCUS project. Regarding this aspect, the feasibility and cost estimation of CCS or CCUS projects should carefully be calculated, including the possible revenue from the indirect or direct utilisation of the captured and stored carbon dioxide. Yet, also in this case, the emissions associated with compressing and transporting the collected oil should also be considered. Another crucial aspect which needs to be considered is despite oil having economic value, depending on the usage, it would again be emitting emissions.

There are other concerns regarding Enhanced Oil Recovery. This related to the fact mentioned earlier that Enhanced Oil Recovery was a technology which had not necessarily been developed for the purpose of mitigating carbon emissions. Robertson and Mousavian (2022) criticise Enhanced Oil Recovery to be considered as an option for reducing carbon emissions. They raise an example of a project where CCUS technology was implemented at a facility where Enhanced Oil Recovery was taken place, but resulted in being “unable to

capture the volume of CO2 it was designed for, not for technical reasons but for economic reasons (Robertson and Mousavian, 2022).”

2.2. Carbon Capture and Utilisation (CCU)

Carbon Capture and Utilisation (CCU) refers to the utilisation process of the captured and stored carbon dioxide. According to the United Nations Economic Commission for Europe (2021), there are mainly three categories of the ways in which the carbon dioxide could be utilised for, which is “mineralisation,” “biological” utilisations, and “chemical” utilisations. According to the United Nations Economic Commission for Europe (2021), the creation of cement from captured and stored carbon dioxide would potentially reduce emitted carbon dioxide, as the process would require less external energy compared to the conventional procedure of producing cement. Cement accounts for 8 percent of the total Greenhouse Gas (GHG) Emissions and therefore would greatly contribute to emission reduction from cement production, although external energy usage would yet be needed to an extent. Carbon dioxide could be converted into different types of chemicals, which could then be developed to make other types of chemicals (the United Nations Economic Commission for Europe, 2021). Therefore, potentially a various kinds of chemicals could be developed by utilising carbon dioxide. The “biological” utilisation of carbon dioxide refers to such as utilising carbon dioxide for enhancing the growing of plants and improving the quality of the

soil (the United Nations Economic Commission for Europe, 2021).

The figure below developed by the United Nations Economic Commission for Europe (2021) shows the possible utilisations of the captured and stored carbon dioxide.

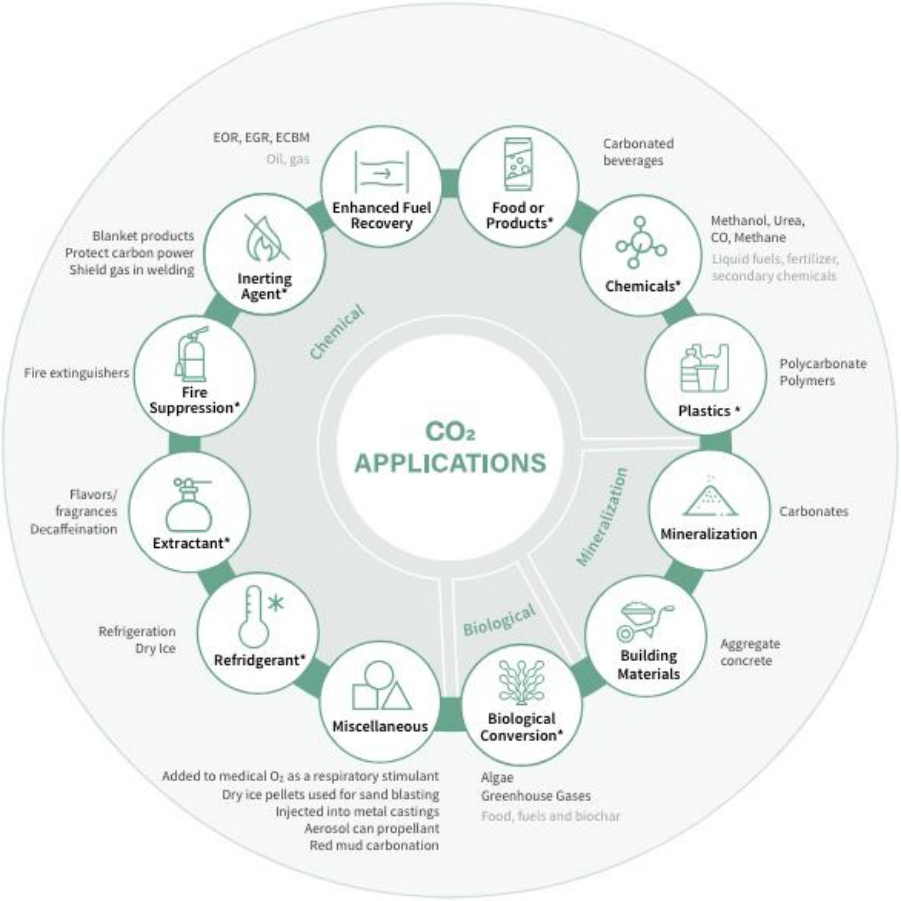

Figure 3: Possible Utilisations of Captured and Stored Carbon Dioxide

Source: The United Nations Economic Commission for Europe (2021).

Technology Brief: Carbon Capture, Use and Storage (CCUS). The United Nations Economic Commission for Europe.

According to the IEA (2024b), currently around 230 Mt of carbon dioxide is being

utilised each year, mainly for direct usage such as for the “fertiliser industry for urea manufacturing (~130 Mt) and for enhanced oil recovery (~80 Mt) (IEA, 2024b).” Various new ways to utilise carbon dioxide is being considered and according to the IEA (2024b), there are existing projects in which carbon dioxide could potentially be utilised in modes other than for direct usage, which include such as producing “CO2-based synthetic fuels, chemicals and building aggregates (IEA, 2024b).” However there is an important aspect which needs to be considered regarding the utilisation of captured dioxide. As raised by the IEA (2024b), it is important that energy is not excessively used in the process of converting carbon dioxide into other substances, especially when being converted to fuels and chemicals. It would be ironic if carbon dioxide had been captured and stored, however energy would additionally be consumed in the process of its utilisation.

Blue Hydrogen

Although it is not a direct utilisation of carbon dioxide which had been captured and stored, “blue hydrogen” is also often mentioned in discussions related to the benefits of utilising CCUS technology. “Blue hydrogen” itself is not produced from the captured and stored carbon dioxide, however it is how hydrogen is referred to when produced utilising CCS technology in its production procedure (Raymond, 2023). Zapantis (2021) explains that blue hydrogen is “produced from fossil fuels with carbon capture and storage (CCS)

(Zapantis, 2021, p. 4)" and this could reduce the emissions associated with the conventional procedures of producing hydrogen (Zapantis, 2021). Therefore, the emissions would be less compared to conventional ways of producing hydrogen; the hydrogen produced by conventional methods is referred to as "grey hydrogen (Raymond, 2023)."

However in any form of utilisation of the captured and stored carbon dioxide, thorough consideration should be made toward possible additional emissions associated with the utilisation process. For example, there could be the additional energy (unless by renewable energy sources) needed for the converting of carbon dioxide into a different form. After the completion of the product, the product may have to be transported to another area, in which the process would also result in energy consumption. Ironically in some cases, the product may be used in a way which results in causing emissions to be released again. By these assumptions, it could be understood that the society today is structured in a way that is reliant on energy. Therefore, we should not be overly satisfied with success of capturing and storing carbon dioxide, and in the near future utilising the carbon dioxide. There should always be consideration toward whether if the activity would not result in causing the releasing of additional emissions. The current state of CCUS is more focused on the capturing and storing process of CCS. However as CCS projects become commercially available, the focus may shift more toward the utilisation phase. This is, as there is potential

economic benefits seen from possible utilisation pathways of carbon dioxide. As this utilisation phase occurs, the direct and indirect causes of additional emissions should carefully be estimated, assessed, and prohibited. Regulations should clearly address this point before the society shifts to the utilisation phase, which may lead to competition among companies due to projected economic revenue. Assuming the shift of focus to the utilisation phase, while continuing to develop CCS for commercial readiness by 2030, Japan should also initiate setting the regulatory environment regarding the utilisation of captured and stored carbon dioxide in order to ensure CCS and CCU technology is contributing to the climate goals.

3. Current Situation of CCS in Japan

As the utilisation process of the captured and stored carbon dioxide could only be conducted upon the successful capturing and storing of carbon dioxide, at the current state, the Government of Japan is focusing on developing and securing the operation of CCS projects.

3.1. CCS Projects in Japan

Japan has been making rapid and significant progress toward implementing CCUS in the near future. As mentioned earlier, the demonstration project of large scale CCS in

Tomakomai, Hokkaido, had been launched in 2012 (ANRE, 2017), and ships suitable for transporting large quantities of liquefied carbon dioxide has been developed having its trial shipping scheduled in October this year (The Japan News, by the Yomiuri Shimbun, 2024). As for the Tomakomai CCS Demonstration Project, the amount of carbon dioxide set as the target to be injected underground (300,000 tonnes of carbon dioxide) had been successfully achieved in November 2019 (The Oil and Gas Division, 2022b). Data has also proven that the stored carbon dioxide has not been affected by natural earthquakes, and nor were earth tremors caused by the procedure of injecting carbon dioxide to the ground (The Oil and Gas Division, 2022b).

After the launch of this demonstrational CCS project, the Government of Japan launched six other CCS projects, resulting in a total of seven projects being explored (Sasayama, 2023). When drafting the projects, the Government of Japan combined different aspects and features for the CCS project to be based, so that the results could act as a "model case (Sasayama, 2023)." The results could then be analysed and compared in order to accelerate efficient, effective, and feasible implementation of CCS technology. Various options were assumed for the three categories of the "source in which the carbon dioxide is to be captured from," "mode of transportation," and "area for storing carbon dioxide (Sasayama, 2023)." The "source in which the carbon dioxide is to be captured from" included various options including such as thermal power plants, steel companies, chemical factories, cement factories,

pulp factories, and hydrogen production facilities. The “mode of transportation” included the two available transportation options of either via pipelines of via shipping. The “area for storing carbon dioxide” included the underground of in-land areas, under the seabed of coastal areas, and under the seabed of offshore areas (Sasayama, 2023).

Categories	Carbon Dioxide Source	Mode of Transportation	Area for Storing Carbon Dioxide
Options	● Thermal power plants ● Steel companies ● Chemical factories ● Cement factories ● Pulp factories ● Hydrogen production facilities	● Pipelines ● Shipping	● Underground of in-land areas ● Under the seabed of coastal areas ● Under the seabed of offshore areas

Table 1: Options for Features of CCS Projects

Source: Table created by Author

based on Information by Sasayama, M. (2023). *経済産業省における CCUS の取組み*. p. 15. The Ministry of Economy, Trade and Industry, the Government of Japan.

Out of the seven CCS projects, five projects are located in Japan, while two of the projects are actually cross-border CCS projects; therefore involving the transporting of carbon dioxide to other countries in order for it to be stored (Sasayama, 2023). The two cross-border CCs projects are to be located in Malaysia and in Oceania.

The Government of Japan is continuing efforts for the launching of CCS projects aimed to be started by 2030 (Sasayama, 2023). They are continuing to explore various options regarding CCS projects, as for example the Tomakomai CCS Demonstration Project assumes “pipelines” to be the mode of transporting carbon dioxide according to Sasayama’s report on the combinations of project feature options (2023). However, although pipelines is assumed to be the main mode of transporting carbon dioxide to the potential storage area, the large-scale ship for transporting liquefied carbon dioxide mentioned earlier called “Excool” would actually conduct a trial run from Kansai Electric Power Co.’s Power Station in Maizuru, Kyoto, to the potential CCS storage site Tomakomai, Hokkaido (The Japan News, by the Yomiuri Shimbun, 2024). The considered power station is located in a distant area from the storage site which is in Hokkaido. From this news report, it could be seen that the Government of Japan is continuing to explore various options regarding CCS and is indeed moving forth significantly toward the aim to officially launch CCS projects (not demonstrational) by the year 2030.

3.2. “The Long-Term CCS Roadmap (Finalised in 2023)”

In 2023, the Government of Japan has also announced the finalised version of the “CCS Long-Term Roadmap (METI, 2023). The “CCS Long-Term Roadmap” includes five core action plans referred to as the “concrete actions (The Oil and Gas Division, ANRE, 2022b)” in which each are included in detail in the report (METI, 2023).

The five “concrete actions are listed below (The Oil and Gas Division, ANRE, 2022b, p. 6).

1. “Study of the legislation of domestic laws required for implementing CCS business”
2. “Efforts aimed to reduce CCS costs”
3. “Study of ideal support from the Government for CCS business”
4. “Promotion of public understanding on CCS business”
5. “Promotion of overseas CCS business”

Source: Quoted from the Oil and Gas Division, ANRE (2022b, p. 6)

The “CCS Long-Term Roadmap” is developed with thorough consideration of various aspects which should be considered in the launching of a CCS project. In addition to these five “concrete actions,” the Government of Japan also emphasises the plans regarding the business aspect of CCS, in order for CCS to be launched as a business by the year 2030 (The Oil and Gas Division, ANRE, 2022b).

The figure below developed by the Oil and Gas Division of ANRE (2022b) shows the

timeline of the business activities and the five “concrete actions.”

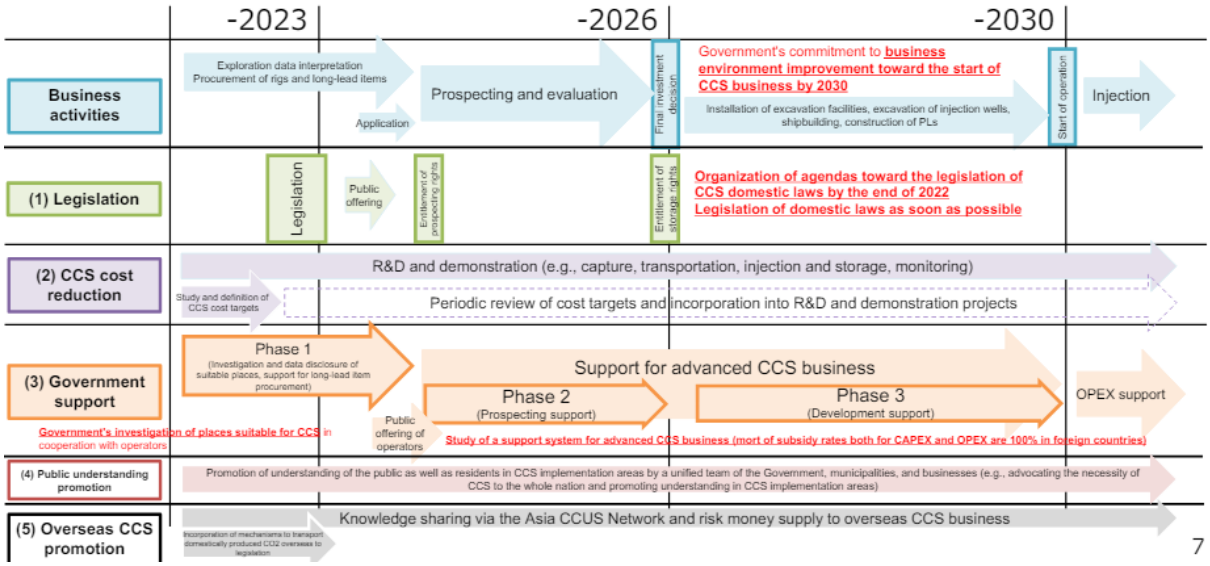

Figure 4: CCS Long-Term Roadmap Timeline

Source: The Oil and Gas Division, ANRE (2022b, p. 7).

As it could be seen from the current situation, planned projects, and the CCS Long-Term Roadmap, the Government of Japan has been emphasising the potential of cross-border CCS while of course making effort toward the official launching of CCS by the year 2023. According to data by the IEA, the annual CCS storage capacity of Japan is estimated to be 120 to 240 million tons in 2050 (The Oil and Gas Division, ANRE, 2022b). Based on this data, according to the Ministry of Economy, Trade and Industry, the Government of Japan (2023), Japan would need to additionally construct 12 to 24 carbon dioxide injection wells every year until 2050; assuming CCS would be launched in 2030, in

order to reach the CCS targets set. As for the overall storage potential, data by research organisations[2] have suggested that there is an estimate of approximately 240 billion tons of potential storage suitable for storing carbon dioxide, in Japan (Oil and Gas Division, ANRE, 2022b). The Ministry of Economy, Trade and Industry, the Government of Japan (2023), states that CCS is one of the keys to mitigating climate change and global warming, and would severely affect the target of reaching carbon neutrality by 2050, if there would be a delay in the deployment and official launching of CCS projects.

4. Proposal for How Japan Can Initiate CCUS Implementation in Asia

Regarding the proposals toward initiating CCUS implementation in the region, this paper will be focusing on suggestions toward Asia as a region. As Asia includes many countries, the proposal would mainly be focusing on addressing the Asian Countries participating in the "Asia CCUS Network," although Australia and the US are also participating countries. The participating countries in Asia, are the ten member states of the Association of Southeast Asian Nations (ASEAN) which are Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam (in Alphabetical order, as listed in ASEAN website) (The ASEAN Secretariat, 2024).

[2] The research organisations referred to here, are the Research Institute of Innovative Technology for the Earth (RITE), the New Energy and Industrial Technology Development Organization (NEDO), and the National Institute of Advanced Industrial Science and Technology (AIST).

4.1. Continuous Knowledge and Experience Sharing

There are several suggestions in order to accelerate the deployment of CCUS, especially CCS, in Asia. As a basis to all proposals, it is crucial that knowledge and experience sharing regarding CCUS projects are continued to be conducted meaningfully. The platform for such discussions was established with the initiative of the Government of Japan together with Economic Research Institute for ASEAN and East Asia (ERIA) (Asia CCUS Network, 2021). The participants of the "Asia CCUS Network" include both countries and "more than 100 companies, and research institutions, and international organisations (Asia CCUS Network, 2021)" related to CCUS. The participating countries are the thirteen countries which are members of the East Asia Summit; the ten ASEAN member states, Australia[3], the US, and Japan (Asia CCUS Network, 2021). The establishment of the "Asia CCUS Network" provided the opportunity for participating countries to collaborate toward accelerating the deployment of CCUS mainly by share knowledge, conduct join-research, and discussing upon challenges and experiences. This has been a significant advancement regarding the situation of CCUS in Asia. With the urgent state of the climate issue, the current main focus for CCUS would be to first efficiently collaborate in order to reduce emissions as a region as a whole. Although there may be concerns regarding competition between businesses, at the current state the urgent focus may be more toward collaborating so that the

[3] Listed in the order in which is stated in the original report (The Oil and Gas Division, ANRE, 2022b).

suitable technology is utilised in order to effectively utilise the potential storage sites and for carbon dioxide to be stored. There are mainly three aims (missions) the “Asia CCUS Network” with the main aim being to “facilitate deployment of CCUS in the EAS region (Asia CCUS Network, 2021).” This goal is to be accomplished mainly through the three kinds of activities which is by promoting “knowledge sharing through holding an annual forum, conferences, workshops, and meetings,” conducting “research studies on technical, economical, and legal standards of CCUS in the EAS region,” and by holding “capacity building training workshops (Asia CCUS Network, 2021).” In addition to this, ANRE (2021a) also raises that the “Asia CCUS Network” would aim to commercialise CCUS by around 2030, through other than knowledge sharing, by conducting research specific to geographical locations on CCUS technology which could be utilised, research regarding economic aspects and regulatory environment, training and development programmes, and promoting CCS Projects utilising the Joint Crediting Mechanism (JCM) (ANRE, 2021a).

Japan has also initiated the establishment of another knowledge-sharing platform addressing decarbonisation, called the “Asia Zero Emissions Community (AZEC) (The Government of Japan, 2024).” The idea of this platform was proposed by Prime Minister Fumio Kishida in 2022, and soon established in 2023 (The Government of Japan, 2024). The aim of establishing this platform was to enhance cooperation among Asian Countries toward reaching carbon neutrality (The Government of Japan, 2024). The platform also emphasises

economic growth and energy security while aiming for decarbonisation, as the aim is to "further advance decarbonisation in Asia toward the goal of carbon neutrality while achieving economic growth and energy security, creating various pathways tailored to each country's circumstances (The Government of Japan, 2024). There are 11 partner Countries participating in AZEC, which is Australia, Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, the Philippines, Thailand, and Viet Nam (Countries are listed in alphabetical order) (The Government of Japan, 2024). Although this platform is not specifically for CCUS, the establishment of this platform has also greatly contributed to encouraging cooperation among Asian Countries toward cross-border CCS projects. The Government of Japan (2024) reports that currently "more than 350 tangible projects are underway in collaboration with both public and private sectors, including approximately 70 Memoranda of Understanding (MOU) signed in the run-up to the AZEC Leaders Meeting (The Government of Japan, 2024)." One of the projects includes the plan for Mitsui O.S.K. Lined Ltd. to develop of a carrier to transport liquefied carbon dioxide in order to be stored (CCS) in Malaysia which intends to provide a storage site as a "global hub for carbon capture and storage (CCS) (The Government of Japan, 2024)."

Global warming and climate change is an issue in which all countries would need to work toward, despite the differences in the country's current situations. Especially regarding CCUS; being a relatively new technology and cost and feasibility still being one of its

challenges (as being pointed out by the Government of Japan), some countries have not yet been able to focus too much on implementing CCUS. However, countries do not equally have potentially suitable storage sites for carbon dioxide, and therefore collaboration between countries would be needed. The International Energy Agency (IEA) (2021a) also points-out that many economies in Southeast Asia "have limited experience and preparedness for CCUS (IEA, 2021a, p. 10)." As of their report published in 2021, there were no projects; not only at the commercial level but of demonstrational level as well, in the Southeast Asian Region (IEA, 2021a). Therefore, one country in a close region may have the storage capacity but may face the challenge of accessing the various needed technology for CCS, and such as the funding for the project. On the other hand, another country may have more experience with research regarding CCS and could potentially collaborate in storing whether locally emitted carbon dioxide or by transporting and storing carbon dioxide emitted in another country.

The IEA (2021a) also suggests that it is important that Southeast Asia would take a regional approach toward transporting and storing carbon dioxide in order to accelerate the deployment of CCUS in the region. The IEA (2021a) raises that the carbon dioxide emitted from countries across the region could be transported to and stored in the potential large storages available in the region. This leads to the second suggestion which is to accelerate cross-border CCS.

4.2. Cross-Border CCS

Knowledge-sharing is of course crucial in order to encourage the whole region to understand the potential of CCUS. However as mentioned in the previous section, not all countries may have the capacity; whether it is storage, technology, or funding, in order to launch CCS projects independently, and cross-border CCS would become a key aspect in storing carbon dioxide effectively for the region as a whole.

Some countries have shown collaborative stances regarding becoming a regional hub for storing carbon dioxide. For example, according to Pertamina; which is the state-owned energy company of Indonesia, Indonesia has potential carbon dioxide storage sites which could store up to 600 gigatons of carbon dioxide (Pertamina; The International Trade Administration, the Department of Commerce, the United States of America, 2024). According to Pertamina, with having potential for storing carbon dioxide, these storage sites could be utilised for both domestic and regional demands for storing carbon dioxide (Pertamina; The International Trade Administration, the Department of Commerce, the United States of America, 2024). The Indonesia Carbon Capture Storage Center (ICCSC) raises that given the geographical location and the potential carbon dioxide storage capacity of Indonesia, Indonesia could become a significant “CCS hub in cross-border operations in transporting CO2 among Singapore, Malaysia, Timor Leste and Australia (ICCSC; The International Trade Administration, the Department of Commerce, the United States of

America, 2024). Indonesia is actively moving toward the deployment of CCS, with having 16 projects on carbon capturing, which includes CCS and CCUS projects which are scheduled to be launched by 2030 (The Indonesia Business Post, 2023). However according to an interview conducted to Mr. Luhut Binsar Pandjaitan, Minister for Maritime Affairs and Investment, there are several challenges for implementing CCS which is that it would "require collaboration from all stakeholders, including regulatory and policy frameworks, infrastructure and technology, finance and funding, as well as public awareness and support (Luhut Binsar Pandjaitan; the Indonesia Business Post, 2023)." This is where the Asia CCUS Network could potentially assist in discussing solutions for this issue. In Indonesia, the Presidential Regulation 14/2024 had been issued in January 2024 which had been regarding the "Implementation of Carbon Capture and Storage Activities (Hakim et al., 2024)." This Presidential Regulation allowed for "carbon capture and storage ("CCS") operators to designate up to 30% of their storage capacity for carbon dioxide ("CO_2") originating from outside Indonesia (Hakim et al., 2024)." The regulation highlights the possibility of cross border CCS, as the content further includes that the "CO_2 could come from emissions by upstream oil and gas activities, refineries, power plants and by industrial activities in Indonesia and overseas (Hakim et al., 2024)." As Indonesia offers the potential storage sites to be utilised for cross-border CCS as well; as a CCS regional hub, cases as such is exactly where countries should collaborate in effectively utilising the storage sites for both the

domestic emissions in Indonesia, and of captured carbon dioxide emissions transported to Indonesia.

According to the Agency for Natural Resources and Energy (ANRE), the Ministry of Economy, Trade and Industry, the Government of Japan (2021a), Malaysia also has high potential for suitable storages for CCUS. Malaysia has many depleted oil fields, which contain thick concentration of carbon dioxide (ANRE, 2021a). The CCS technology of the "Enhanced Oil Recovery" method could be utilised in order to capture the carbon, then inject the carbon dioxide to the oil fields in order to store them (ANRE, 2021a).

The major challenge regarding cross-border CCS would be the regulations and transporting technology. For areas where pipelines exist and could be repurposed for the transporting of carbon dioxide, or new pipelines could be developed, the issue may not be as complex. There may already be pipelines delivering other substances, and the regulations may be able to be adapted in order to transport carbon dioxide. However, the issue would be far more complicated in situations where the carbon dioxide to be stored may only be transported via shipping, due to its geographical distance. As discussed earlier, there are various international regulations applicable to shipping, and many do not specifically mention the transporting of carbon dioxide for the purpose of storing it underground. The issue here, is that as in the case of Article 6 of the London Protocol, existing regulations could be interpreted to be prohibiting the shipping of carbon dioxide to another country for the purpose

of CCS. Although the amendment to Article 6 of the London Protocol is being proposed in order to allow the shipping of carbon dioxide for CCS, currently it has not yet been ratified (James-Olsen, Magnussen, & Voraa, 2022). There is another issue regarding the shipping of carbon dioxide, which is that long-distance transporting of large quantities of carbon dioxide could hold severe risk of damaging the environment if the emissions would result in being released to the atmosphere and the marine environment. Ideally, it would be efficient if carbon dioxide could be transported to another country which has the capacity for storing it underground. However the regulations need to be amended so that the shipping would not violate the regulations, safety measures should be ensured, risks should be assessed, and the technology enabling the long-distant shipping of liquefied carbon dioxide in large quantities.

Two of the CCS projects initiated by the Government of Japan are cross-border CCS projects, assuming the transporting of carbon dioxide to Malaysia and Oceania for storage (Sasayama, 2023). Japan is working toward the implementation of this project, however given the complexity of cross-border CCS it may take a while for cross-border CCS to be a normalised practice (commercially available) throughout the Asian Region. Even with earlier success of the cross-border projects, regulations may differ among different countries. The availability of ships capable to deliver the capture carbon dioxide would be another issue to be considered. There would also be the issue of having the necessary capacity for storing the arrived carbon dioxide ready to be stored. By necessary capacity, this considers various

aspects such as the availability of the machines necessary to inject the carbon dioxide underground and the human resources of people who will be capable of handling this procedure. It would pose another risk if carbon dioxide is nowhere to be able to be stored and is left at the site. On the other hand, as mentioned earlier the ships for shipping may not be available for transporting carbon dioxide at all. Nevertheless, of course efforts should be continued aiming for cross-border CCS to reach the state of readiness to be launched as a formal project. Therefore considering the possible issues which need to be addressed even after CCS becomes commercially available, while continuing the efforts of aiming to launch CCS projects officially by 2030, there needs to be alternative actions to be taken to address this pressing issue. Japan should continue to take initiative in conducting the demonstrational CCS projects, aiming for it to be launched as commercially available projects by 2030. With the success of these projects and demonstrated experiences, Japan could potentially support the storing of carbon dioxide of other countries as well. By the storing of carbon dioxide of other countries, this refers to providing technological support in compressing and storing the emissions which had been captured in other countries for it to be stored domestically in the considered country. As the situation of global warming and climate change is urgent, while it is important that each country commits to its own Nationally Determined Contributions (NDCs), cooperating among the whole region in order to mitigate the issue itself would be essential. The discussion of market competition would most likely be raised more when it

comes to the utilisation of the captured and stored carbon dioxide. This is, as the various products converted from the considered carbon dioxide would have economic value. However, the carbon dioxide must first be captured and stored before any discussion proceeding to the utilisation phase (CCU).

4.3. Establishing a Carbon Market in Asia

a) Carbon Credits

Considering the various challenges regarding the current situation of CCS, establishing a carbon market in Asia would need to be discussed. According to the Japan Organization for Metals and Energy Security (JOGMEC) (2023), a carbon market mainly refers to two different schemes which is the “cap-and-trade (emissions trading” scheme and the “baseline and credit scheme (JOGMEC, 2023, p. 4).” “Carbon credits” is defined as “GHG emission reductions from project activities that can be specified and sold either domestically or in other countries (JOGMEC, 2023, p. 4).” Referencing another definition, according to Walsh and Toffel (2023), “carbon credits” is defined as “financial instruments where the buyer pays another company to take some action to reduce its greenhouse gas emissions, and the buyer gets credit for the reduction (Walsh & Toffel, 2023).” Two definitions were included, as it could be understood that the application of “carbon credits” could be broad, as they could be applied in the case of project activities (definition by

JOGMEC, 2023) or simply referring to where companies would pay other companies to reduce emissions on behalf of them (Walsh & Toffel, 2023). Depending on the mechanism or scheme, rather than company to company, the stakeholders of the project may be more inter-governmental although there are of course, also companies involved in the project itself. Walsh and Toffel (2023) raise concerns that some companies have been allowed the choice to "buy their way out (Walsh & Toffel, 2023)" by simply paying other companies to reduce emissions while they would continue their operations (Walsh & Toffel, 2023). As Walsh and Toffel (2023) raises, it is indeed an aspect which needs to be considered when discussing upon the effectiveness of emission reduction by companies. There is also the aspect of social responsibility associated to this, as the emitting companies should yet realise their responsibility toward climate issues and show commitment toward making effort to reduce their emissions rather than relying on buying the carbon credits. However the discussion is different when it comes to carbon credits for CCS projects. CCS requires advanced technology and funding for the project. Moreover as discussed throughout this paper, cross-border CCS is even more complicated as it requires long-distant shipping of liquefied carbon dioxide and complying with the various marine regulations; in which may have to have the proposed amendments to allow shipping of carbon dioxide to be ratified, before any launching of projects. Even regarding CCS itself, it is currently undergoing demonstrational projects. However regarding CCS projects itself, Japan is aiming toward commercialising

CCS projects by 2030. Therefore, as CCS becomes commercialised in Japan with the success of the demonstrative projects, the technology would be available for launching CCS projects. In this case, by utilising carbon credits for CCS projects in other countries, this would accelerate the utilisation of CCS technology in Asia for reducing emissions. Specifically, Japan would be able to provide the technology and funding needed to capture the carbon emissions of another country and store it in the country, but by receiving the carbon credits for the emissions reduction. This would be explored in more detail later as the Joint Crediting Mechanism (JCM) would be discussed. However, applying carbon crediting systems to CCS projects would potentially be benefiting the whole region by earlier deployment of CCS technology in the Asian Region.

Regarding carbon markets itself, there are mainly two different types of markets which are either “compliance markets” and “voluntary markets (JOGMEC, 2023).” “Compliance markets” are markets established by the government or based on “government-led schemes (JOGMEC, 2023, p. 4).” On the other hand, “voluntary markets” are established by private organisations. “Compliance markets” comprise of mainly three kinds of frameworks (mechanisms) which are international frameworks, bilateral frameworks, and domestic transactions (JOGMEC, 2023).

JOGMEC (2023) raises that for countries of small economies with limited financial support for CCS projects, it would be important that schemes which allow for collecting

finances by monetising carbon credits would be established. They also points-out that “it is important to improve the value of CCS carbon credits, maintain a high standard carbon price, and promote the social deployment of CCS (JOGMEC, 2023, p. 31).” JOGMEC (2023) suggests that CCS should become an “economically viable business (JOGMEC, 2023, p. 31)” in order for the ASEAN region to reach carbon neutrality. They raise that carbon credits for CCS should be set based on the “CDM successor scheme and bilateral scheme (e.g., JCM) (JOGMEC, 2023, p. 31).” The CDM scheme is the Clean Development Mechanism which is a carbon credit mechanism which had been created with the Kyoto Protocol (JOGMEC, 2023).

The differences in the project procedures of the Joint Crediting Mechanism (JCM) and the Clean Development Mechanism (CDM) are shown in the figure below.

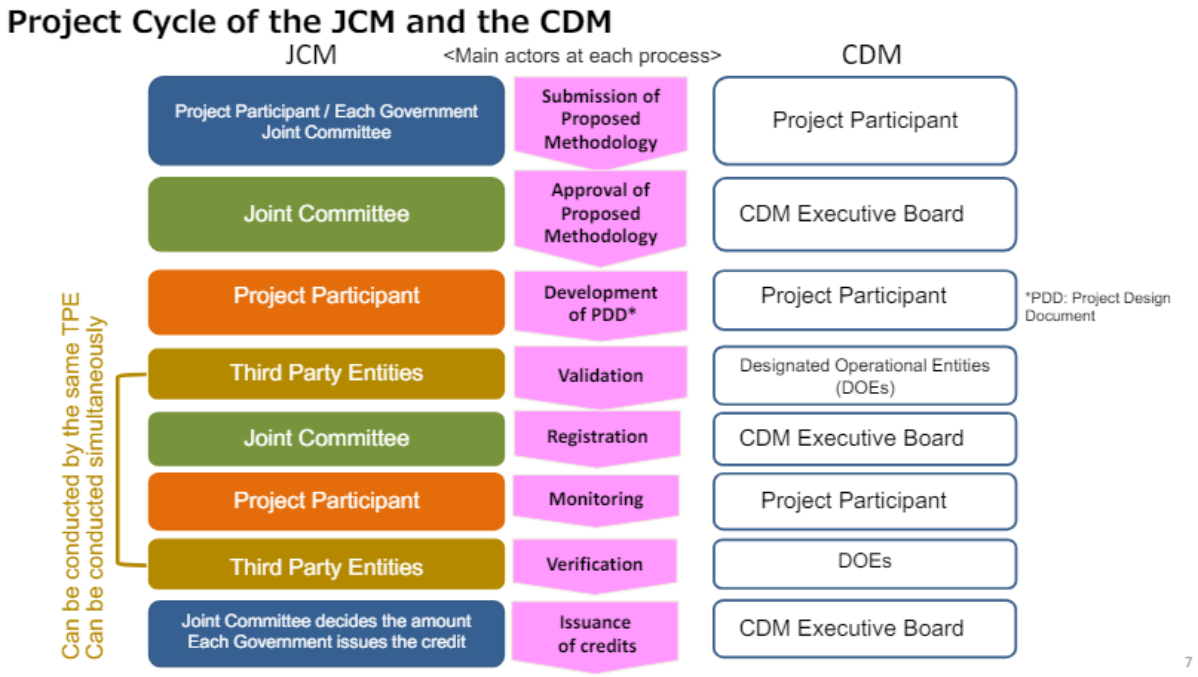

Figure 5: The Project Procedures of the Joint Crediting Mechanism (JCM) and the Clean Development Mechanism (CDM)

Source: Shiomi, K. (2023). *Overview of CCS activities on the Joint Crediting Mechanism (JCM)*. The Global Environment Affairs Office, the Ministry of Economy, Trade and Industry, the Government of Japan.

As it could be seen from the comparison figure above, one of the beneficial aspects of JCM compared to CDM, is the enhanced efficiency of the project. As high-lighted in the figure, the validation and verification process which is to be conducted by “third party entities” could be conducted simultaneously (Shiomi, 2023). Therefore, this would increase the efficiency of the overall project. Another feature to be mentioned, is that the project would have a specific “Joint Committee” formed by Japan and the other Country in the

bilateral agreement for the project. There could be positive aspects for the “CDM Executive Board” assessing the projects, “approving the methodology of the project” and “issuing the credits,” as the standards would be aligned (Shiomi, 2023). However there may also be positive aspects to having a committee dedicated to the specific project, as the committee may be able to promptly revise and respond to concerns regarding project proposals, if any. Regarding the procedure of “issuing credits,” it should not be much different among JCM and CDM, as both would strictly be aligning with the regulations.

The Joint Crediting Mechanism (JCM)

JCM refers to the Joint Crediting Mechanism, and is a bilateral carbon crediting mechanism, which is a mechanism which “appropriately evaluated contributions from Japan to GHG emission reductions or removals in a quantitative manner, and Japan uses them to achieve its NDC (Joint Crediting Mechanism, n,d.).” JCM is currently being revised in order to be applied for CCS projects as well (JOGMEC, 2023). JCM is a scheme specific for Japan and another country. Therefore it would not be a scheme which would be applicable across the Asian Region. Yet the fact that emissions would be reduced would remain the same. This is, as although the carbon emission reduction credits would be counted as the Japan’s carbon emission reductions, it would have yet reduced emissions utilising the sources in which were not able to be utilised for emission reduction, without the collaboration between countries.

JCM would become a key to accelerating CCUS deployment in the Asian Region. ANRE (2018) also raises that this mechanism would benefit both Japan and especially developing countries. Not just limited to CCS and CCUS, many advanced low-carbon emission solutions are costly and in some cases it is difficult to foresee the revenue to be collected, therefore being a challenge to attract investments (ANRE, 2018). However by conducting projects utilising the Joint Crediting Mechanism (JCM), the developing countries would be able to participate in emission reduction projects which would have been difficult to take place without the provided funding and technology for the project (ANRE, 2018). ANRE (2018) also raises that JCM is designed to be far more simple compared to the Clean Development Mechanism (CDM) including the fact that JCM is a bilateral agreement. With the agreement being between two countries, it also enables efficiency and reduction of costs (ANRE, 2018). As stated by Shiomi (2023), JCM also ensures that carbon emissions reduction is taken place accurately, as the system would ensure “the avoidance of double counting through corresponding adjustments (Shiomi, 2023, p. 3).”

The figure below shows the mechanism (structure) of the Joint Crediting Mechanism (JCM).

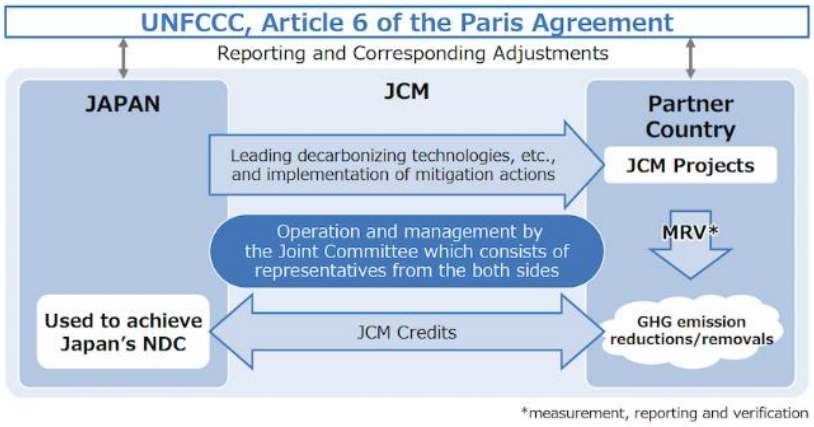

Figure 6: The Mechanism (Structure) of the Joint Crediting Mechanism (JCM)

Source: The Ministry of Economy, Trade and Industry (METI) and Ministry of the Environment (MOE), (n.d.). *Joint Crediting Mechanism, About the Mechanism*. Joint Crediting Mechanism.

From the figure above, the "Joint Committee" would be handling the operations and management of the project (The Ministry of Economy, Trade and Industry and Ministry of the Environment, n.d.). As it could be understood from the figure, the distribution of tasks are very clearly organised. There have been many project cases of JCM projects, with projects with 26 countries being underway as of April 2023 (The Global Environmental Affairs Office, Environmental Policy Division, Industrial Science, Technology and Environment Policy Bureau, the Ministry of Economy, Trade and Industry, the Government of Japan, 2021).

Feasibility studies are currently being conducted in order to apply the JCM scheme to CCS and CCUS projects (Shiomi, 2023). The Ministry of Economy, Trade and Industry

(METI) has been conducting JCM Feasibility studies since 2019, and as of the fiscal year 2022, three projects had been taken place, which were the “CCUS Project at Sukowati Oil Field in Indonesia,” the “CCS Project in Gundih Gas Field in Indonesia,” and the “CCS at Arthit gas producing field in Thailand (Shiomi, 2023).” As an example of the JCM feasibility study projects for CCS, the “CCS Project in Gundih Gas Field in Indonesia” is projected to be able to capture 300,000 tons of carbon dioxide per year which would be transported and injected underground (Shiomi, 2023). The transportation from the source where the emitted carbon dioxide is captured would be transported by pipelines (Shiomi, 2023). In this case, the pipeline for transporting carbon dioxide is to be constructed. The estimated length of the pipeline would be approximately 4 kilometres onshore, which would be connecting the gas processing facility to the carbon dioxide injection well (Shiomi, 2023). The injection well for carbon dioxide storage is also planned to be constructed at the depth of 3,600 metres (Shiomi, 2023).

With the Joint Crediting Mechanism (JCM) already successfully being applied to various different projects, and with the demonstrational CCS Projects in order to access the feasibility of the project, the application of JCM may currently be the most realistic pathway for utilising the potential storage sites for carbon dioxide storage. Physically transporting the emissions captured in Japan to another country would require shipping by specific types of carriers which could hold liquefied carbon dioxide of large quantities. Even if this is enabled,

there will be the issue of existing regulations which do not specifically mention CCS but could be interpreted as to be prohibiting the transport of carbon dioxide via shipping, for the purpose of storing it in another country. The project would also be costly and would require time for the demonstrated cross-border CCS projects to be brought to commercial level. Therefore, it may be most realistic at the current state to utilise the CCS technology Japan has, in order to effectively utilise the CCS storage sites other countries have been offering as potential "global hubs for CCS storage." CCS Projects based on JCM would be beneficial for both countries. It would benefit the other country as Japan would be proving the financial and technological support for effectively utilising the recognised potential carbon dioxide storage and be capturing the emissions of the country. On the other hand, the reduced carbon emissions would be credited as part of Japan's emission reductions, so this would benefit Japan, contributing toward Japan's Nationally Determined Contribution (NDC).

Being in the state of conducting the feasibility studies through demonstrational projects, the current JCM scheme does not include CCS projects in its list of applicable projects (Shiomi, 2023). The feasibility of the CCS projects would most likely be the key factor to whether if CCS would be included to the list of JCM applicable projects. According to a report in 2023, regarding the cost for JCM Projects, "the project cost burdened by Japanese side is 100% supported by Japanese government (METI/NEDO[4]) (Shiomi, 2023, p.

[4] The New Energy and Industrial Technology Development Organization (NEDO)

8).” As the project cost of the Japanese side is not supported by private funding, the feasibility must be assessed carefully as it comes from the National Budget. Regarding this point, the Global Environmental Affairs Office, Environmental Policy Division, Industrial Science, Technology and Environment Policy Bureau, the Ministry of Economy, Trade and Industry, the Government of Japan (2021) raises that one of the challenges regarding JCM Projects is the attraction of funding from private funds. The Global Environmental Affairs Office states that the current system should be made more flexible, and projects in which would be mainly being financed by the private sector should be enabled. In relation to this, ANRE (2023) also raises that the financial sources for projects need to be diversified in order to conduct projects of larger scale. By diversifying the funding sources, ANRE (2023) includes private funds to be included.

ANRE (2023) also raises that Japan is working toward raising the recognition of the JCM scheme, and aiming toward expanding JCM “into an international standard (ANRE, 2023).” Therefore, this could potentially be started from expanding this scheme to be an scheme for the Asian Region. This may be a possible option, although for CCS it is currently being demonstrated, projects utilising the JCM scheme has already been demonstrated with various countries in Asia. Upon successfully completing the feasibility studies of JCM CCS Projects, an option could be for Japan to also suggest a regional scheme based on JCM, in order to accelerate decarbonisation in Asia. The beneficial aspect for this, would be that this

may expand opportunities for decarbonisation projects between the Countries in Asia which are geographically located close to each other. Another possibility could be, if the JCM scheme could be considered for more than three countries as well. This assumes cases in which for example, Japan would like to reduce its emissions by cross-border CCS from Indonesia to Malaysia. This suggestion is made assuming that in some cases, it may be more feasible to transport carbon dioxide to another country for it to be stored. This may be due to various reasons such as having existing infrastructure or pipelines which could be repurposed for the transporting of carbon dioxide. However, this may complicate the credit issuance, so careful allocations of benefits should be agreed upon between all participating parties, before the project is launched. Nevertheless, as Japan has been working toward increasing JCM Projects in general and has been testing the possibility of JCM CCS Projects, this would significantly contribute to decarbonisation utilising CCS technology, in Asia.

b) Carbon Pricing

Carbon pricing has mainly two different mechanisms which is the Emissions Trading System (ETS) and carbon taxes (World Bank, n.d.). The Emissions Trading System (ETS) is also referred to as the “cap and trade system” and according to the World Bank (n.d.) it is defined as a scheme which “caps the total level of greenhouse gas emissions and allows those industries with low emissions to sell their extra allowances to larger emitters (World Bank,

n.d.).” A carbon tax is defined as the scheme which “directly sets a price on carbon by defining a tax rate on greenhouse gas emission or – more commonly – on carbon content of fossil fuels (World Bank, n.d.).” The next section would first explain the example of the European Union Emissions Trading System (EU ETS), as it is a carbon emissions trading system which applies to all Member States of the European Union. Although there are no equivalent Unions in Asia, there potentially could be an Asian Region Version of the Emissions Trading System.

The European Union Emissions Trading System (EU ETS)

The European Union Emissions Trading System (EU ETS) is an Emissions Trading System of the EU which is the “world’s first major carbon market (The European Commission, n.d.a.).” The EU ETS is a mechanism which sets a “cap” for the greenhouse gas emissions so that polluters would be paying for the amount of emissions which exceeds the cap which is set (The European Commission, n.d.b.). The EU ETS was launched in 2005, and is operated with trading phases which are set, they are currently in the Fourth Trading Phase which is set from 2021 to 2030 (The European Commission, n.d.b.). The aim for the introduction of the Emissions Trading System is to of course reduce the emissions in Europe. However by having such taxing system has other benefits as well, as the revenue collected from the EU ETS would then be utilised as part of financing for the EU’s green transition

(The European Commission, n.d.b.). The EU ETS is applied to all Member States of the European Union, and Icelend, Liechtenstein, and Norway. According to the European Commission (n.d.b.) the EU ETS "covers emissions from around 10,000 installations in the energy sector and manufacturing industry, as well as aircraft operators flying within the EU and departing to Switzerland and the United Kingdom – or around 40% of the EU's emissions (The European Commission, n.d.b.)." Therefore, the EU ETS not only considers the emissions from the energy sector and manufacturing industry which is the most commonly discussed upon, but also considers the emissions from aircrafts, which is often not brought to the centre of discussions regarding emissions however is also crucial to address. The European Commission (n.d.b.) also intends to have EU ETS cover emissions which are emitted from maritime transport from 2024.

As there is currently no Union in Asia of equivalent concept to the European Union, the direct application of the EU ETS as a model may be challenging, as for the current state. However, as raised in the explanation for the EU ETS, the revenue derived from the system is then utilised for the purpose of green transformation in Europe. Therefore, having a similar scheme across Asia may potentially support funding to be placed for decarbonisation purposes. Although based on the research for this paper, there were no statements regarding whether id the recently established knowledge-sharing platforms of CCUS (the "Asia CCUS

Network") and for achieving decarbonisation (the "Asia Zero Emissions Community") considered the potential establishing of such as the Emissions Trading Systems (ETS). However, it may yet contribute to possible implementations of such carbon pricing systems, as Asian Countries[5] would collaborate more as a region, and would have a platform to be able to discuss the possibilities of this option as well.

Countries in Asia are known to be highly dependent on fossil fuels and therefore with high emissions. For example, according to data by the IEA, as of 2021, Indonesia had been the ninth highest emitter of carbon dioxide from fuel combustion, accounting for 1.7 percent of total global emissions (IEA, 2021b). The emissions severely need to be reduced in Asia in order to effectively mitigate the climate issue. For many countries in the ASEAN Region, economic development is also significantly important, while they do recognise the importance of mitigating climate change and are indeed making effort to address this issue as well. Indonesia has been considering implementing carbon tax and had initially planned to be establishing a carbon pricing mechanism in early 2022, however this plan has been delayed several times (Global CCS Institute, 2022a).

According to research by Mizuho Information & Research Institute (2017), although as of 2017, it showed how Japan's carbon tax rate was relatively low compared to other countries. However yet, research results showed that there had been reduction seen in carbon

[5] Mainly Asian Countries are participating in the "Asia CCUS Network" and "Asia Zero Emissions Community."

dioxide emissions which could possibly also be the effect of the imposed carbon tax (Mizuho Information & Research Institute, 2017). Moreover, research as of this point, had shown that "energy originated CO2 in 2030 is expected to be reduced by 4.4% (approx. 54 million tCO2) compared to 2013 emissions level by carbon tax's price and budget effects (Mizuho Information & Research Institute, 2017, p. 8)." Recent research conducted by Ishikawa (2024) of the Nomura Research Institute also raises how Japan's carbon tax rate is significantly low compared to Europe. However, Ishikawa (2024) also raises the importance of having a carbon price set.

It is not specified why carbon pricing has not been widely implemented among ASEAN Countries, nor the reason as to why for example Indonesia has been considering the implementation of a carbon pricing scheme however has been delaying its implementation several times (Global CCS Institute, 2022a). One of the reasons which could be the cause, could simply be that the environment (industrial environment and such as policy background) was not ready for the scheme to be implemented and brought to practice. Related to this, another possibility could be that the effective rate of carbon taxes is not yet ensured and is continued to be subject to internal discussion. Another possibility could be the balance between economic development which is much needed as well for the country and setting priorities and boundaries for addressing the climate issue which is also urgent, but mitigating it without causing severe damages to the domestic industries. These reasons may also be

applicable to other countries in the ASEAN Region, as possible reasons in which the majority of countries in the region have not yet implemented any kind of carbon pricing mechanism. However, as proven by the carbon taxing scheme in Japan, even if the taxation rate is relatively or even significantly low compared to such as Europe, as regional situations are different, taxing of carbon dioxide emissions could still be effective in reducing emissions. As Ishikawa (2024) raises, it may indeed effect the economy in situations where carbon tax would be imposed in trade. The inequality of carbon tax rates with other countries may cause inequality in the burden which has to be paid when trading with countries with higher carbon tax rates. However, as most of the countries in Asia (especially of the ASEAN Countries which is the main discussion in this paper) have not yet implemented carbon taxes, the standard for the region could be set at a standardised rate, starting with a low rate. While CCS is regarded to have high potential for emission reduction, schemes should be set for regulating further emissions to be made, or at least be reducing this as much as possible. Given the differences in economic situations, it may be a challenge to implement a standardised rate for carbon tax. Yet, as taxing carbon dioxide emissions has been proven to be effective regardless of the rate being low compared to other regions, there should be a scheme established even if the late would start at a low price. Japan already has a carbon pricing scheme. However, applying this rate across the region may affect some economies, by the sudden taxation. Therefore, in order to not cause inequality for Japan nor negative effect

to other economies, a carbon taxation system should be developed specifically for taxing emissions which were not able to be captured by CCS. As of the current state, CCS is not commercially available. Establishing a taxation scheme now despite the CCS technology being going through demonstration projects, may actually have a positive effect on CCS development. Companies would be further encouraged to either reduce their emissions or invest in developing technology for applying CCS technology. The tax revenue could then be utilised for financing CCS projects. Therefore, although it would be a challenge to determine the right rate, a carbon tax for the purpose of encouraging accelerating development of CCS project implementation should be considered. The Agency for Natural Resources and Energy [ANRE], the Ministry of Economy, Trade and Industry, the Government of Japan (2023) also raises that it is important that carbon pricing rates are set at rates which would not be negatively affecting industries, as this may further cause negative effects to various aspects, such as declination of competitiveness in the international market. With realising these considerations toward the economy and having implemented carbon taxing already, Japan should take the initiative in establishing a carbon market for the Asian Region; specifically among the countries participating in the “Asia CCUS Network” in which Japan has established together with ERIA.

4.4. Establishing Rules to Ensure CCUS Contributes to Emission Reduction

As discussed earlier in the section on carbon capture utilisation (CCU), after commercial availability of CCS, the focus may shift more toward the utilisation phase of the capture carbon dioxide. Theoretically, it is in fact beneficial that carbon dioxide would be captured, stored, then finally utilised for another purpose. Depending on the form carbon dioxide is utilised or converted to, it may have economic value and could be appealing to business. However the concern with this, would be that additional emissions would be disregarded with the focus being put too much on the economic value of utilising the carbon dioxide. It would be problematic if the utilisation process results in additional emissions from energy consumption, such as while converting the carbon dioxide to another product and transporting it to where there is commercial demand for it. These aspects also need to be considered. Nevertheless, if captured and stored carbon dioxide is successfully converted to a form which holds economic value, the revenue could then be counted as part of funding for the overall CCUS project.

As the current state of development is mainly on the CCS phase, there still could be rules set before competition between businesses suddenly evolves. As Japan has been taking initiative in encouraging the collaboration between Asian Countries as a Region, Japan should initiate the establishing of basic rules or guidelines regarding the utilisation of carbon dioxide. This would be crucial in order to ensure that the whole process of CCUS; including

both CCS and CCU, would be contributing to emission reduction and the climate goals. This is an important aspect which should be initiated from an early state, in order to avoid the second phase of CCU resulting in additional emissions despite the effort and investments toward securing the technology of CCS.

5. Conclusion

Carbon Capture, Utilisation, and Storage (CCUS) is a technology which may have high potential in mitigating global warming and climate change. With successful implementation and Technological development may even allow carbon dioxide in the air to be captured, potentially removing historical emissions from the atmosphere (Global CCS Institute, 2022b). Carbon Capture Storage (CCS) is the first crucial stage which has to be completed in order to proceed to the utilisation phase of the stored carbon dioxide. As discussed in this paper, there are various issues which need to be considered and addressed, regarding most of the procedures included in the process of a CCUS project. However yet, the technology is a key factor which may be able to reduce large volumes of carbon dioxide effectively and efficiently, upon successful completion of the currently conducted demonstration projects and in the accumulated practices.

The Government of Japan has not only been realising the high potential of CCUS, but has been conducting multiple demonstration projects for CCS, with the aim to formally

launch CCS projects by 2030 (Sasayama, 2023). There are currently seven demonstrative projects being conducted, with two being cross-border CCS projects (Sasayama, 2023). The projects have been planned and designated so that a combination of various possible features (options) composing a CCS project would be demonstrated as a "model case" upon its successful completion of the demonstration project (Sasayama, 2023). The Government of Japan has also been emphasising the need for collaboration among Asian Countries (which is not limited to cross-border CCS). In 2020, the Government of Japan and ERIA together had proposed establishing a knowledge-sharing hub for CCUS called the "Asia CCUS Network (Asia CCUS Network, 2021). The knowledge-sharing hub had soon been established in the following year, 2021 (ANRE, 2021a). Continuing to take initiative to call for collective effort to mitigate the climate issue as a Region, the introduction of a carbon market may be introduced. The international (Asian Region) Version of the JCM Scheme may be a realistic option once JCM CCS Projects are proven to be feasible and CCS is officially added to the list of projects JCM could be applied to. Another option could be the introduction of carbon taxing. Carbon taxation has proven to be effective even if set at lower rates compared to other countries. Therefore, a carbon taxation system could be implemented across Asia in order to encourage industries to commit to reducing their emissions and prevent over-reliance of carbon dioxide removal technologies. CCUS (especially CCS) is much needed for the current situation however it should not be misunderstood to be a "solution" to the climate issue. The

issue of reducing further emissions to be released should also be addressed.

The current focus is on the first phase of CCUS which is the capturing and storing of carbon dioxide (CCS). However as discussed in the section regarding the utilisation of the captured and stored carbon dioxide (CCU), upon commercial availability of CCS, the focus may start shifting toward the utilisation phase. As the current society is heavily reliant on energy, the additional consumption of energy and thus leading to unintended additional emissions should be carefully avoided. With commercial availability of CCS and technological stability of CCU, companies may start competing toward the utilisation of captured and stored carbon dioxide. As Japan has been initiating networks to bring together Asian Countries to collaborate as a Region, Japan should also take-on the role for establishing guidelines or regulatory environment in order to ensure that CCUS would be contributing to emission reduction, and eventually to the climate goals.

In order to address the pressing issue of global warming and climate change, collaboration of various modes among the Asian Region would be necessary. Therefore, suggestions by four different aspects or approaches in which Japan should take-on the role for initiating the implementation of CCUS had been discussed upon in this paper.

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