GLOBAL CCS INSTITUTE

Workshop Report

Southeast Asia CCS Accelerator

Workshop 1

Bangkok, Thailand
15-16 May 2023

Contents

1. Introduction

Achieving net-zero greenhouse gas emissions by mid-century, consistent with stabilising global warming at between 1.5 and 2 degrees Celsius, requires trillions of dollars of investment in climate mitigation projects across all sectors, in all jurisdictions. The essential role of CCS, alongside all other mitigation options in meeting ambitious climate targets, is well established by decades of research and analysis. This fundamental truth is now evident in some government policy and private sector investments which together have supported unprecedented growth in the CCS-Project pipeline over recent years. However, progress is patchy and overall it is insufficient to meet climate targets. Global installed CCS capacity must increase by a factor of over 100 by 2050 to avoid dangerous interference with the global climate.

The greatest need for CCS exists in hard to abate sectors, particularly those with process emissions, and in economies that rely upon fossil fuels to support their rapid economic growth. Consequently, it is imperative that CCS advances rapidly in Southeast Asia which hosts a significant proportion of the world's emissions-intense industry and has a growing dependence on fossil energy.

Since June 2020, the Institute has been organising the Southeast Asia CCUS Roundtable with support from governments and industry. The roundtable has attracted stakeholders from ASEAN countries, Japan, Australia, Spain and UK. Many constructive and insightful discussions were held at those roundtables. Outside the roundtable, the Institute has had extensive engagement with stakeholders in the region, including governments, oil/gas companies, power companies, research organisations, and NGOs. These engagements have identified three critical challenges for CCS deployment in the region;

- the absence of specific and comprehensive CCS regulation,
- insufficient enabling policy to support a business case for investment, and
- lack of data and appraisal of geological storage resources for CO_2.

It is clear that a collaborative and action-oriented initiative in Southeast Asia is necessary to accelerate CCS project investment and deployment, consistent with the urgency attached to climate mitigation. In service of this need, the Global CCS Institute created the Southeast Asia CCS Accelerator (SEACA). SEACA serves as a collaborative platform between governments, multilateral organisations and the private sector, with interests in CCS in ASEAN. SEACA aims to accelerate the commercial deployment of CCS in ASEAN as an essential component of the region's efforts to deliver an energy transition and mitigate climate change. SEACA will also directly support ASEAN Member States (AMS) in their efforts to build capacity to deploy CCS as an important component of the implementation of the ASEAN Plan of Action for Energy Cooperation (APAEC) Phase 2: 2021-2025 for ensuring energy security, accelerating energy transition and enhancing energy sustainability toward low carbon economy in the region

SEACA is structured under three pillars that broadly represent the most significant challenges to investment in CCS in Southeast Asia. Those pillars are:

1. CCS Regulation
2. Enabling Policy
3. Geological Storage Resource Development

As the output of SEACA in its first-year implementation, the GCCSI and ASEAN Centre for Energy (ACE) will organise three (3) workshops and further develop the ASEAN CCS Deployment Framework and Roadmap. It is expected to set the reference and guidance for ASEAN Member States in charting the pathway towards the commercial deployment. SEACA focuses on new-term commercial deployment of CCS in the region.

2. SEACA Workshop

The 1st SEACA Workshop was held on 15 and 16 May 2023 in Bangkok, Thailand, and was co-organised by the Global CCS Institute and the ASEAN Centre for Energy (ACE). The workshop was hosted by the Department of Mineral Fuels, Ministry of Energy of Thailand and formed part of a series

of research projects being completed by the GCCSI for the Economic Research Institute for ASEAN and East Asia (ERIA). The agenda of the 1st SEACA Workshop is attached as ANNEX 1.

The Workshop was attended by the representatives from six (6) ASEAN Member States (Brunei Darussalam, Cambodia, Lao PDR, Malaysia, Myanmar, Philippines and Thailand) from the government sector, regulatory authorities, and state-owned companies, as well as the invited participants from other government entities, industries, universities, consulting companies, etc. The list of participants is attached as ANNEX 2.

2.1 Day 1 (15 May 2023)

OPENING REMARKS

Mr. Alex Zapantis, General Manager Commercial, Global CCS Institute, delivered his opening remarks. He conveyed that policies between government are required to enable international trade and carbon dioxide storage services. He emphasized the importance of developing storage facilities and supportive policies, as well as coordinated actions to drive the necessary investment for a successful CCS development. Lastly, he stated that this workshop was intended to identify actions that can be done to improve advancement of CCS in Southeast Asia.

Dr. Veerapat Kiatfuengfoo, Deputy Permanent Secretary, Ministry of Energy, Thailand delivered his opening statement on behalf of Mr. Kulit Sombatsiri, Permanent Secretary, Ministry of Energy, Thailand and SOE Leader of Thailand. He stated that Thailand has committed to achieve carbon neutrality by 2050 and net zero emissions in 2065 as stated in the COP 26. He further stated that in the COP 27, Thailand has submitted a new NDC to reduce GHG emissions by 40% by 2030. He emphasized the importance of fossil fuel, particularly coal, in the energy sector while transitioning to a 100% clean energy target.

Mr. Beni Suryadi, Manager of Power, Fossil Fuel, Alternative Energy and Storage (PFS) Department of the ASEAN Centre for Energy (ACE) delivered his opening statement on behalf of Dr. Nuki Agya Utama, Executive Director of ACE. He conveyed the key message from the 21st Asean Forum on Coal (AFOC) Council Meeting that the meeting has high expectations of the 1st SEACA Workshop to support the acceleration of CCS projects in ASEAN region. He emphasized the important roles of CCS in decarbonizing the energy system in ASEAN. He stated that based on the 7th ASEAN Energy Outlook, energy demand is expected to triple by 2050 compared to 2020, where fossil fuels are dominating the energy system. He stated that Clean Coal Technologies (CCT) and CCS/CCUS are inevitably required to reduce emissions in ASEAN. He hoped that the outcomes from this workshop could also be utilised to support the development of the study on ASEAN CCS Deployment Framework and Roadmap.

Mr. Shigeru Kimura, Special Advisor to the President of Energy Affairs, Economic Research Institute for ASEAN and East Asia (ERIA) delivered his opening statement. He stated that despite ASEAN significantly increasing its renewable energy share, particularly in hydrothermal, geothermal, solar, and wind, ASEAN will continue to use coal and gas as energy sources and the shifting of coal to gas will happen largely after 2040. Moreover, he emphasized that, beyond 2040, ASEAN will apply CCS to coal and gas power plants to mitigate 550 Mt CO_2 equivalent by 2050.

SESSION 1: ASEAN Study on CCS Framework

Suwanto, the representative of ACE presented planning for a study to develop the ASEAN CCS Deployment Framework and Roadmap. The workshop noted the following highlights:

In all scenarios based on the 7th ASEAN Energy Outlook, fossil fuel dominates the energy system. Coal, mainly used in power and industry sector, comprises of 22.1% of energy in the baseline scenario and 18.3% in the Accelerated Policy Scenario (APS) in 2050. Therefore, the role of CCS/CCUS is vital

for decarbonising ASEAN's energy systems.

ASEAN has a short-term target of achieving 23% of renewable energy share in 2025, a medium-term target of reducing emissions as per ASEAN Member State NDCs by 2030 and long-term targets of net zero or carbon neutrality by 2050. It is important that the ASEAN CCS deployment framework and roadmap addresses how to deploy CCS to achieve ASEAN short, medium and long term energy targets.

ACE will use information and analysis produced by SEACA to support the development of the CCS Deployment Framework and Roadmap.

SESSION 2: CCS Projects, Opportunities & Ambitions In ASEAN

Overview of SE Asian Facilities

Chris Consoli, the representative of Global CCS Institute presented the Overview of Southeast Asian Facilities. The workshop noted the following highlights:

As of May 2022, there are 257 commercial CCS facilities in development, construction or operation: 37 operational, 20 in construction, 97 advanced development, and 103 early development.

CCS facilities had an average capture capacity size of 1.2 million tonnes per annum (Mtpa) with the largest operating capture capacity of 10.6 Mtpa operated by Petrobras Santos (Brazil).

In ASEAN, there are 12 commercial CCS facilities which are located in Indonesia (7), Malaysia (3), Thailand (1), and Timor-Leste (1). Only the Kasawari project in Malaysia is in construction; the remaining 11 facilities are in development. The average capture capacity is 1.9 Mtpa. CCS development in ASEAN is considered at nascent stage.

Presentation from ExxonMobil – Singapore

Justin Oettmeier, the representative of ExxonMobil – Singapore presented the Asia Pacific CCS Overview. The workshop noted the following highlights:

ExxonMobil has partnered with Malaysia, Indonesia, Australia, Japan, Korea, and China in developing CCS projects.

In Malaysia, project development agreements (PDAs) were executed with Petronas to jointly pursue CCS activation. These PDAs focused on maturing technical scope, developing a commercial framework, and establishing advocacy plans to support regulation and policy development.

In Indonesia, a Heads of Agreement (HoA) was executed with Pertamina to develop CO_2 storage with potential capacity to store up to 1 Gt of CO_2. This agreement focused on developing a commercial model for regional hub development and supporting development of enabling policy.

ExxonMobil has established policy enablers for CCS which is divided into four aspects: (1) strategic vision, (2) storage incentive, (3) emitter incentive, and (4) ability to operate.

Presentation from PTTEP – Thailand

Yanadet Sripanich, Ph.D., the representative of PTT Exploration & Production (PTTEP) presented Striving Toward Thailand's Net-Zero Target with Carbon Capture Storage. The workshop noted the following highlights:

In 2018, Thailand had total emission of 373 $MtCO_2$ equivalent and aimed to reduce GHG emissions by 40% with international support by 2030. Thailand targets carbon neutrality by 2050 and net-zero GHG emission by 2065.

PTTEP has committed to support Thailand's emission reduction targets through CCS projects including at the Arthit gas field (Gulf of Thailand) which aims to be the first CCS facility in Thailand.

To make CCS possible in Thailand, there were six (6) aspects identified, which include technology readiness, project demonstration, decarbonization policy, supportive policy and regulation, storage, and public understanding. The last three aspects were emphasized as needing more effort, including the need for supportive policy in the form of incentives or carbon markets/ecosystems, CCS regulation, and improving the public's understanding of CCS as a scientifically proven technology.

Presentation from Government of the Northern Territory – Australia

Dr. Howard Smith, the representative of Northern Territory Government - Australia presented The Northern Territory's CCS Hub. The workshop noted the following highlights:

The Northern Territory has identified gas reserves in excess of 30 Tcf offshore and more than 500 Tcf onshore in Australia. Developing the extensive gas resources of the Northern Territory is required to underpin the new economy.

The Northern Territory commenced planning to develop Middle Arm, in Darwin Harbour, into an industrial precinct in 2019. Incorporation of the industrial ecology approach that included CCS was instrumental in acquiring AUD1.8 billion funding for enabling infrastructure required for the low emissions hub.

Key developments in CCUS in the Northern Territory include (1) establishing a decarbonisation working group to develop a low emissions industrial hub at Middle Arm, (2) collaborating with the Timor-Leste Government and the LNG industry to secure access to the Bayu-Undan field as a CO_2 storage formation, and (3) collaborating with the Australian Government and LNG industry to secure additional CO_2 storage capacity in North Australian waters.

Regarding the Australian policy, it was noted that offsets targeted under existing policies alone are inadequate for managing the volumes of CO_2 currently emitted by industry in the Northern Territory.

Presentation from Japan Organization for Metals and Energy Security (JOGMEC)

Dr. Sakura Nishioka, the representative of JOGMEC presented JOGMEC's CCS Activities in Southeast Asia. The workshop noted the following highlights:

JOGMEC was established with a mission to secure a stable supply of natural resources to Japan and realizing carbon neutrality through CCS, including the supply of low carbon fuels such as hydrogen and ammonia and renewable energy.

There are several CCS activities in Southeast Asia, particularly in Indonesia, which include the Jatibarang CCUS (CO_2-EOR) pilot project in West Java and CCS study for blue ammonia production in Sulawesi. Furthermore, a regional screening study to identify suitable CCS storage resources in the ASEAN region has also been conducted.

A small-scale CO_2 injection into a depleted oil reservoir has been successfully completed at Jatibarang CCUS pilot project in Indonesia as a first step towards future commercial scale CO_2-EOR and CCS.

To contribute to building institutional infrastructure for CCS deployment, JOGMEC has published a 'Handbook for CCS Carbon Credits' to unlock the potential carbon market for CCS deployment, and

a “CCS guideline” to promote CCS and emphasize JOGMEC’s view.

Presentation from METI – Japan

Norihiko Saeki, the representative of METI – Japan presented Japan Policy Toward CCS. The workshop noted the following highlights:

CCS is a necessary and inevitable measure to accomplish a carbon neutrality target by storing residual emissions of CO_2. Joint development of CCS reservoirs and the establishment of export and import mechanism is necessary for the ASEAN region.

Key issues mentioned in the G7 Climate, Energy and Environment Ministers’ Communique on the deployment of CCS technologies include the potential for CCS hubs, export/import mechanism for CO_2, and recognising CCU/carbon cycling.

METI is developing Japan’s national strategy on a CCS including a long-term roadmap that is divided into two phases. The first phase runs until 2030 and is focused on building the business model for CCS. The second phase is the full deployment of CCS from 2030 to store 120-240 million tonnes of CO_2 by 2050.

In June 2021, the Asia CCUS Network (ACN), an international industry-academia-government platform, was established by METI. It aims to share knowledge and develop a business environment for CCUS throughout Asia.

Presentation from Mitsubishi Corporation – Japan

Shoji Hara, the representative of Mitsubishi Corporation – Japan presented Mitsubishi Corporation’s CCS Activities. The workshop noted the following highlights:

Mitsubishi will invest approximately USD 15 billion by FY2030, in areas including renewable energy, copper, natural gas, hydrogen and ammonia, while maintaining a sound balance sheet.

Mitsubishi will pursue global initiatives to double renewable power capacity and create next generation energy supply chains. Moreover, a target to achieve 100% non-fossil power generation by 2050 has been set.

Mitsubishi is working with industrial partners to provide multiple carbon neutral solutions including CCS, CCU, hydrogen, ammonia, and carbon offsets (credits).

Mitsubishi has already participated in some CCS projects to proactively decarbonise existing projects, including a CCS project in Sulawesi and an LNG CCUS project in Tangguh, Indonesia.

Key issues related to the development of international CCS include financing/cost recovery: cost of CO_2 capture, transportation, injection and storage, and legislations/regulation of CO_2 storage including the management of liability.

Presentation from Santos – Adelaide Australia

Matt Sherwell, the representative of Santos – Adelaide Australia presented Santos’ CCS Hubs. The workshop noted the following highlights:

Santos’ carbon capture and storage hub strategy includes the Darwin and Bayu-Undan Hub, Western Australia Hub, and Moomba Hub.

Moomba CCS in South Australia will store 1.7 million tonnes of CO_2 per year. Construction of the project is 60% complete and commissioning is expected in 2024.

Timor-Leste – Bayu-Undan is expected to have a capacity of 10 million tonnes per year. The existing gas production operation at Bayu-Undan is expected to cease soon and the CCS project offers to create a new industry for Timor-Leste.

SESSION 3: Policy Pillar – Issues, Opportunities, and Barriers

Eric Williams, the representative of Global CCS Institute presented Policy Pillar of CCS Deployment in Southeast Asia. The workshop noted the following highlights:

Eric described the Global Economic Net Zero Optimisation (GENZO) model which finds the lowest cost technology mix required to meet net-zero emission targets by mid century. Based on GENZO, energy efficiency meets increasing final energy demand until 2040. Strong growth is observed in primary fossil energy and renewable energy. Moreover, CCS on fossil energy grows, starting from coal and followed by gas and oil in 2040. This trend is followed by the rapid growth in CO_2 captured from hydrogen production.

The Present Value (PV) of capital investment in technologies with carbon capture needed in Southeast Asia is around USD 587 billion. Singapore has the highest CO_2 prices to achieve net zero targets of USD 1,500 – 1,600 per tCO_2 from 2050, while CO_2 prices in other ASEAN countries is around USD 400 – 600 per tCO_2 in 2050. These results assume that there is no CO_2 emissions trading between regions.

Policy is required to incentivise investment. Policies help to mitigate the negative effects of market failures on cost, revenues, and risks. Moreover, it will enable investors to generate a reasonable return on their investment. Thus, it will help in supporting the decision to invest in CCS.

Several policy intervention options were presented, including placing a value on CO_2 storage, providing capital support (capital grant, low-cost finance, accelerated depreciation), direct equity investment by government, government procurement policies, and regulation.

Regarding regulation, caution is required to avoid losing production capacity to jurisdictions with less regulation or to jurisdictions with strong policy support for CCS.

Discussion points:

- It was suggested that assessing bankability of the projects is one of the important factors.
- It is important to identify the risks and uncertainties associated with CCS projects.
- The consideration of institutional and financial aspects, as well as the recognition of the role of technology, can lead to cost reduction and market creation.
- Conducting Monte Carlo analysis or running sensitivity anaysis could also be done in the model to explore many uncertainties.
- The need to determine appropriate policy instruments to address the technical, financial and institutional challenges of CCS was noted. These policy instruments may include the implementation of carbon mechanisms to create a CCS market, the implementation of specific policies to support CCS deployment, and speeding up carbon trading implementation.
- Challenges identified by PTTEP, which plans to develop CCS projects include uncertainties in capture and storage, the additional cost of implementing CCS, insufficient recognition that CCS will act to support energy transition more efficiently, regulatory and policy uncertainties associated with cross-border transport of CO_2, the need to enhance public perception of CCS and the risk of local “not in my backyard” opposition to projects.

SESSION 4: Regulation Pillar – Issues, Opportunities, and Barriers

Ian Havercroft, the representative of Global CCS Institute presented the Regulation Pillar, aimed at supporting CCS Deployment in Southeast Asia. The workshop noted the following:

The role of law and regulation is to:

1. formalise national, regional, and international policy commitments to the technology's deployment,
2. ensure the legality of operations under existing national or regional laws,
3. address the novel aspects of the technology,
4. clarify rights and responsibilities of operators and relevant authorities, and
5. promote investor confidence, environmental protection, and public safety.

The majority of ASEAN countries have yet to develop CCS-specific legal and regulatory frameworks.

There are common themes and shared challenges across the ASEAN region, which are:

1. national policies towards emissions reduction, including net-zero commitments, present significant challenges and opportunities for deployment,
2. limited development of CCS-specific law and regulation across the region, and
3. uncertainty regarding the administration of CCS operations in some jurisdictions.

Priority actions for policymakers and regulators are:

1. consideration of CCS within national policy architecture;
2. scrutiny of international law to ensure that outstanding uncertainties are addressed;
3. review of domestic legal and regulatory regimes; and
4. the timely development of legal and regulatory frameworks.

CCS-specific law and regulation is critical to supporting more widerspread deployment of the technology. The removal of any remaining national and international legal barriers to the technology will be also be critical.

Discussion points:

- Regulators and policymakers need to consider the various forms of liability applicable to CCS operations, noting that different countries may have different liability management approaches. It was noted that the risk is at its highest during the injection phase of CCS and decreases over time as monitoring and intervention takes place.
- Adopting a streamlined and simpler approach to the permtting and/or licensing of storage operations may facilitate project development and incentivize investment.
- It was noted that other jurisdictions have successfully developed CCS-specific legal and regulatory regimes, based upon existing regulatory frameworks. Adopting this approach had proven a positive step for regulators that were familiar with existing regulations and the regulation of similar activities (e.g. oil and gas operations). It was suggested that this approach could increase efficiency and avoid the need to design entirely new regulatory frameworks.
- Participants highlighted the urgency for developing law and regulation in the region. It was also noted that stakeholder collaboration will be essential in this process, and regulations should not be developed in isolation.
- To support CCS deployment in the region, at the scale and pace required, it was proposed that further support and knowledge sharing be provided to governments. Collaborative efforts between industry experts, policymakers, and regulators may ultimately help expedite the regulatory process.
- Noting the potential capacity and resources gap amongst state regulators, it was suggested that governments seek external expertise and empower regulatory bodies with the necessary resources.
- Greater direct engagement with governments in the region, on legal and regulatory issues, and in particular the approach to overcoming gaps and obstacles in national regimes, would

ultimately expedite the development process.

SESSION 5: Storage Pillar – Issues, Opportunities, and Barriers

Chris Consoli, the representative of Global CCS Institute presented Storage Pillar of CCS Deployment in Southeast Asia, which is. The workshop noted the following highlights:

CCS can be applied to a range of industries to mitigate emissions including the cement, chemical, power, refining, steel, and oil and gas industries.

Analysis of potential geological storage resources in ASEAN indicates that the total capacity is more than sufficient to meet demand. However, the location of specific storage formations in saline formations is unknown, published storage resource estimates do not have transparency in their location, method or data, and there is almost no open access to data. This lack of transparency and clarity reduces the confidence in the results of these studies and reduces their value to CCS project developers.

The ASEAN region requires a comprehensive program to identify and characterize geological storage resources using a clearly defined and accepted method and where data is published and available.

A coordinated approach to storage resource development in ASEAN would accelerate the deployment of CCS in south east Asia. A series of public-private partnership characterizing storage basins in each country could be an effective way of delivering the work. A public database of hydrocarbon fields and saline formations with critical information including location, extent and reservoir-seal properties would support more targeted studies by CCS project developers..

Discussion points:

- Regarding efforts undertaken to gather comprehensive data from multiple sources for the purpose of carbon capture and storage, the primary objective is to collect broad-level data required for CO_2 storage characterisation and resource estimates. This data can be in the form of ranges and averages.
- Storage characterisation and resource estimation should be undertaken using standardized methodologies and data.
- The importance of ASEAN government geological survey's input, and their commitment to understanding the storage potential of their own basins for project development was emphasized.
- Early investment and intervention by relevant parties were seen as essential to manage risk effectively.
- Political challenges were considered relatively easier to address, whereas regulations posed difficulties in initiating activities and required understanding from involved parties. It was noted several times that storage development will guide policy on CCS.
- Public concerns were acknowledged, but their impact on project development was not seen as prohibitive at the early stage.
- The CCS readiness index developed by the Global CCS Institute was mentioned as a tool to assess countries' preparedness for CCS deployment, focusing on regulations, policy support, and storage development.
- Educating regulators and policymakers about the manageable risks and economic feasibility of CCS was emphasized.
- The importance of providing training programs and capacity building in geoscience to member countries was recognized as one of the strategies in a successful CCS development.
- Public-private collaboration was emphasized as one of the important roles in implementing CCS.

SESSION 6: Plenary Discussion Session – Overflow Time

The workshop noted the following:

There was a concern about the affordability of achieving net-zero emissions. The current price of CO_2 in Europe is just over 100 euros. Long-term CO_2 prices in GENZO can grow to as high as 1,700 USD in Singapore if CO_2 trading between regions is not allowed. Without CCS costs are even higher. The model shows that abatement costs can reach far higher costs per tonne of CO_2 in industries where abatement is difficult or expensive.

The model's predictions are based on current knowledge and assumptions, and it accounts for our current assessment of future cost reductions and technology improvements, though it does not attempt to account for unforeseen technological advancements. While breakthroughs can happen and costs may come down, it is important not to rely solely on those possibilities. We must take action with the current technologies and available knowledge.

Economies of scale play a significant role in the cost of CO_2 transport. Larger scales of transport, such as through pipelines, can significantly reduce costs compared to smaller volumes. The model assumes that investments in CO_2 pipelines are done to maximize the potential for economies of scale. Scaling up CO_2 infrastructure not only brings cost advantages but also reduces risks and increases the options for CO_2 utilization or storage.

There are situations where CO_2 storage can present new business opportunities, such as providing a revenue stream and offsetting emissions costs. Some businesses are emerging solely focused on CO_2 storage as their business model.

Urgency to address climate change continues to grow, and the business case for CCS is expected to become more favourable as governments provide support similar to what has been seen in the renewables sector. Sharing the risk and ensuring the whole industry moves forward is crucial, and this requires collaboration between the public and private sectors.

The workshop suggested forming a small working group or utilizing the current group to discuss and share experiences on CCS topics.

Shipping is becoming an important aspect of the CCS process. While the exact cost of shipping depends on factors such as distance, it is considered a relatively small part of the total CCS cost per tonne of CO_2. The model suggested that shipping CO_2 can range from 5 USD to 30 USD per tonne. However, it was also noted that the scale and infrastructure play a significant role in the overall cost.

2.2 **Day 2 (16 May 2023)**

OPENING REMARKS

Alex Zapantis, General Manager Commercial Global CCS Institute, welcomed delegates, gave a recap of Day 1 and outlined the objectives for Day 2. He conveyed that private sector plays an important role to drive CCS forward as it has the expertise, resources, and capacities needed. But that private sector can only invest if the business case is sufficiently strong, and this requires the assistance of governments through policy and regulation. He hoped that by the end of today's discussion, several actions can be presented for each of the pillars which can help to accelerate and advance CCS in Southeast Asia.

SESSION 1: Policy Pillar – The Way Forwards

The Workshop noted the following:

Taking a case sample from Thailand, current carbon prices on the Thai voluntary trading system are low and unlikely to create significant incentives for CCS. There were also concerns about the compatibility of carbon credits in the voluntary market with the implementation of emission trading systems (ETS) where engaging with regulators to ensure that voluntary carbon credits are not overshadowed by ETS regulations is of importance. Moreover, it was emphasized that one or two dollars of CO_2 pricing is not going to do much, unless there is a big compliance incentive to do it, like in Europe. In addition, on the grant and loan side, it was noted that Governments in this region have great difficulty providing significant funding. Thus, it was recommended that there are some sources of funding from multilateral development banks.

Implementing a carbon pricing scheme at very low rates, such as one or two dollars per tonne, may not provide strong incentives for significant investments in decarbonization. However, in the case of Singapore, there is a carbon tax of $5/tonne that has been implemented for a few years. This tax might not individually motivate specific entities to make substantial decarbonization investments, but the government is committed to utilizing the collected funds to support decarbonization activities in one or two specific markets. Some of the funds collected from this tax might be available to support CCS.

Several suggested policies for promoting CCS in the regions include coordination for cross-border CCS hubs, establishing the value proposition of CCS for neighbouring industries, allocation of limited incentives, and incorporating capture equipment from the outset. Furthermore, it was discussed that considering the absence of some essential elements, public financing may be necessary if carbon pricing mechanism and market elements are not yet in place.

It was suggested that the Government should invest in the entire value chain or infrastructure systems such as pipelines as the costs of CCS can be allocated to various infrastructure projects and support from the government can be sought to initiate and increase investment in CCS. The workshop also noted the idea to assist the Governments in developing roadmaps and strategies for CCS deployment. Moreover, it was noted that each country's roadmap for achieving their emissions reduction goals and the seriousness of their commitments might vary. Factors such as the energy mix, renewable energy adoption, and the availability of CCS options are different across ASEAN member states.

It is necessary to have some roadmaps, short-term and long-term roadmaps around CCS and climate strategies in general. Moreover, Government should take the first step investing in infrastructure like pipelines to help kick start the CCS hubs in the region and establish regulations.

There was an emphasis on the importance of ensuring that new facilities are "capture-ready" to support future CCS deployment. This requires the establishment of regulations that mandate capture readiness for new facilities. One of the suggestions was to convince the Government about the benefits of such regulations. This would also involve demonstrating that the cost burden on business is manageable.

Collaboration with project developers is a crucial factor for success. Engaging with developers who possess the necessary capital and expertise at the early stages of project development is seen as valuable.

The workshop noted that in many cases, the Government Officials may have a high-level understanding, but there is often a lack of technical expertise or political push to effectively drive progress. This can lead to clashes and difficulties in advancing CCS initiatives within the Government.

The workshop recommended to continue to develop the GENZO model and to clearly and transparently document its assumptions.

SESSION 2: Regulation Pillar – The Way Forwards

The workshop noted the following:

To further develop law and regulation in the region, several key actions were highlighted as critical, including: the promotion of transboundary legislation, the establishment of financial agreements between nations, and the development of dedicated legislation for CCS projects. A variety of supportive actions were proposed, including, the development of model frameworks, analytical studies, and detailed national regulatory assessments were suggested as a means of supporting these outcomes. There was also an emphasis on the need for broader education on the critical issues, across the region.

It was acknowledged that different countries are at different stages of the regulatory journey. Review of existing laws and regulations, analysis of other countries' experience, and detailed discussion with key stakeholders, may all be important actions for determining appropriate pathways for developing legislation.

It was suggested that policymakers and regulators also leverage academic research and expertise, to supplement industry knowledge. The potential role of leading universities and academics in supporting the implementation of CCS legislation was highlighted. The role these actors may play in influencing public opinion and supporting government decision-making was also noted.

Regulation should also include establishing a monitoring reporting and verification (MRV) system for CO_2 storage, address CO_2 transportation and CO_2 purity requirements. Transboundary movement of CO_2 also requires regulation and agreements between nations related to carbon accounting, liabilities and compliance with the London Protocol (where applicable).

Participants noted that a working group on liability should involve lawyers, as well as representatives from the private sector, and government. It was emphasized that the Government should understand the technical elements and associated risks of liability, especially with regard to long-term storage liability.

Technical advisors should be part of the legal and regulatory conversation, alongside lawyers and regulators, to ensure the technical practicalities of law and regulation are considered.

The institute expressed its willingness to take the lead and convene discussions, but also welcomed and the input and collaboration from individual countries, organizations, or industry.

Several potential actions were highlighted by participants, including the establishment of working groups to explore key issues and themes, and conduct high level engagement in policy discussions.

SESSION 3: Storage Pillar – The Way Forwards

The workshop noted the following:

CCS and CO_2 storage are urgent matters. Lessons learnt from other regions should be considered to accelerate storage development collectively. Appraising storage sites, including depleted oil and gas fields and saline formations, should consider reservoir and seal characterisation, storage resources and accessibility.

The driving force for CO_2 storage is policy. An operator needs security through long-term policy and support. Moreover, appropriate regulation and supportive policy are essential enablers of storage.

ASEAN member states (AMS) are at varying stages of CCS development. Some AMS, such as Indonesia, Malaysia, and Thailand are driving forward and actively pursuing CCS projects. Vietnam is slightly behind in their storage development efforts. Meanwhile, countries like Lao PDR, Myanmar, Cambodia, and the Philippines have yet to initiate storage resource assessments. Philippines also stated that the assessment of storage should be identified to further analyse the whole CCS value

chain.

Collaboration among countries, agencies, international oil and gas companies and multilateral organisations was considered crucial in the development of storage sites. International agencies like the European agencies and Japan were mentioned as potential collaborators in storage site investigations.

Based on the above points, it became clear that there is a need for a storage resource development program, considering not only well-explored areas like offshore Sarawak but also other countries such as the Philippines. Assessing the storage potential of various regions would de-risk storage analysis for future CCS development.

The storage resource development program would develop a standardized methodology for CCS assessment; this was deemed crucial. Establishing a clear framework and greater transparency in data and methodology would enhance confidence in CO_2 storage assessments.

The workshop noted the idea of establishing a public database of storage-related seismic and well data, particularly derived data from major depleted fields and saline formations. Therefore, it is recommended to also engage with associations on geology or geophysics to gather data information.

The CarbonSafe program in the United States was highlighted as a model for assessing and developing storage projects. The program involved collaborations between academia, government surveys, and industry to map saline formations, identify depleted fields and structures, and provide storage resource estimates. This data is available on a website with data available for download. Another model was UK Stored, which was built by a similar UK-based group of collaborators. Their database hosts storage data and resource calculations available to the public, completed by a third-party, Pale Blue Dot (now Storegga).

Building confidence in CO_2 storage capacity estimates is crucial. The storage resource management system, similar to the petroleum resource management system, involves uncertainty and confidence levels in storage estimates.

It is important to consider the long-term perspective and steps beyond the initial data set. Planning for future data requirements, working with Governments, and ensuring consistency in assessment variables were deemed crucial.

The workshop emphasized the importance of addressing the cost aspect of carbon capture and storage. The cost implications of large-scale implementation need to be thoroughly considered and discussed.

The concept of reusing existing infrastructure was highlighted as a way to reduce the cost of CCS projects.

The workshop noted some possible action plans, including establishing a public database of geological storage data in ASEAN, creating a working group for storage characterisation and resource calculation.

CLOSING

Mr. Alex Zapantis, General Manager Commercial, Global CCS Institute, delivered the closing statement of the workshop. He believed that information and discussions at this workshop will help ASEAN to further the advancement of CCS in the region. He also emphasized the importance of CCS and CO_2 storage, and the importance of learning the lessons from other regions in this matter.

The workshop noted that the 2nd workshop is tentatively scheduled for November 2023 in Jakarta.

3. Outcomes

The workshop provided significant insights into the challenges and opportunities for CCS in Southeast Asia. The discussions held in the workshop, in the margins of the workshop, and in numerous engagements with stakeholders since the workshop has enabled the Institute to distill a set of actions that would, if implemented, support CCS deployment in Southeast Asia.

Those actions, summarized in the table below, will be further described and proposed to ASEAN stakeholders with the objective of recruiting support for their implementation. Progress made in implementing these actions will be reported at the next SEACA workshop in November 2023.

RECOMMENDED ACTIONS TO ACCELERATE CCS DEPLOYMENT IN SOUTHEAST ASIA

Policy Pillar

Title	Description
Primer on the value of CCS to inform government	A short document discussing the value that CCS provides in meeting Net Zero targets, making clear that while CCS does come at a cost, it comes at a lower cost than many other options.
Narrative on CCS value to public	Develop a simple narrative for the public to explain the value of CCS and its importance.
Roadmap / strategy for CCS investment and larger climate commitments for ASEAN countries, including:	Building on GENZO model results, develop a roadmap for CCS investment in the context of climate commitments in ASEAN countries that includes a discussion of 1) regulation, 2) CCS policies and measures, such as the requirements of capture-ready greenfield facilities, eventual government support to private investment in CCS (drawing on international funds wherever possible), and exploring the option to shift taxation from taxing value of output to taxing CO_2 to create funds for CCS and other energy transition investments. 3) Phase out energy subsidies or any other market distorting policies. 4) Government-funded infrastructure to kickstart CCS (e.g. pipelines), which could be supported by multilateral development banks and could be a bilateral agreement with a country like Japan that would cost-share the investment as part of an agreement to take CO_2 from Japan. 5) regional coordination -- policy alignment, enabling policy for cross-border hubs, etc. 6) staging -- focus on industry that can pass on cost (e.g. industries that are not predominantly exposed to international trade, such as cement) but also have relatively low cost of capture. 7) CCS targets and timetable. 8) long-term: CO_2 pricing policies, such as ETS with links to international carbon markets, which could build on voluntary markets in the region to transition to compliance markets.
Working group on GENZO assumptions and data	Form a working group that reviews and updates assumptions and data in the GENZO model.

Regulation Pillar

Title	Description
Establish a Legal and Regulatory Working Group (WG)	A WG aimed at addressing priority issues for the region and responsible for refining the content of the ARRP product. WG Meetings will focus upon the essential elements in the design of CCS-specific law and regulation, ranging from the conceptual to discrete topics. They will also identify other actions and initiatives that may assist regulators and policy makers to develop their capacity and confidence to develop regulations for CCS.
Establish a National Regulators Sub-Working Group (S-WG)	A smaller government-only WG to enable more confidential discussion of key legal and regulatory issues (See the Australian Government Network for an example). The WG will operate in parallel to the higher-level WG.
ASEAN Regional Regulatory Principles (ARRP) Document	A technical document aimed at identifying and analysing the approach to developing CCS-specific law and regulation in the region. To build upon best-practice examples and work undertaken by the WGs.

Storage Pillar	
Title	**Description**
Establish Storage Working Group	Engage CCOP to establish a storage working group of geological surveys to build an ASEAN Storage Database. Partner with UKStored (UK), NETL (USA), GeoCapacity (EU).
High Level Strategy	Storage Working Group to produce a high level strategy and methodology to create a public database using standardised, derived data of saline formations and fields
Engage Data Providers, geological surveys and industry	Engage service providers (IHS Markit, WoodMac, Rystad etc) on producing a public database of standardised, derived data of saline formations and fields

ANNEX 1 – WORKSHOP AGENDA

Day 1. 15 May 2023

Time	Activities
08:00 – 08:45	**Registration**
08:45 – 09:00	**Welcome & Introduction to SEACA** Alex Zapantis, General Manager Commercial, Global CCS Institute
09:00 – 09:05	**Statement by Deputy Permanent Secretary, Ministry of Energy, Thailand** Dr. Veerapat Kiatfuengfoo
09:05 – 09:10	**Statement by Manager of Power, Fossil Fuel, Alternative Energy and Storage (PFS) Department of the ASEAN Center for Energy (ACE)** Mr. Beni Suryadi, ASEAN Centre for Energy (ACE)
09:10 – 09:15	**Statement by Economic Research Institute for ASEAN and East Asia (ERIA)** Shigeru Kimura, Special Advisor to the President of Energy Affairs
09:15 – 09:25	**ASEAN Study on CCS Framework** Suwanto, Senior Research Analyst, Power, Fossil Fuel, Alternative Energy and Storage (PFS) Department, ASEAN Centre for Energy (ACE)

09:25 – 11:00	**CCS Projects, Opportunities & Ambition in SE Asia** A series of 10-minute presentations by project developers/proponents and other stakeholders to describe their CCS project or ambition/aspiration for CCS in South East Asia • Overview of SE Asian Projects, Chris Consoli, Principal Consultant Storage, Global CCS Institute • Justin Oettmeier, VP of Technical Development, Asia Pacific, Exxon Mobil - Singapore • Yanadet Sripanich, Business Lead, CCS, PTTEP - Thailand • Howard Smith, Government Lead Carbon Capture Utilisation and Storage, Government of the Northern Territory - Australia • Dr Sakura Nishioka, Deputy Director, Hydrogen and CCS Project Department, JOGMEC - Japan • Norihiko Saeki, Director of CO_2 Capture Utilization and Storage, Oil and Gas Division, Agency for Natural Resources and Energy, METI - Japan • Shoji Hara, Assistant General Manager Business Development Dept., Natural Gas Group, Mitsubishi Corporation – Japan • Matthew Sherwell, Regulatory & Market Development, Santos - Adelaide Australia
11:00 – 11:30	**Break**
11:30 – 12:30	**Policy Pillar – Issues, Opportunities & Barriers** Eric Williams, Principal Consultant Economics, Global CCS Institute • Presentation of GCCSI Analysis • Panel discussion Moderator: -Alex Zapantis, General Manager Commercial, Global CCS Institute Panelists: -Eric Williams, Principal Consultant Economics, Global CCS Institute -Han Phoumin, Senior Economist, Economic Research Institute for ASEAN & East Asia -Nopasit Chaiwanakupt, SVP., Carbon and Energy Solutions Division, PTT Exploration and Production Public Company Limited

12:30 – 13:30	**Regulation Pillar – Issues, Opportunities & Barriers** • Presentation of GCCSI Analysis, Ian Havercroft, Principal Consultant Policy, Legal & Regulation, Global CCS Institute • Panel discussion Moderator: -Alex Zapantis, General Manager Commercial, Global CCS Institute Panelists: -Ian Havercroft, Principal Consultant - Policy, Legal & Regulatory, Global CCS Institute -Scott Neilson, Partner, Allen & Overy -Piti Eiamchamroonlarp, Program Director, Faculty of Law, Chulalongkorn University
13:30 – 14:30	**Lunch**
14:30 – 15:30	**Storage Pillar – Issues, Opportunities & Barriers** • Presentation of GCCSI Analysis, Chris Consoli, Principal Consultant Storage, Global CCS Institute • Panel discussion Moderator: -Alex Zapantis, General Manager Commercial, Global CCS Institute Panelists: -Chris Consoli, Principal Consultant Storage, Global CCS Institute -Yanadet Sripanich, Business Lead, CCS, PTTEP -Dr Young Joo Lee, Director, CCOP Technical Secretariat, CCOP
15:30 – 16:00	**Break**
16:00 – 16:45	**Plenary Discussion Session – Overflow time**
16:45 – 17:00	**Day 1 Close** Alex Zapantis, General Manager Commercial, Global CCS Institute
18:00	**Reception in Ballroom 2**

Day 2. 16 May 2023

Time	Activities
09:15 – 09:30	**Day 2 Opening** Alex Zapantis, General Manager Commercial Global CCS Institute • Welcome recap of Day 1, Objectives for Day 2
09:30 – 10:30	**Policy Pillar – The Way Forward** • Discussion of Possible Actions – facilitated by Alex Zapantis, General Manager Commercial, Global CCS Institute and Eric Williams, Principal Consultant Economics, Global CCS Institute
10:30 – 11:00	**Break**
11:00 – 12:00	**Regulation Pillar – The Way Forwards** • Discussion of Possible Actions – facilitated by Alex Zapantis, General Manager Commercial, Global CCS Institute and Ian Havercroft, Principal Consultant Policy, Legal & Regulatory, Global CCS Institute
12:00 – 13:00	**Storage Pillar – The Way Forwards** • Discussion of Possible Actions – facilitated by Alex Zapantis, General Manager Commercial, Global CCS Institute and Chris Consoli, Principal Consultant Storage, Global CCS Institute
13:00 – 14:00	**Lunch**
14:00 – 14:30	**Workshop Close** Alex Zapantis, General Manager Commercial, Global CCS Institute • Overview of discussions • Next Steps • Workshop Close

ANNEX 2 – WORKSHOP DELEGATES

First name	Surname	Organisation
Aaron	Lawson	Santos
Abdul Matiin bin	Haji Muhammad Kasim	Brunei Climate Change Secretariat (BCCS)
Alex	Zapantis	Global CCS Institute
Anne	Deniaud	TotalEnergies
Apanee	Luengnaruemitchai	Program Management Unit For Competitiveness (PMUC)
Apiradee	Suwannathong	Department of Mineral Fuels Thailand
Atikom	Channumsin	Electricity Generating Authority of Thailand (EGAT)
Beni	Suryadi	ASEAN Centre for Energy (ACE)
Bowornsak	Wanichkul	ExxonMobil
Bulin	Sanooj	Baker & McKenzie
Chatchawan	Chaichana	Mining Engineering and Petroleum Department, Faculty of Engineering , Chiang Mai University
Chris	Consoli	Global CCS Institute
Christina	Angelica	TotalEnergies
Citra	Endah Nur Setyawati	ERIA
Danuwas	Lambasara	PTTEP
Darunee	Meemongkolkiat	ExxonMobil
Decha	Chainapong	New Energy and Industrial Technology Development Organization (NEDO)
Eric	Williams	Global CCS Institute
Goran	Galic	Allen & Overy
Han	Phoumin	ERIA
Hang	Kimhourn	General Department of Petroleum, Cambodia
Hiroshi	Nambo	Global CCS Institute
Howard	Smith	Northern Territory Government, Australia
Ian	Havercroft	Global CCS Institute
Inphavong	Bounmany	Ministry of Energy and Mines, Lao PDR

Jaturong	Jerdsakulboon	PTTEP
Jeffrey	Tan	IFC
Jen Deng	Lee	CCUS & Hydrogen Collaborations, DCCEEW , Australia
Jintawat	Chaichanawong	Program Management Unit For Competitiveness (PMUC)
Jirat	Udomsri	PTTEP
Joaninha da Costa	Freitas	Autoridade Nacional do Petróleo e Minerais, Timor-Leste
Jose Celestino Araujo	Nay	Autoridade Nacional do Petróleo e Minerais, Timor-Leste
Justin	Oettmeier	ExxonMobil
Kawamura	Hironori	New Energy and Industrial Technology Development Organization (NEDO)
Keith	Burnard	IEA Greenhouse Gas R&D Programme
Kenta	Asahina	Ministry of Economy, Trade and Industry of Japan (METI)
Kittiwat	Thaweecharoen	Siam MOECO
Kiuchi Shigeru	Shigeru	New Energy and Industrial Technology Development Organization (NEDO)
Mae	Moh Mine	Electricity Generating Authority of Thailand (EGAT)
Marivic	Uzarraga	Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)
Masumi	Takanashi	Japan Organization for Metals and Energy Security (JOGMEC)
Matthew	Sherwell	Santos
Min	Aung	Ministry of Natural Resources and Environmental, Myanmar
Mohd	Amirulazry Bin Mohd Amin	Energy Commission of Malaysia
Mohd	Helmi Mohd Zaihan	Energy Commission of Malaysia
Muanjit	Chamsilpa	Baker & McKenzie
Muhamad	Prawira	IFC
Muhammad	Zulhaimi	Petronas
Myra	Fiera F. Roa	Department of Energy, Philippines
Narongrat	Poovarawan	Department of Mineral Fuels Thailand
Narongsak	Mavong	Electricity Generating Authority of Thailand (EGAT)
Natchana	Boonchaluay	Department of Mineral Fuels, Thailand

Nattaporn	Meetanatharvorn	PTTEP
Natthaphong	Sirijirasuk	PTTEP
Nawin	Viriyaempikul	Program Management Unit For Competitiveness (PMUC)
Neeracha	Tridech	Thailand Greenhouse Gas Management Organization (TGO)
Nenito	C.Jariel Jr.	Department of Energy, Philippines
Niwat	Themmajak	Thailand Science Research and Innovation (TSRI)
Nomesia	Dos Reis	Autoridade Nacional do Petróleo e Minerais, Timor-Leste
Nopasit	Chaiwanakupt	PTTEP
Norihiko	Saeki	Ministry of Economy, Trade and Industry of Japan(METI)
Nurkhayrul	Bariyyah Haji Abd Salam	Brunei Climate Change Secretariat (BCCS)
Nuttavut	Intarode	Siam Cement Group (SCG)
Nutthatida	Phuangsaijai	The Board of Investment of Thailand (BOI)
Peter	Cockcroft	Autoridade Nacional do Petróleo e Minerais, Timor-Leste
Phongsakorn	Chaibamrung	Department of Mineral Fuels Thailand
Piti	Eiamchamroonlarp	Faculty of Law, Chulalongkorn University
Piyada	Saejia	PTTEP
Piyapat	Panthong	Department of Mineral Fuels Thailand
Pongvipa	Lohsomboon	Thailand Science Research and Innovation (TSRI)
Prapai	Numthavaj	Petroleum Institute of Thailand (PTIT)
Prapatsorn	Deejam	Office of Natural Resources and Environmental Policy and Planning (ONEP)
Premrudee	Kanchanapiya	Thailand National Metal and Materials Technology Center, National Science and Technology Development Agency
Rachaneekorn	Limpagomol	Department of Mineral Fuels, Thailand
Sabarina	Samhadi	PETRONAS
Sakura	Nishioka	Japan Organization for Metals and Energy Security (JOGMEC)
Sarah	Hardman	Global CCS Institute
Sarah	Wilson	Allen & Overy
Sawanya	Opaskornkul	PTTEP

Scott	Neilson	Allen & Overy
Shigeru	Kimura	ERIA
Shoji	Hara	Mitsubishi Corporation
Siti	Aishah Binti Mohd Safian	Ministry of Natural Resources, Environment and Climate Change, Malaysia
Somnuek	Jaroonjitsathian	PTT Public Company Limited
Songyang	Wu	Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)
Sorayut	Phakcharoen	Petroleum Institute of Thailand (PTIT)
Sri	Wirya	ExxonMobil
Suchanan	Chaemthong	Department of Mineral Fuels Thailand
Sumon	Sumetchoengprachya	Thailand Greenhouse Gas Management Organization (TGO)
Sunny	Lee	INPEX
Supalak	Parn-anurak	Department of Mineral Fuels, Thailand
Suparit	Tangparitkul	Mining Engineering and Petroleum Department, Faculty of Engineering , Chiang Mai University
Suthasin	Chiamchit	Department of Mineral Fuels Thailand
Suwanto		ASEAN Centre for Energy
Swawaporn	Sophanodora	PTTEP
Takamitsu	Hirono	Diamond Gas International Pte. Ltd.
Taro	Yanagidate	Mitsubishi Corporation
Thanasorn	Thanavibul	Department of Mineral Fuels Thailand
Thansorn	Wimolrattanasil	PTT Public Company Limited
Thet	Minn	Ministry of Natural Resources and Environmental, Myanmar
Thibault	Mirmand	TotalEnergies
Utsanee	Pengcham	Office of Natural Resources and Environmental Policy and Planning (ONEP)
Vansit	Vayongsa	Ministry of Energy and Mines, Lao PDR
Veerapat	Kiatfuengfoo	Ministry of Energy, Thailand
Visut	Bunthai	Electricity Generating Authority of Thailand (EGAT)
Weerawat	Chantanakome	Ministry of Energy, Thailand

Wuttipong	Kongphetsak	Department of Mineral Fuels Thailand
Xiaoliang	Yang	Global CCS Institute
Yanadet	Sripanich	PTTEP
Year	Chansaravuth	General Department of Energy, Cambodia
Young Joo	Lee	Coordinating Committee for Geoscience Programmes in East and Southeast Asia (CCOP)
Yuthana	Charoenwong	BLCP Power Limited
Zhang	Jiutian	Beijing Normal University

ANNEX 3 – PRESENTATIONS