Capacity Building Role on CCUS Deployment and Development in APEC Economies for Sustainable Development Goals

APEC Energy Working Group

July 2025

Asia-Pacific
Economic Cooperation

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APEC Project: EWG 205 2023A

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APEC#225-RE-04.7

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Executive Summary

The APEC Workshop on Carbon Capture, Utilization, and Storage (CCUS) Deployment and Development for Sustainable Development Goals took place in Bangkok, Thailand, on 25-26 March 2025, convening policymakers, experts, and stakeholders from the Asia-Pacific (APEC) region to examine the essential function of CCUS technologies in combating climate change and fulfilling sustainable development objectives. The workshop sought to promote collaboration, technological advancement, and the formulation of policies to expedite the implementation of CCUS throughout the region.

Keynote addresses and panel discussions highlighted the significance of CCUS in attaining net-zero emissions and enabling energy transformations. Experts presented a comprehensive analysis of worldwide CCUS developments, emphasizing the opportunities and problems associated with large-scale implementation. A key subject was the necessity for transnational cooperation to create uniform regulatory frameworks, mitigate excessive costs, and enhance investment in essential infrastructure. Participants emphasized the advancements in geological carbon dioxide (CO_2) storage and the evolution of Direct Air Capture (DAC) as synergistic approaches for decarbonizing challenging sectors.

The event also examined the varied energy profiles of APEC economies, ranging from coal-dependent economies to those at the forefront of renewable energy. This variability offers both possibilities and obstacles for the implementation of CCUS. Economies such as Australia and Indonesia, possessing substantial geological storage capacity, are poised to assume pivotal roles in the establishment of regional CCUS networks for the transit and storage of CO_2. Moreover, discussions addressed the necessity for comprehensive regulatory frameworks to guarantee the safety, transparency, and efficiency of CCUS projects. The establishment of cross-border regulatory frameworks was highlighted to enhance CO_2 transport and storage, especially for industries functioning within APEC economies.

PPPs are essential for addressing the financial obstacles to CCUS, with financial incentives such as carbon pricing and subsidies considered necessary to render CCUS technology competitive with alternative emissions reduction techniques. CCUS projects in APEC and beyond will need government-corporate cooperation to grow. The workshop recognized that, although renewable energy and energy efficiency are significant, CCUS is essential for decarbonizing industries such as cement, steel, and chemicals, where emissions are intrinsic to manufacturing methods.

The workshop ended with several proposals, including the creation of unified policy frameworks that incorporate carbon pricing, subsidies, and financial incentives to promote CCUS. It emphasized the significance of regional cooperation within APEC to improve knowledge exchange, collaborative enterprises, and the establishment of transnational CO_2 storage facilities. Moreover, public engagement was deemed essential for obtaining societal acceptability of CCUS, especially in communities affected by storage initiatives. The session underscored that CCUS is essential for the region's pursuit of Sustainable Development Goals (SDGs) and combating climate change, necessitating a cohesive, collaborative strategy across borders and sectors.

List of Abbreviations

AI - Artificial intelligence

ANGEA - Asia Network for Green Energy and Action

APEC - Asia-Pacific Economic Cooperation

CCS - Carbon Capture and Storage

CCUS - Carbon Capture, Utilization, and Storage

CERI - Clean Energy Research Institute

CNPC - China National Petroleum Corporation

CPC - Chinese Petroleum Corporation

CO_2 - Carbon Dioxide

COP26 - Conference of the Parties 26

CSLF - Carbon Sequestration Leadership Forum

DAC - Direct Air Capture

DMF – Department of Mineral Fuels

EIA - Environmental Impact Assessment

EPA - Environmental Protection Agency

EOR - Enhanced Oil Recovery

ERIA - Economic Research Institute for ASEAN and East Asia

EV - Electric Vehicle

GCCSI - Global Carbon Capture and Storage Institute

IEA - International Energy Agency

IPCC - Intergovernmental Panel on Climate Change

ISO - International Organization for Standardization

ITMOs - Internationally Transferred Mitigation Outcomes

LCOE - Levelized Cost of Energy

LNG – Liquefied National Gas

METI - Ministry of Economy, Trade and Industry

MRV - Monitoring, Reporting, and Verification

MOEA - Ministry of Economic Affairs

MOU - Memorandum of Understanding

Mtpa - Million Tons Per Annum

NDCs - Nationally Determined Contributions

NETs - Negative Emission Technologies

NETL - National Energy Technology Laboratory

NSTC - National Science and Technology Council

NZE - Net-Zero Emissions

PPPs - Public-Private Partnerships

RMT - Risk Management Tool

SAF - Sustainable Aviation Fuel

SDS - Sustainable Development Strategy

SDGs - Sustainable Development Goals

TLP - Transition Loan Protocol

UNFCCC - United Nations Framework Convention on Climate Change

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Introduction

Background

The need to combat climate change has amplified the significance of Carbon Capture, Utilization, and Storage (CCUS) as a pivotal technology in worldwide endeavors to diminish carbon dioxide (CO_2) emissions. The problem of attaining net-zero emissions is particularly substantial for APEC economies, which possess various energy sectors and industrial landscapes. Although conventional decarbonization strategies, like the adoption of renewable energy, are crucial, they may be inadequate for mitigating emissions from hard-to-decarbonize sectors such as cement, steel, and chemicals. In these sectors, where emissions are intrinsically linked to industrial processes, CCUS technologies have emerged as an essential instrument for achieving sustainable development objectives. The extensive implementation of CCUS encounters numerous challenges, such as elevated expenses, regulatory barriers, and insufficient infrastructure for CO_2 transportation and storage. As APEC economies strive to fulfill their climate pledges, critical inquiries persist: How can these economies efficiently enhance CCUS technologies? How can they synchronize policy throughout the region to facilitate CCUS implementation? What function may public-private partnerships (PPPs) serve in mitigating the financial difficulties related to these technologies?

This paper aims to investigate these inquiries, analyzing both the prospects and obstacles related to CCUS implementation in APEC economies. The paper seeks to provide concrete recommendations for expediting CCUS adoption and furthering climate objectives in the area, based on insights gathered during the APEC Workshop on CCUS Deployment and Development for SDGs. The workshop convened experts, policymakers, and stakeholders to discuss the challenges and prospects of growing CCUS technologies.

The APEC region hosts the globe's greatest carbon polluters, many of which depend on fossil fuels and energy-intensive sectors for economic development. Although CCUS presents considerable potential for emission reduction, its extensive implementation is hindered by numerous obstacles, such as elevated capital expenditures, insufficient regulatory frameworks, and an absence of infrastructure for CO_2 transportation and storage. The varied energy profiles and industrial frameworks in the region hamper the extensive implementation of CCUS technologies.

This paper will examine how APEC economies may address these issues to enhance the deployment of CCUS technologies, thereby contributing to global climate initiatives and promoting the SDGs. The report will explore inquiries such as: How can APEC economies alleviate the substantial expenses and technological obstacles associated with CCUS? What function might regional collaboration and policy harmonization serve in promoting CCUS implementation? In what ways might PPPs assist in addressing the financial obstacles associated with the implementation of CCUS technologies?

This study synthesizes observations from the APEC workshop, providing essential recommendations for policymakers and stakeholders to expedite CCUS adoption, assist APEC economies in achieving climate objectives, and promote sustainable economic growth.

Opening

The opening session, presented by Mr Patpicha Ratanapreechachai, Director General of Department of Mineral Fuels, Thailand, a Project Overseer.

Introduction to APEC Workshop

By Project Overseer

(25 March 2025)

APEC workshop on "Capacity Building Role on CCUS Deployment and Development in APEC economies for Sustainable Development Goals"

25 - 26 March 2025

Pullman Bangkok King Power, Bangkok (2 mins)

Ladies and Gentlemen,

Distinguished participants, honored speakers, and colleagues,

Good morning. It is with great respect and appreciation that I extend a warm welcome to you on behalf of the Department of Mineral Fuels, Ministry of Energy of Thailand, to this important APEC Workshop on the Capacity Building Role in CCUS Deployment and Development within APEC economies for Sustainable Development Goals.

As many of you may know, Thailand has demonstrated a significant dedication to the international community in tackling the challenges posed by climate change. During the United Nations Framework Convention on Climate Change (UNFCCC) COP26, Thailand expressed its commitment to reducing greenhouse gas emissions by 40% by 2030, attaining carbon neutrality by 2050, and achieving net-zero emissions by 2065. In pursuit of these ambitious goals, it is widely recognized that Carbon Capture, Utilization, and Storage (CCUS) technologies play a crucial role in addressing greenhouse gas emissions and fostering a sustainable, low-carbon economy.

In accordance with this domestic directive, the Department of Mineral Fuels (DMF), as the designated agency responsible for overseeing petroleum exploration and production, has been assigned to play a leading role in driving the application of CCUS technologies in Thailand. We are diligently pursuing the advancement of CCUS through four key pillars:

1. Technical framework
2. Regulatory and legal framework
3. Commercial framework and incentives
4. Stakeholder engagement framework

This workshop represents a significant step in our commitment to enhancing capacity and deepening knowledge on CCUS. We aim to unite APEC member economies, experts, and relevant stakeholders to facilitate knowledge exchange, share experiences, and investigate opportunities for collaboration in promoting CCUS deployment within the region.

In the coming two days, this workshop will aim to deepen participants' comprehension of CCUS technologies, assess policy and regulatory frameworks, identify barriers, and discuss opportunities for regional cooperation. This effort is in harmony with APEC's objectives to promote energy efficiency, low-carbon solutions, and sustainable economic development.

Lastly, I wish to extend our sincere appreciation to APEC, the co-sponsoring economies, and the international experts for their essential contributions in making this workshop possible.

It is with great pleasure that I now extend an invitation to the Director General of the Department of Mineral Fuels to deliver the official opening remarks.

Thank you.

Follow by the opening session of Mr Warakorn Brahmopala, Director General of the Department of Mineral Fuels

Welcoming Keynote

By Director General

(25 March 2025)

APEC workshop on "Capacity Building Role on CCUS Deployment and Development in APEC economies for Sustainable Development Goals"

25 - 26 March 2025

Pullman Bangkok King Power, Bangkok (2 mins)

Distinguished guest, ladies and gentlemen,

On behalf of the Royal Thai Government, it is an honor to be present today at this significant workshop of the Asia-Pacific Economic Cooperation (APEC) workshop, focusing on "Capacity Building Role on CCUS Deployment and Development in APEC economies for Sustainable Development Goals."

We must collectively address the significant challenge of climate change. CCUS — Carbon Capture, Utilization, and Storage — represents an essential technology that enables us to capture carbon dioxide (CO_2) emissions from industrial processes and power generation, allowing for their reuse in diverse applications or secure underground storage. This technology presents a considerable opportunity to mitigate greenhouse gas emissions, thereby facilitating the shift toward a low-carbon economy.

This workshop provides a valuable opportunity for the sharing of knowledge, the exchange of experiences, and the exploration of best practices. I am pleased to join this gathering of distinguished experts, policymakers, and stakeholders from the APEC region, contributing to our shared goals and collaborative efforts.

I wish to express sincere thanks to the organizers and APEC for their efforts in bringing together such a distinguished group of experts, policymakers, and stakeholders from across the Asia-Pacific region. Participating in these discussions presents a significant opportunity as we work toward accelerating the deployment of CCUS technologies and reach our common sustainability objectives.

Thailand is dedicated to promoting sustainable energy solutions and has established ambitious domestic objectives—to attain Carbon Neutrality by 2050 and achieve Net-Zero Greenhouse Gas Emissions by 2065. We are committed to thoughtfully coordinating our policy strategies and actions in pursuit of these objectives, and we acknowledge the significant contribution that CCUS will make in achieving this goal. The discussions taking place today and tomorrow are of significant importance in tackling the technical, regulatory, and financial obstacles that limit the deployment of CCUS. I am particularly interested in exploring innovative policy frameworks and regional collaboration models that can facilitate CCUS development, as well as how we might effectively apply these insights within our economies.

I am confident that by working together and enhancing our capabilities, we can achieve meaningful progress in tackling these challenges. This event shows the potential of international cooperation to foster meaningful and significant advancements.

Finally, I wish to convey my sincere appreciation for the chance to be present here today. I look forward to our ongoing discussions and the opportunity to gain insights from all of you. I firmly believe that by collaborating, we can fully realize the potential of CCUS and play a significant role in fostering a sustainable, low-carbon future for the Asia-Pacific region.

Thank you.

Session 1: Keynote Speech - "The Role of CCUS in Achieving Net-Zero Targets"

Speaker: Mr Alex Zapantis (GCCSI)

The inaugural session of the APEC workshop commenced with a profound keynote talk by Mr Alex Zapantis, a distinguished authority from the Global CCS Institute (GCCSI), regarding the critical significance of CCUS in attaining net-zero emissions. The session promoted CCUS as a vital answer in the worldwide endeavor to address climate change. This keynote address was essential in establishing the framework for subsequent debates and emphasized the imperative of implementing CCUS technologies to achieve global climate objectives.

1.1 Global Overview of CCUS Technologies

Mr Zapantis commenced with a comprehensive overview of CCUS technology, highlighting their significance in the worldwide decarbonization initiative. CCUS has emerged as a highly promising technology for the capture and permanent storage of CO_2 emissions that would otherwise exacerbate global warming. In a context where mitigating carbon emissions from industries processing poses a considerable problem, CCUS technologies present a feasible option. These sectors contribute significantly to CO_2 emissions, and their operations frequently produce emissions that cannot be entirely mitigated through alternative decarbonization strategies, including the implementation of renewable energy or electrification.

Mr Zapantis emphasized that CCUS technologies operate in three fundamental phases (Figure 1):

- Capture - The initial phase entails the sequestration of CO_2 emissions from industrial operations or power production facilities. Numerous techniques exist for CO_2 capture, such as post-combustion, pre-combustion, and oxy-fuel combustion.
- Transport - After capture, the CO_2 is conveyed via pipelines or alternative transportation methods to storage locations. This phase necessitates substantial infrastructure investments, encompassing pipelines, storage facilities, and monitoring systems.
- Storage or Utilization - The acquired CO_2 is either sequestered underground in geological formations or employed for diverse industrial applications.

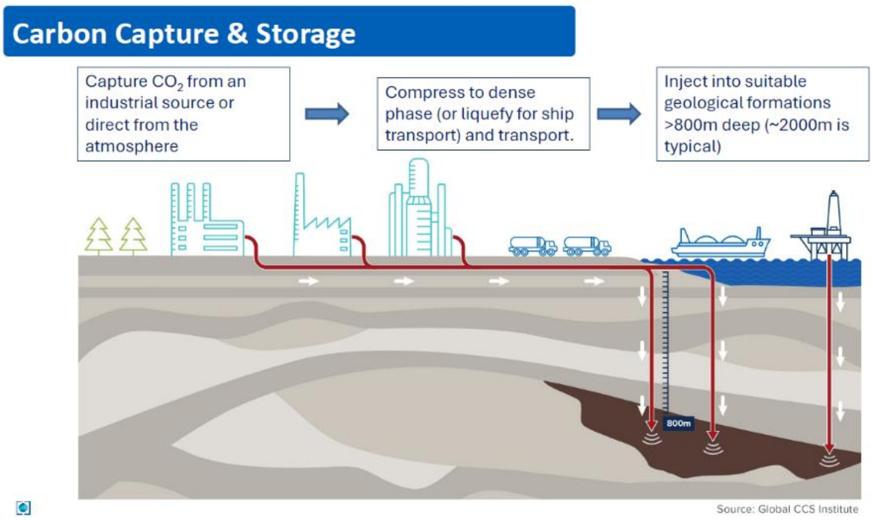

Figure 1: Carbon Capture, Utilization, and Storage (CCUS)

Each phase of CCUS has progressed over time, with rapid breakthroughs in capture technologies—such as Direct Air Capture (DAC), which directly removes CO_2 from the atmosphere—being created. These technologies possess the capacity to substantially increase CO_2 capture, facilitating the achievement of global climate objectives.

1.2 Trends in Global CCUS Deployment

In his presentation, Mr Zapantis highlighted the substantial advancements achieved in CCUS over the past decade. The international landscape of CCUS technology has significantly transformed, as an increasing number of economies and sectors acknowledge the essential function of CCUS in attaining net-zero emissions. The Global CCS Institute reports that there are currently more than 30 large-scale CCUS operations worldwide (Figure 2), capturing millions of tons of CO_2 each year. Prominent projects include Gorgon and Moomba in Australia, the Boundary Dam in Canada, and Sleipner in Norway. These projects have demonstrated the technological viability of CCS without associated enhanced oil or gas recovery operations and have indicated that the technology can be scaled to capture substantial quantities of CO_2.

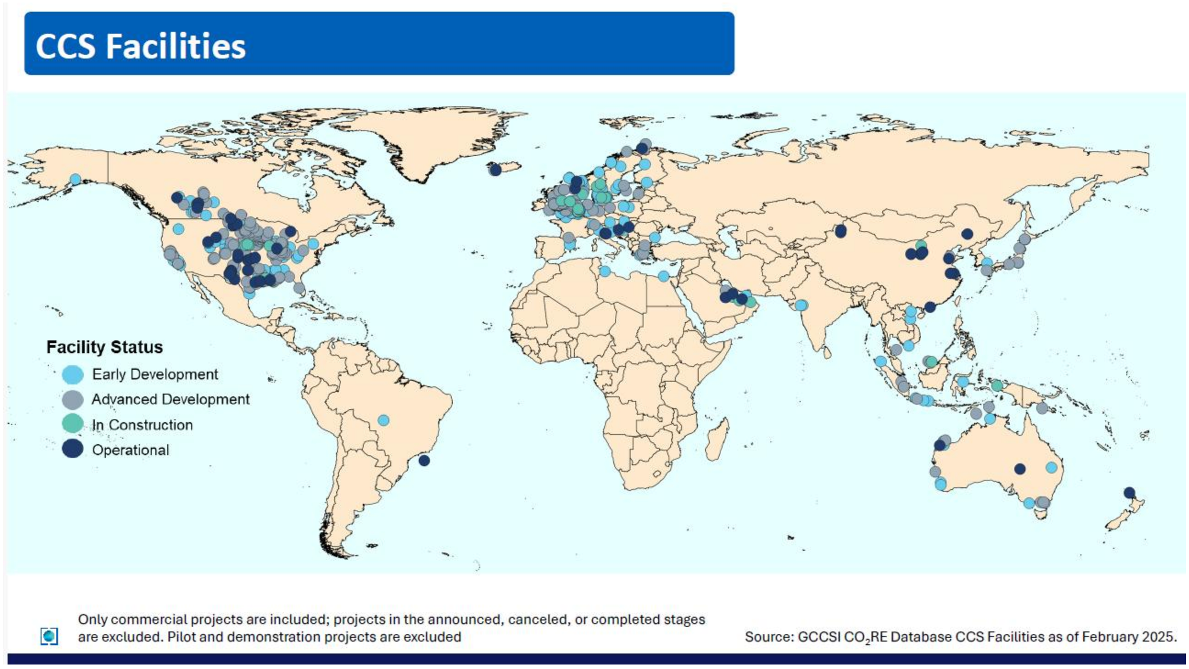

Figure 2: CCS Facilities worldwide

Mr Zapantis underscored that, despite advancements, the deployment of CCUS remains constrained and faces numerous obstacles to expanding. He indicated that the current global CCUS capacity is unable to fulfill the emissions reduction targets mandated by the Paris Agreement. Notwithstanding technological progress, the infrastructure necessary for extensive implementation remains inadequately built, particularly in emerging economies. Furthermore, the substantial expenses related to the capture, transportation, and storage of CO_2 continue to pose a considerable problem.

1.3 CCUS in Net-Zero Pathways

A substantial segment of Mr Zapantis' address emphasized the need for CCUS in achieving worldwide net-zero trajectories. As governments globally implement net-zero emissions objectives, it is evident that CCUS will be integral to realizing these lofty aims. The International Energy Agency (IEA) has emphasized that, in the absence of CCUS, achieving the climate objectives established by the Paris Agreement would be unfeasible, especially for sectors where emissions are inherent to the manufacturing process. The IEA's forecasts suggest that CCUS may account for 15% of the worldwide emissions reductions required by 2050 to restrict global warming to 1.5°C over pre-industrial levels.

He emphasized that CCUS is crucial in industries like steel production, cement manufacturing, and refining, where carbon-intensive processes cannot be readily substituted with renewable energy. He elaborated that in the energy sector, although renewable sources such as solar and wind can supplant fossil fuels for electricity generation, businesses such as cement and steel emit CO_2 as a byproduct of the chemical reactions involved in their production processes. Eliminating these pollutants is challenging without the implementation of CCUS devices. Consequently, CCUS functions as a crucial facilitator in decarbonizing challenging sectors and assists these industries in transitioning to low-carbon production while preserving their operational viability.

He observed that CCUS exerts a dual influence in mitigating climate change. It not only inhibits CO_2 emissions into the atmosphere but also presents the possibility of carbon removal, therefore facilitating a route to negative emissions. As the global community strives toward net-zero emissions, the capacity to extract CO_2 from the atmosphere is becoming progressively vital. Direct Air Capture (DAC) technologies are regarded as essential in the direct sequestration of CO_2 from the atmosphere, serving as a vital instrument in combating climate change.

1.4 Opportunities and Challenges in Scaling Up CCUS

Notwithstanding the great potential of CCUS, Mr Zapantis recognized that the expansion of these technologies presents a significant hurdle. The primary obstacle to the deployment of CCUS is the expense. The capital expenditure necessary for CCUS projects is considerable, and the technology's commercial feasibility remains under development. Despite substantial expenditures in CCUS technologies by certain governments and companies, the lack of a definitive economic model that promotes extensive implementation continues to pose a challenge. The elevated expenses associated with the capture, transportation, and storage of CO_2 must be diminished to render CCUS competitive with alternative emissions reduction methods.

A significant difficulty is the absence of infrastructure for CO_2 transportation and storage. The infrastructure required for cross-border CO_2 transfer and the establishment of storage centers is presently inadequate. Establishing CO_2 pipelines and storage facilities requires substantial financial commitment, and getting regulatory approval for these initiatives can be lengthy and complex. Concerns exist over the long-term stability of CO_2 storage sites and the potential for leakage, necessitating comprehensive monitoring and testing systems.

Mr Zapantis also addressed the policy and regulatory impediments that restrict CCUS implementation. Although numerous economies have implemented climate policies and emission reduction objectives, CCUS is frequently inadequately included in domestic climate initiatives. In certain instances, regulatory frameworks are inadequate or absent, hindering corporations' ability to invest in CCUS initiatives. The absence of international coordination and defined standards for CO_2 transit and storage poses further challenges to the extensive implementation of CCUS.

Notwithstanding these obstacles, he emphasized numerous prospects for the expansion of CCUS technologies. A significant opportunity lies in the establishment of PPPs to fund CCUS initiatives. Governments can significantly contribute to CCUS innovation by offering financial incentives, subsidies, and carbon pricing systems to mitigate the substantial expenses associated with CCUS implementation. International collaboration offers APEC economies the chance to exchange knowledge, technology, and infrastructure, positioning the region as a leader in CCUS technological advancement.

Mr Zapantis closed his keynote by advocating for enhanced investment in CCUS and the establishment of appropriate governmental frameworks to stimulate private sector participation. He underscored that, although CCUS alone would not resolve the climate catastrophe, it is an essential instrument in a comprehensive plan for climate change mitigation.

1.5 Implications for APEC economies

Following the presentation of the global context of CCUS, Mr Zapantis redirected attention to the APEC region. He observed that APEC economies encounter distinct hurdles in implementing CCUS technologies due to their varied industrial foundations and energy characteristics. The region hosts some of the globe's top CO_2 emitters, especially in coal and natural gas power generation, heavy industry, and refining industries.

Nonetheless, he emphasized the potential for APEC to assume a leadership role in CCUS. The region possesses extensive geological storage potential, especially in economies such as Australia; Indonesia; and Malaysia, which can accommodate billions of tons of CO_2. By utilizing these natural resources and coordinating initiatives across APEC economies, the area can assume a pivotal role in enhancing CCS implementation.

Mr Zapantis asked APEC to prioritize CCUS as an essential element of its climate plans and to invest in the necessary infrastructure, legislation, and financial incentives to expedite its implementation. He articulated assurance that, with regional cooperation, APEC economies could surmount hurdles and harness the potential of CCUS technology to promote sustainable development and attain net zero emissions.

1.6 Key Takeaways and Conclusion

Mr Alex Zapantis's keynote talk emphasized the crucial need for CCUS in attaining the ambitious net-zero emissions targets by 2050. Mr Zapantis underscored that CCUS is not merely a technology but an essential element of the global climate strategy, particularly in sectors where alternative decarbonization methods are inadequate. Sectors including steel, cement, and chemical manufacturing, which contribute significantly to CO_2 emissions, cannot readily shift to renewable energy sources or electrification alone. CCUS provides a viable method for capturing and storing the CO_2 produced by these companies, thus considerably diminishing their environmental impact. CCUS technologies are essential in energy generation sectors, especially where fossil fuels remain central to domestic energy portfolios, providing a means to reduce emissions while ensuring energy security.

The keynote emphasized the increasing global investments in CCUS, with several large-scale projects currently functioning worldwide. These examples exemplify the viability of CCUS, illustrating that it is both technically achievable and scalable. As economies endeavor to fulfill Paris Agreement objectives and other climate obligations, the need for CCUS technologies is escalating. The continuous global investment in CCUS indicates an increasing acknowledgment of the technology's significance in attaining net-zero emissions, particularly as economies advance toward more stringent climate policies.

The address highlighted the significant prospects for APEC economies to spearhead CCUS deployment throughout the region. The region has some of the globe's largest industrial economies, characterized by high-emission sectors, rendering it a crucial area for CCUS implementation. The region possesses extensive geological storage potential, especially in economies such as Australia; Indonesia; and Malaysia, which can accommodate billions of tons of CO_2. By utilizing these natural resources and coordinating initiatives across APEC economies, the area can assume a pivotal role in enhancing CCS implementation. However, as Mr Zapantis pointed out, there are still significant challenges related to technological costs, inadequate infrastructure, and policy development deficiencies that need to be addressed. The financial obligation of implementing CCUS, especially the capital expenditure necessary for infrastructure such as CO_2 pipelines and storage facilities, constitutes a significant obstacle. In the absence of targeted legislative frameworks and financial incentives, the expansion of CCUS technology will continue to be challenging.

Ultimately, international cooperation and policy harmonization were emphasized as crucial for addressing these problems and enhancing CCUS implementation. The intricate structure of CCUS, including many industries, economies, and technologies, necessitates international collaboration to optimize regulatory frameworks, enable cross-border CO_2 transportation, and guarantee that commercialization is both technically feasible and economically sustainable. Mr Zapantis advocated for ongoing knowledge exchange and collaboration among economies, sectors, and entities to establish a unified worldwide initiative for the extensive implementation of CCUS.

In conclusion, Mr Alex Zapantis's keynote address established a robust framework for the next workshop discussions by delivering a thorough review of the significance of CCUS in achieving global emissions reduction objectives. The views presented at the session highlighted that, although CCUS technologies are crucial for mitigating emissions from hard-to-decarbonize industries, substantial obstacles have to be addressed. These encompass substantial initial expenditures, infrastructural constraints, and the necessity for integrated and supportive governmental frameworks. Nonetheless, with appropriate investments, collaboration, and regulatory coherence, the APEC area possesses a distinctive chance to spearhead the worldwide CCUS transformation. Mr Zapantis emphasized that CCUS is an essential instrument in the shift toward a low-carbon future, and global cooperation will be imperative for its extensive deployment.

Session 2: Panel Discussion - "Global CCUS Landscape and Opportunities for APEC"

Moderator: ***Dr Piya Kerdlap (PXP Sustainability)***
Speakers: ***Mr Danuwas Lambasara (PTTEP)***
Mr Vitaly Osokin (Chevron)
Mr Somnath Kansabanik (Rystad)

The second session of the APEC Workshop on CCUS Deployment and Development began with a panel discussion moderated by Dr Piya Kerdlap, Managing Director of PXP Sustainability. The presentation, titled "Global CCUS Landscape and Opportunities for APEC," featured three eminent experts: Mr Danuwas Lambasara, Vice President of the CCS Department at PTTEP; Mr Vitaly Osokin, Deputy General Manager of Corporate Business Development at Chevron; and Mr Somnath Kansabanik, Principal Director at Rystad. Each speaker offered critical perspectives on CCUS technologies, regional challenges, and the possibility for APEC economies to integrate CCUS as a core component in reducing industrial CO_2 emissions.

2.1 Thailand CCUS Landscape and Opportunities for APEC

The discussion began with Mr Danuwas Lambasara, who explained Thailand's progress in CCUS technology and the nation's emerging role as a potential regional Carbon Capture and Storage (CCS) hub within APEC. He conducted an extensive analysis of Thailand's CCS initiatives, with particular emphasis on the Arthit CCS Project (Figure 3), which is Thailand's first significant carbon capture undertaking. The venture is located at the PTTEP-operated Arthit Gas Field and intends to inject CO_2 into underground geological formations by 2028. This effort aims to sequester 1 million tons per annum (mtpa) of CO_2 and demonstrates Thailand's capability to integrate CCUS into its energy sector. He asserted that the Arthit CCS Project will serve as a model for future CCS initiatives in the economy, showcasing the technological and practical feasibility of CO_2 injection into saline aquifers or exhausted gas reserves.

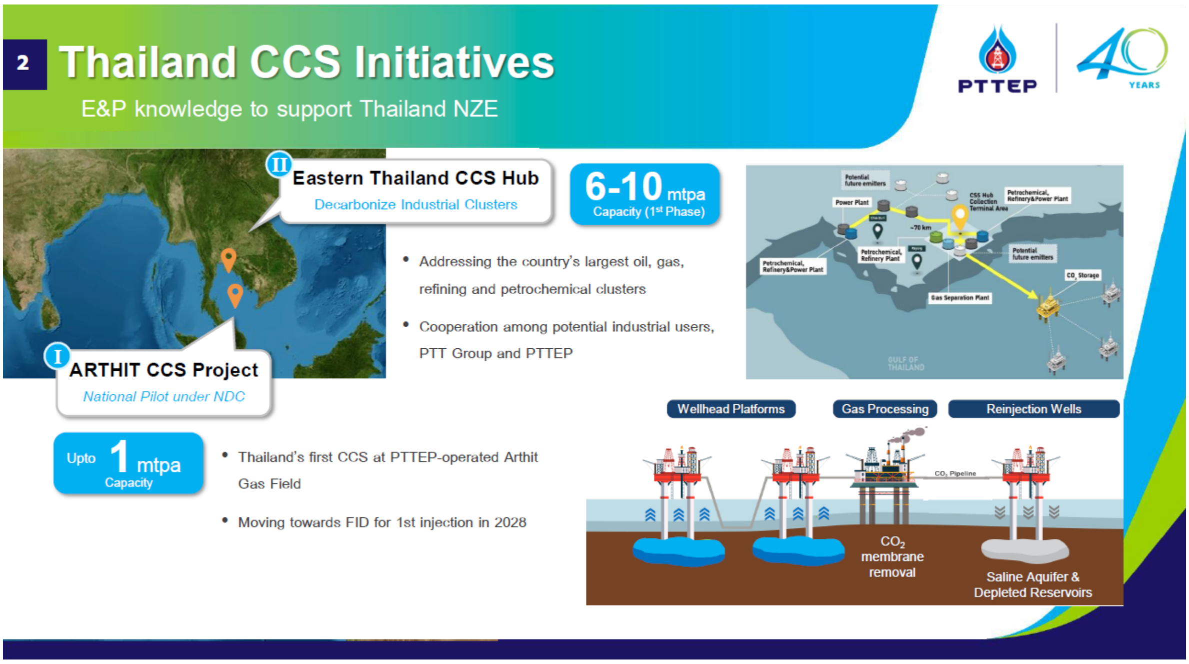

Figure 3: Thailand Arthit Project

Mr Lambasara emphasized that Thailand's CCS objective includes the creation of many centers across the economy to reduce emissions from high-emission industrial sectors such as oil and gas, refining, and petrochemicals. These sectors represent significant sources of CO_2 emissions, and CCS hubs will be crucial for mitigating this pollution. The Eastern Thailand CCS Hub will concentrate on emissions from industrial clusters, aiming to sequester 6 to 10 million tons of CO_2 annually in its initial phase. He highlighted that, through domestic storage, Thailand's regional policy aims to position itself as a cross-border CO_2 storage center, facilitating CCS for neighboring APEC economies.

2.2 Chevron’s Role in Advancing a Lower Carbon Future

Following Mr Lambasara’s presentation, Mr Vitaly Osokin clarified Chevron’s commitment to advancing CCUS technology and its holistic strategy for achieving a low-carbon future. Mr Osokin outlined Chevron's involvement in global CCUS programs, highlighting the company's efforts to broadly integrate CCUS across its operations. He emphasized that Chevron's plan focuses on using existing infrastructure to reduce the carbon intensity of its operations, including oil and gas processing, refining, and petrochemical production.

Mr Osokin discussed Chevron's CCUS operations, particularly the Gorgon CCS Project in Australia, which is acknowledged as one of the largest and most efficient CCS projects globally. The Gorgon Project captures CO_2 from natural gas production and sequesters it in offshore geological formations. He noted that the Gorgon Project had captured well over 11 million tons of CO_2, illustrating the potential of CCUS to significantly reduce greenhouse gas emissions in large-scale industrial settings.

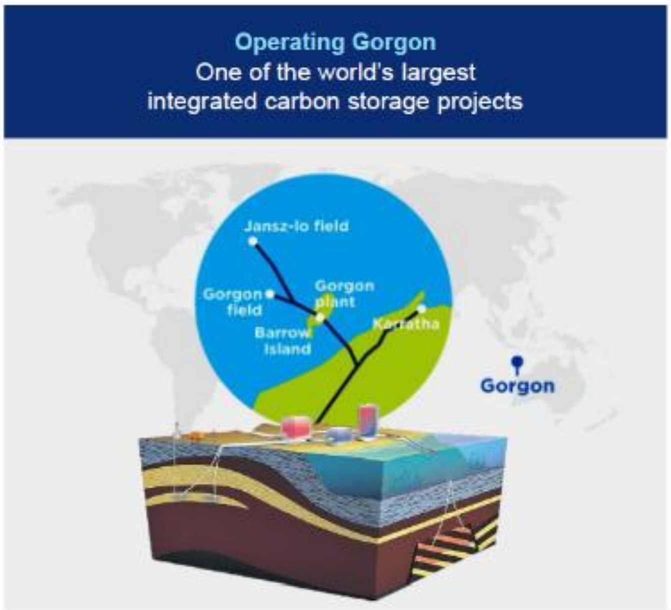

Figure 4: Operating Gorgon

Mr Osokin also addressed Chevron's innovative energy solutions, namely its efforts in hydrogen production, which integrates CO_2 absorption with hydrogen creation from natural gas. This technology enables the corporation to decarbonize its industrial operations while generating hydrogen—a vital fuel for low-carbon energy systems. He articulated that blue hydrogen may function as a pivotal facilitator of industrial decarbonization, particularly when integrated with CCUS technology to sequester the concomitant CO_2 emissions.

Mr Osokin emphasized the significance of regional cooperation in advancing CCUS. He emphasized that Chevron's collaborations with other energy firms and governments are crucial for establishing the infrastructure and regulatory frameworks necessary for the global expansion of CCUS. He underscored the necessity for APEC economies to collaborate by exchanging expertise, technology, and financial resources to address the difficulties confronting the CCUS business.

2.3 Global CCS Success Stories: Key Insights and Lessons Learned of Northern Lights Project

Mr Somnath Kansabanik, Principal Director (Rystad) presented on the Global CCS success stories: Key insights and lessons learned Northern Lights Project. The Northern Lights Project, located off the coast of Norway, stands at the forefront of this effort, providing a model for the successful large-scale implementation of CCS. This project represents not only a technological milestone but also a key lesson in collaboration, regulatory alignment, and the scaling of infrastructure necessary to address global carbon emissions.

The Northern Lights Project is part of the broader Longship initiative, aimed at creating a cross-border CO_2 storage network in Europe. One of the primary insights from the project is the ability to implement large-scale CO_2 storage solutions, particularly offshore, which can capture and securely store emissions from various industrial sectors. This method is crucial for mitigating emissions from industries that are difficult to decarbonize, such as cement production, steel manufacturing, and chemical processing, where CO_2 emissions are inherently linked to the manufacturing process.

A key aspect of the Northern Lights Project is its scalability. Unlike other CCUS projects that are confined to a single industrial site, the Northern Lights project is designed to offer cross-border storage capacity. This allows for emissions to be captured from multiple economies and a wide range of industries, thus increasing the flexibility and market appeal of the project. The use of Norway's vast geological CO_2 storage potential, particularly in deep-sea storage formations 2,000–3,000 meters below the seabed, further enhances the scalability of the project.

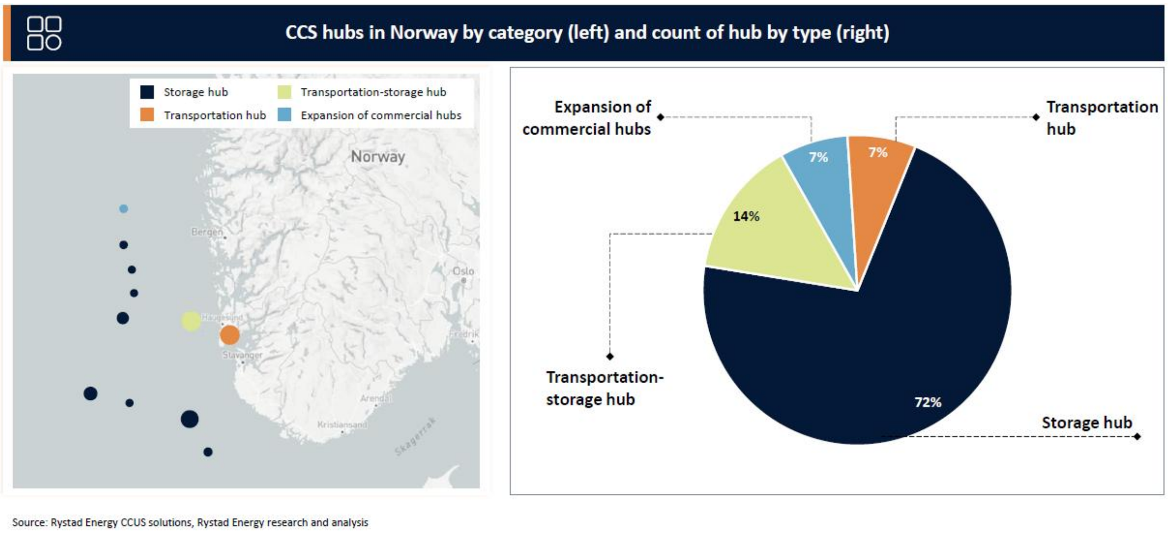

Figure 5: Northern Lights Project's hubs

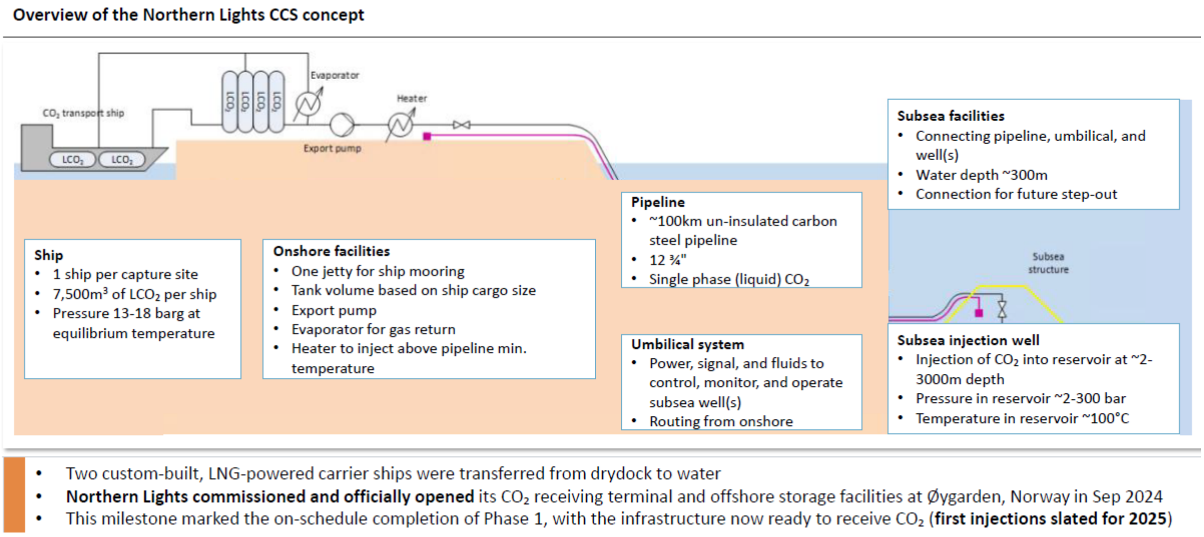

Figure 6: Overview of the Northern Lights CCS concept

The project also highlights the importance of strong PPPs in advancing CCUS technology. Major industrial players, including Chevron, have signed long-term agreements with Northern Lights to store CO_2, demonstrating the commercial viability of the technology. This indicates that CCUS is not only an environmental necessity but also an emerging economic opportunity, where both governments and industries collaborate to drive forward solutions to mitigate climate change.

Furthermore, the Northern Lights Project underscores the significance of regulatory alignment in ensuring the safe and successful implementation of CCUS technologies. The Norwegian government has implemented stringent safety protocols and monitoring systems, providing a model for other economies. This regulatory clarity fosters investor confidence, ensuring that the necessary infrastructure can be developed and maintained. By securing both public and private investment, the project demonstrates that large-scale CCUS initiatives can be financially feasible, paving the way for future developments in carbon capture and storage.

The Northern Lights Project offers several crucial lessons that can inform the successful deployment of CCUS technologies in other regions and industries. One of the key lessons is the importance of building a robust and transparent regulatory framework. The Norwegian government has implemented stringent safety protocols, including extensive monitoring systems to ensure that CO_2 remains securely stored in the underground geological formations. The ability to guarantee the long-term safety of CO_2 storage sites has been central to the project's success, as it addresses public concerns about potential leakage. By providing clear and reliable guidelines for CO_2 storage and monitoring, the Norwegian regulatory framework has created a model for other economies looking to develop their own CCUS projects.

Public-private collaboration has also been critical to overcoming the challenges faced by the Northern Lights Project. Public skepticism around CCUS technologies, particularly regarding the risks of CO_2 leakage and environmental harm, has been a significant barrier. Through proactive engagement with local communities, government agencies, and industry stakeholders, the project has worked to build public trust and ensure broad support for its goals. This has proven essential for the smooth progression of the project and securing long-term financial commitments from key industrial players, including Chevron.

Financial and technical challenges have also played a significant role in shaping the lessons learned from Northern Lights. The project required substantial upfront investments in infrastructure development, including the creation of subsea storage facilities, transportation pipelines, and CO_2

capture technologies. Securing these investments required clear policy direction, long-term regulatory stability, and financial incentives, underscoring the importance of government support in making CCUS financially viable. The Northern Lights Project has proven that, with sufficient investment, technical challenges related to scaling CCUS technology can be overcome, creating a blueprint for future global CCUS initiatives.

2.4 Panel Discussion

The panel discussion, facilitated by Dr Piya Kerdlap, highlighted numerous crucial aspects concerning the future of CCUS in the APEC region. The panelists underscored that CCUS is essential for mitigating emissions from industries within APEC economies that are challenging to decarbonize. Industries including cement production, steel manufacture, and heavy transportation produce substantial emissions that cannot be adequately mitigated by alternative decarbonization methods, such as renewable energy or electrification. In these areas, CCUS provides a viable and scalable solution for capturing and storing CO_2 emissions, therefore allowing APEC economies to achieve their climate objectives while sustaining industrial growth and economic stability. Mr Lambasara from PTTEP emphasized that areas with significant industrial operations in oil and gas must include CCUS in their climate strategies to attain substantial emissions reductions.

The dialogue indicated that the substantial expenses linked to CCUS implementation, especially regarding infrastructure investment, constitute a significant obstacle to the widespread adoption of CCUS technology among APEC economies. Mr Osokin from Chevron emphasized that the financial obligation of developing the requisite infrastructure—comprising CO_2 pipelines, capture facilities, and geological storage locations—is considerable. The substantial initial expense is accompanied by regulatory ambiguity, especially in areas where policy frameworks for CCUS are either under construction or absent. In the absence of explicit legislative frameworks and financial incentives, CCUS technologies may find it challenging to compete with alternative, lower-cost solutions like renewable energy or enhancements in energy efficiency. Consequently, APEC economies must establish solid regulatory frameworks that provide long-term investment security and economic incentives to promote extensive CCUS implementation.

Notwithstanding these limitations, the panelists concurred that APEC economies possess substantial prospects to spearhead global initiatives in CCUS development. The geological storage potential of the region, along with its industrial proficiency, uniquely positioned it to emerge as a global leader in CCUS technologies. Mr Kansabanik from Rystad highlighted that APEC economies, characterized by their varied industrial foundations and availability of extensive geological storage resources, have the potential to establish a formidable CCUS infrastructure that addresses both regional and global demands. Numerous APEC economies, with their robust energy production and heavy industry sectors, are strategically positioned to lead in CCUS implementation within their energy transition frameworks.

The discussion underscored the significance of PPPs, financial incentives, and regional collaboration to expedite CCUS implementation throughout the APEC area. Mr Lambasara and Mr Osokin emphasized the necessity of engaging the private sector in CCUS investments, asserting that although governments should establish the regulatory framework and offer initial financial assistance, the private sector must assume a predominant role in advancing the commercialization of CCUS technologies. PPPs provide a sustainable framework for expanding CCUS by utilizing governmental policy assistance and private sector ingenuity. Moreover, financial incentives, like tax credits and subsidies, are crucial for closing the economic disparity between CCUS technology and more established, cost-effective alternatives.

The panelists concurred that regional collaboration is vital for addressing the problems associated with CCUS deployment in the APEC area. APEC economies must collaborate to develop cross-border infrastructure, including CO_2 transit pipes and regional storage facilities. This partnership may facilitate the sharing of geological storage sites among economies, allocate the expenses of infrastructure development, and permit the transit of CO_2 from high-emission areas to appropriate storage sites. The panel highlighted that APEC possesses a distinctive opportunity to function as a platform for information exchange, facilitating the dissemination of best practices, successful case studies, and innovative technology to assist APEC economies in expediting CCUS implementation. Establishing a synchronized, regional strategy will be essential for the expansion of CCUS technologies and for guaranteeing that each economy can participate in and gain from the unified initiative.

The panelists emphasized that public engagement and education are essential for the effective implementation of CCUS technologies. Mr Kansabanik observed that public perception of CCUS constitutes a substantial obstacle in numerous areas, especially regarding the safety of subterranean CO_2 storage. To establish trust, it is imperative to engage local populations in CCUS decision-making processes, furnishing them with clear and transparent information regarding the safety, advantages, and enduring environmental consequences of CCUS technology. Public endorsement will be crucial for the advancement of CCUS projects, enabling them to proceed without substantial resistance or legal impediments. Governments and industry must allocate resources to outreach initiatives, educational campaigns, and public consultations to guarantee that communities are aware and may actively engage in the development of CCUS implementation.

The panel discussion offered essential insights into the prospects and problems related to CCUS implementation in the APEC area. The panelists emphasized that while CCUS is crucial for mitigating emissions in challenging sectors, considerable obstacles persist, such as elevated costs, regulatory ambiguity, and insufficient infrastructure. APEC economies possess a distinctive opportunity to spearhead global CCUS implementation, owing to the region's geological storage resources and industrial proficiencies. To actualize this potential, APEC economies must collaborate, establish a coordinated regional strategy, and promote PPPs. Monetary incentives, regional cooperation, and public involvement will be essential for expediting the implementation of CCUS technology and guaranteeing its sustained success. By confronting these problems and utilizing the region's advantages, APEC economies may significantly contribute to the advancement of CCUS as a crucial technology in combating climate change.

2.5 Key Takeaways and Conclusion

The panel discussion on CCUS highlighted the technology's essential function in mitigating emissions from challenging-to-decarbonize industries such as cement, steel, and heavy transportation. These sectors generate substantial emissions that cannot be mitigated only by renewable energy or electrification. CCUS provides a scalable method for the capture and storage of CO_2, enabling APEC economies to achieve climate objectives while maintaining industrial expansion. Nonetheless, significant financial and legal obstacles persist, especially in establishing the infrastructure necessary for CCUS, including CO_2 pipelines and storage facilities. Regulatory ambiguity exacerbates investment challenges. Governments must formulate explicit regulations and provide financial incentives to render CCUS competitive with more economical options.

Notwithstanding these limitations, APEC's extensive geological storage capacity and robust industrial foundation enable it to spearhead worldwide CCUS initiatives. PPPs are crucial for the advancement of CCUS, with governments offering regulatory assistance and initial financing, while the private sector propels commercialization. Regional collaboration is essential, especially for the development of cross-border infrastructure like CO_2 pipelines and shared storage facilities, which would lower deployment costs and enhance efficiency. Public participation and education are essential for addressing apprehensions over the safety of CO_2 storage. Transparent communication and the inclusion of local populations in decision-making will foster trust and facilitate more effective implementation.

In conclusion, CCUS is essential for mitigating emissions from industries that are challenging to decarbonize. Despite ongoing hurdles, including elevated costs, legal ambiguity, and public perception, APEC economies possess the capacity to spearhead CCUS growth. Through the collaboration on a unified strategy, the establishment of explicit laws, and the promotion of PPPs, APEC may significantly contribute to the advancement of CCUS technologies and the mitigation of climate change.

Session 3: Technical Session - "Geological Storage of CO_2: Technical Advances and Challenges"

Speaker: ***Dr Juan Zhou (CERI)***

During the third session of the APEC workshop, Dr Juan Zhou from the Huangneng Clean Energy Research Institute (CERI) presented a comprehensive analysis of the technical dimensions of geological CO_2 storage, emphasizing China's advancements in CCUS technologies. She, a preeminent authority in geological storage, emphasized the swiftly changing dynamics of CO_2 capture and storage in China, underscoring significant technical innovations, the economy's objectives for developing CCUS, and its contribution to global initiatives aimed at diminishing carbon emissions.

3.1 China's engagement with CCUS and Geological CO_2 Storage

Dr Zhou highlighted China's crucial position in the global CCUS framework, especially with the advancement of geological CO_2 storage technologies. To achieve its climate objectives, China has progressively adopted CCUS technology to reduce carbon emissions from its industrial and energy sectors and mitigate emissions from fossil fuel consumption. In 2016, the Energy Technology Revolution Innovation Action Plan (2016-2030) explicitly outlined the strategic direction, innovation objectives, and key initiatives for CCUS technological innovation. The government's dedication to extensive CCUS implementation corresponds with its objective of attaining carbon neutrality by 2060. She underscored that geological CO_2 storage in China is important to these objectives, as it possesses the capacity to mitigate a substantial fraction of emissions from heavy industries and coal-fired power plants.

Dr Zhou emphasized multiple significant advancements in China's geological CO_2 sequestration technologies. China has made substantial investments in research and development to enhance the geological storage efficiency of its saline aquifers and oil reservoirs. Chinese scientists and engineers have made a notable contribution to geological storage through site characterization, which involves evaluating the suitability of geological formations for CO_2 sequestration.

China has established advanced geological modeling and seismic imaging techniques that support preliminary assessment of subsurface formations. These technical approaches facilitate the identification of potentially suitable locations for CO_2 storage, while further validation is required to ensure long-term containment security. Dr Zhou elucidated that the application of 3D seismic imaging and deep borehole data yields essential insights into reservoir architecture and caprock integrity, both vital for mitigating leakage.

Dr Zhou also addressed China's emphasis on improving monitoring technology for CO_2 storage. China has made significant progress in developing real-time monitoring systems utilizing temperature and pressure sensors to detect CO_2 migration within storage sites. These monitoring systems are deployed to detect CO_2 plume movement and enhance the safety of CO_2 storage.

3.2 China's Major Geological CO_2 Storage Projects

Dr Zhou elaborated on numerous significant CCUS initiatives in China that incorporate geological CO_2 sequestration. As China's first integrated commercial CCUS facility, the Sinopec Qilu project demonstrates a full-chain CCUS project capturing 1Mt/yr CO2 from coal-to-gas tail gas for EOR applications. China Huaneng Group is developing the world's largest post-combustion CO2 capture facility in the Huaneng Longdong Energy Base, with an annual capacity of 1.5 million tonnes. This groundbreaking project incorporates an innovative biphasic CO2 capture process and dedicates 200,000 tonnes of captured CO2 each year to saline aquifer storage. She indicated that these projects exemplifies China's capability to execute CCUS on a large scale and acts as a paradigm for other APEC economies aspiring to emulate effective geological storage programs.

Dr Zhou indicated that China is enhancing its geological storage infrastructure through the development of long-distance CO_2 pipeline transport systems. These systems will enable the capture of CO_2 in one area and its transportation to storage facilities in adjacent areas, thereby promoting regional CCUS hubs. She explained that this methodology is particularly advantageous in the APEC region, where economies own disparate geological storage capacities and must cooperate on CO_2 transport and storage strategies.

3.3 Challenges in CO_2 Storage in China

Notwithstanding China's significant progress in CCUS and geological CO_2 storage, Dr Zhou recognized many critical difficulties that remain to be resolved. A significant challenge is the suitability evaluation of potential storage sites. Although China possesses extensive geological formations appropriate for CO_2 storage, it must acquire further geological data to target a certain storage site. Extensive geological surveys are required to confirm specific reservoirs' capacity and containment security for commercial-scale deployment.

The economic feasibility of CCUS technologies remains ambiguous in numerous sectors beyond the oil and gas industry. She articulated that, China has been exploring preliminary measures to support CCUS development through R&D funding mechanisms and subsidy incentives, but large-scale adoption faces barriers from technological limitations, uneven local finances, and implementation challenges across diverse regions.

3.4 China's Role in Regional Collaboration for CCUS

Dr Zhou underscored that China's participation in regional cooperation on CCUS technology will be pivotal to the success of CCUS in the APEC area. China's comprehensive CCUS technology system and geological storage capabilities equip it to spearhead CCUS advancement in the area. She emphasized the significance of knowledge dissemination and capacity enhancement within APEC. Building on its developing CCUS capabilities, China could support regional capacity development through mutually beneficial technology exchanges with other APEC economies.

3.5 Key Takeaways and Conclusion

The extended technical session conducted by Dr Juan Zhou concentrated on China's preeminence in CCUS technology, especially in geological CO2 storage and its notable progress. She emphasized that China has become a global frontrunner in CCUS technology development. China has achieved significant advancements in site characterization, monitoring technologies, and CO_2 injection systems, all essential for the secure and efficient execution of geological CO_2 storage. These achievements place China at the forefront of CCUS research.

The Huaneng Longdong CCUS Project was presented as an example illustrating the scalability and technical feasibility of geological CO_2 storage in extensive industrial and energy activities. The projects demonstrate China's technological prowess in implementing CCUS technologies in challenging industrial applications, particularly in coal-fired power plants with flue gas CO_2 concentrates typically below 15% - a technically demanding scenario for carbon capture.

Notwithstanding China's technological preeminence, she emphasized the need for further geological data to determine the most advantageous sites for extensive geological CO_2 storage. Geological studies and site characterization are essential for guaranteeing the long-term stability and safety of storage locations. Increased data collection and research expenditure are essential to augment China's capacity to identify and establish secure and efficient CO_2 storage sites economy-wide.

In conclusion, the comprehensive technical session conducted by Dr Juan Zhou highlighted China's preeminent position in CCUS technologies. China's continuous technological progress in site characterization, monitoring, and CO_2 injection systems establishes it as a global frontrunner in CCUS innovation. The Sinopec Qilu Project and the Huaneng Longdong CCUS Project demonstrate the technical scalability of geological CO_2 storage, proving the feasibility of large-scale carbon capture, utilization, and storage (CCUS) initiatives in real-world applications.

Furthermore, the session emphasized the significance of regional cooperation within APEC to enhance CCUS technologies. China plays a crucial role in the future of APEC's CCUS, especially in technological transfer and regional knowledge dissemination. Through collaboration, APEC economies may surmount the technological, economic, and legal obstacles that impede CCUS implementation and establish a more unified strategy for geological CO_2 storage. In this context, APEC economies possess the capacity to emerge as worldwide leaders in CCUS, making substantial contributions to the reduction of global emissions and the shift toward a low-carbon economy.

Session 4: Policy and Regulation Session - "Regulatory Frameworks for CCUS: Best Practices and Challenges"

Speaker: ***Dr Pedro Van Meurs (VAN MEURS ENERGY)***

The fourth session of the APEC workshop concentrated on the legal frameworks essential for facilitating CCUS deployment, provided by Dr Pedro Van Meurs, a specialist in energy law and policy. Dr Van Meurs presented a comprehensive examination of the legal, policy, and regulatory obstacles that must be surmounted to effectively deploy CCUS on a substantial scale. The workshop examined worldwide best practices and the particular regulatory challenges confronting APEC economies in the advancement of CCUS technologies.

Dr Van Meurs commenced by underscoring the necessity of a transparent and consistent regulatory framework for the implementation of CCUS. The effective execution of CCUS technologies relies not solely on the technical viability of capturing, transporting, and storing CO_2, but also on the establishment of policies and regulations that ensure legal certainty for stakeholders, including governments, investors, developers, and communities. In the absence of a definitive framework, essential private sector investments in CCUS infrastructure and technology are unlikely to occur.

He noted that CCUS is distinctive in its integration of the energy industry and environmental policies. Consequently, it necessitates collaboration among several government sectors and levels—energy, environment, transportation, and finance—along with cooperation between the public and private sectors. Dr Van Meurs emphasized that rules should harmonize environmental protection, economic incentives, and public acceptability to foster an environment conducive to the implementation of CCUS technology.

4.1 Key Regulatory Issues in CCUS Deployment

Dr Van Meurs proceeded to examine some critical regulatory hurdles that must be resolved for the effective global expansion of CCUS. The problems encompass CO_2 storage and liability, control of CO_2 transit, and the regulatory and approval processes for CCUS projects.

A critical difficulty in geological CO_2 storage is establishing legal responsibility for the CO_2 after its injection into subterranean formations. Such an issue is referred to as the matter of long-term liability. He emphasized that governments must assume responsibility for the long-term oversight and accountability related to CO_2 storage, guaranteeing that the stored gas is securely confined without presenting environmental hazards.

A significant difficulty is the regulation of CO_2 transportation. Numerous CCUS projects will necessitate cross-border CO_2 transit, requiring international treaties and legal agreements to set uniform regulations for such transportation. This is especially significant in areas such as APEC, where economies collaborate on CO_2 storage resources. In the absence of definitive legislative frameworks for cross-border CO_2 pipes and transport infrastructure, the large-scale execution of these projects is unfeasible.

Moreover, the permissions and approvals for new infrastructure—such as capture facilities, pipelines, and storage sites—are frequently intricate and necessitate the consent of several governmental entities. Dr Van Meurs emphasized the necessity of expediting permission procedures and establishing explicit rules for developers to guarantee the prompt implementation of CCS projects. Governments must implement protocols that facilitate approvals while upholding essential environmental and safety criteria.

Dr Van Meurs also underscored the necessity for comprehensive environmental and social impact evaluations Environmental Impact Assessment (EIA) for CCUS initiatives. These evaluations are essential to guarantee that CO_2 storage locations do not adversely affect nearby ecosystems or communities. He emphasized that collaboration with local stakeholders, especially indigenous tribes, farmers, and landowners, is crucial for securing the social permission for CCUS initiatives.

Governments must establish clear regulatory frameworks that facilitate public engagement to alleviate societal apprehensions over the safety of CO_2 storage.

Ultimately, Dr Van Meurs addressed the significance of carbon pricing and financial incentives in promoting private sector investment in CCUS technologies. He contended that in the absence of a carbon price or carbon tax, CCUS technologies will persist as economically uncompetitive relative to other low-carbon alternatives. In areas lacking carbon pricing, governments ought to implement subsidies, tax credits, or direct financial incentives to promote investment in CCUS. Emissions trading systems (ETS) and carbon credits may offer financial incentives for CCUS initiatives.

4.2 Best Practices in CCUS Regulation: Case Studies

Dr Van Meurs undertook an examination of outstanding global practices in CCUS regulation, including effective regulatory frameworks from areas such as Europe and North America. The European Union's Carbon Capture and Storage Directive is one of the most sophisticated regulatory systems for CCUS. This directive delineates explicit protocols for CO_2 storage, monitoring, and liability, mandating that economies create national registries for CO_2 storage locations. It also requires that storage sites be monitored for a duration of up to 20 years following the injection of CO_2 to assure safety. Dr Van Meurs emphasized that such frameworks offer the legal assurance necessary to entice corporate investment in CCUS initiatives.

In North America, the United States Environmental Protection Agency (EPA) has instituted Class VI well regulations expressly for initiatives to sequester CO_2. These regulations guarantee the safe and secure storage of CO_2, incorporating measures for monitoring and public transparency. He underscored that these regulatory frameworks are crucial for establishing the legal and economic conditions necessary for the large-scale success of CCUS technologies.

4.3 Challenges for APEC economies in Adopting CCUS Regulations

Although worldwide best practices are available, Dr Van Meurs recognized that numerous APEC economies encounter distinct obstacles stemming from their varied regulatory frameworks, industrial compositions, and stages of economic growth. A primary difficulty is regulatory fragmentation, wherein various government bodies supervise distinct facets of CCUS projects, including energy, environment, and land use. He advised APEC economies to strive for the harmonization of their CCUS rules to establish a uniform set of standards throughout the region. He proposed the formation of national CCUS task forces to synchronize the endeavors of diverse governmental entities and stakeholders.

APEC economies, especially developing economies, face the difficulty of insufficient technological and regulatory competence. Certain economies may be deficient in the expertise or resources necessary to enact and enforce intricate CCS legislation. He suggested prioritizing capacity-building activities and technical assistance programs to enable these economies to acquire the requisite skills and knowledge for efficient CCUS regulation. International organizations such as the Global CCS Institute may significantly contribute by offering training, workshops, and recommendations to regulators and policymakers.

Cross-border CO_2 storage is a considerable barrier for APEC economies. Numerous economies in the region are physically proximate and share industrial emissions, rendering cross-border CO_2 storage a crucial element of efficient CCS implementation. Nonetheless, significant legal and regulatory obstacles to cross-border CO_2 transportation and storage persist. He underscored that APEC economies must prioritize the establishment of regional regulatory frameworks that enable the collaborative utilization of storage sites and CO_2 transportation infrastructure. APEC may significantly contribute to facilitating cooperative initiatives among member economies to establish a cohesive regulatory framework for cross-border CO_2 storage.

4.4 Recommendations for APEC economies

Dr Van Meurs closed his talk by offering multiple ideas for APEC economies to enhance CCUS implementation and surmount regulatory obstacles. The following recommendations are included:

Establish Explicit Legal and Policy Frameworks: Governments ought to establish uniform laws for CCUS technologies, encompassing CO_2 storage, transportation, and responsibility. Well-defined frameworks will offer the legal certainty required for private investment and expedite the expansion of CCUS initiatives.

Encourage Investment in CCUS: Governments ought to offer financial incentives, including tax credits, subsidies, and carbon pricing mechanisms, to render CCS economically feasible for the private sector. Carbon markets and emissions trading systems (ETS) may offer continuous incentives for the implementation of CCUS.

Enhance Public Engagement and Communication: Public trust and acceptance are essential for CCUS initiatives. Governments ought to implement public outreach and educational initiatives to enhance understanding regarding the advantages and safety of CCUS, particularly in relation to CO_2 sequestration. Clear communication and community engagement will foster trust and obtain social licenses.

Promote Regional Cooperation: APEC economies ought to collaborate on the advancement of CCUS technologies, regulatory harmonization, and knowledge exchange. This partnership will facilitate the removal of obstacles to transnational CO_2 storage and establish regional networks of storage facilities and transit infrastructure.

4.5 Key Takeaways and Conclusion

The Policy and Regulation Session, conducted by Dr Pedro Van Meurs, offered essential insights into the legislative frameworks necessary for the expansion of CCUS technology in the APEC region. A primary takeaway from the discussion was the acknowledgment that a transparent and stable legislative framework is crucial for the effective implementation of CCUS technologies, particularly in intricate domains like CO_2 storage, transportation, and liability. He underscored that CCUS technology cannot be efficiently scaled without a regulatory environment that offers the assurance required by governments, investors, and industry. Ambiguity in legislative frameworks—particularly about responsibility for long-term storage—can significantly hinder investment in CCUS initiatives. Governments must establish explicit standards for accountability for the long-term safety of CO_2 storage sites, encompassing potential liability for leaks or seismic occurrences. Such frameworks are crucial for attracting investment and fostering public trust in CCUS technologies.

A significant topic addressed in the workshop was the importance of global best practices in CCUS regulation. Dr Van Meurs emphasized instances from Europe's CCS Directive and the U.S. Environmental Protection Agency's (EPA) Class VI standards as effective frameworks for governing geological CO_2 storage. The CCS Directive delineates the regulations for CO_2 capture, transportation, and storage, offering a thorough regulatory framework that can be modified by other regions. The EPA's Class VI standards particularly oversee CO_2 sequestration in deep geological formations, guaranteeing secure and efficient CO_2 storage. These international best practices provide significant insights for APEC economies seeking to establish their own CCUS regimes. By implementing analogous standards and regulatory frameworks, APEC economies can guarantee the secure, effective, and scalable deployment of CCUS technologies while promoting international cooperation.

Dr Van Meurs noted regulatory fragmentation and insufficient technical capability as major obstacles for APEC economies in implementing CCUS legislation. Numerous economies within the APEC region possess disjointed regulatory frameworks, with various bodies supervising distinct facets of CCUS technologies. The energy industry, environmental protection agencies, and transportation authorities may possess overlapping jurisdiction regarding CO_2 storage and transit; nonetheless, they often exhibit a deficiency in coordination over policy formulation and execution. The absence of regulatory consistency can result in confusion, delays, and inefficiencies in the development of CCUS projects. Furthermore, the technical capabilities in several APEC economies remain underdeveloped, complicating the drafting and enforcement of intricate CCUS legislation. He proposed that APEC economies might gain from capacity-building programs and international collaboration to enhance their technical proficiency and regulatory frameworks in CCUS.

A key message from the discussion was the necessity for regional collaboration in establishing cross-border CO_2 storage arrangements. As CCUS technologies are implemented on a greater scale, the capacity to share geological storage sites across domestic borders will become increasingly vital, particularly in regions like APEC, where emissions-intensive businesses frequently extend across many economies. He contended that transnational CO_2 transport and storage necessitate standardized legislation to promote collaboration among adjacent economies, thereby establishing a unified infrastructure for CCUS implementation. Such an arrangement may encompass collaborative CO_2 pipelines, storage facilities, and monitoring systems, facilitating cost-sharing among economies while guaranteeing the secure and effective transportation and storage of CO_2. Regional collaboration will enable APEC economies to utilize each other's geological storage resources and alleviate the financial burden of constructing infrastructure individually.

The key finding emphasized the significance of financial incentives, carbon pricing, and public participation in facilitating the effective implementation of CCUS technologies throughout the APEC region. Dr Van Meurs underscored that in the absence of suitable financial mechanisms, such as carbon pricing or carbon credits, the economics of CCUS will continue to be problematic. Carbon pricing establishes a definitive market signal for CCUS initiatives, guaranteeing that enterprises are economically incentivized to absorb and sequester CO_2. Financial incentives, such as subsidies or tax credits, are essential for diminishing the initial capital expenditures of CCUS technologies and enhancing their appeal for private sector investment. Moreover, public engagement is essential for fostering public trust in CCUS technology, especially in regions where geological CO_2 storage initiatives are underway. Governments must endeavor to ensure that local communities comprehend the advantages of CCUS, particularly its function in alleviating climate change, and possess confidence in the safety of these technologies.

In conclusion, the Policy and Regulation Session, led by Dr Pedro Van Meurs, illuminated the essential function of regulatory frameworks in the effective implementation of CCUS technology throughout the APEC area. The workshop emphasized that clear, stable, and consistent policies are essential for the effective scaling of CCUS, especially regarding CO_2 storage, transportation, and responsibility. Global best practices, including Europe’s CCS Directive and the U.S. EPA’s Class VI standards, provide significant insights for APEC economies in structuring their regulatory regimes. The workshop highlighted the considerable problems presented by regulatory fragmentation and deficiencies in technical capacity within the area. Overcoming these obstacles necessitates robust regional cooperation, capacity-building initiatives, and the establishment of standardized cross-border storage arrangements.

The session underscored that financial incentives and carbon pricing are essential for encouraging private-sector investments in CCUS, while public participation is crucial for obtaining a social license for large-scale CCUS initiatives. As APEC economies advance in formulating and executing their CCUS regulatory frameworks, it is imperative to promote collaboration, knowledge exchange, and collective infrastructure development to guarantee the efficacy of CCUS technology across the area. By tackling these legislative and policy obstacles, APEC economies may expedite the implementation of CCUS and assume a prominent position in the worldwide battle against climate change.

Session 5: Keynote Speech - "Energy Transition, with Particular Emphasis on Low-Carbon Technologies"

Speaker: ***Dr I Gusti Suarnaya Sidemen (ERIA)***

On the second day of the workshop, an effective keynote speech was made by Dr I Gusti Suarnaya Sidemen, representing the Economic Research Institute for ASEAN and East Asia (ERIA). Dr Sidemen, highlighted the necessity of evaluating transition technologies to achieve the global objective of net-zero emissions (NZE). He discussed the updated Technology List and Perspectives for Transition Finance in Asia (TLP), a comprehensive inventory of essential technologies for decarbonisation in Asia and assesses the potential of various transition technologies based on key criteria, including emissions impact, affordability, and reliability/maturity, which broadens its scope to encompass both green and transition technologies across various sectors, including upstream, power, midstream, downstream, and energy end-use.

He emphasized the notable advancements in CCS technology, encompassing enhancements in CO_2 storage, transportation, and capture. The incorporation of innovations like artificial intelligence (AI) and advanced materials has enhanced the efficiency of CCS, positioning it as a crucial technology for achieving NZE. Financial challenges associated with deploying CCS in developing economies within the Asia-Pacific region necessitate blended financing models that integrate public and private investments.

Dr Sidemen highlighted the critical role of regulation in the effective implementation of CCS. Regulations ought to be customized to the distinct requirements of each economy, taking into account both public and private frameworks. The success of CCS projects is contingent upon public acceptance, as evidenced by previous initiatives that encountered resistance stemming from insufficient public approval. Effective communication and stakeholder engagement are essential for addressing barriers and facilitating the successful implementation of CCS technologies.

5.1 Transition Technology Assessment to meet Net-Zero Emissions

The assessment aims to deliver a factual overview of each chosen transition technology, assisting financial institutions and other stakeholders in comprehending their appropriateness for technology selection and the distribution of transition finance. The objective is to stimulate the allocation of funding for these technologies, thus promoting a systematic and equitable approach to attaining NZE. Furthermore, it will provide a framework that delivers a thorough overview of potential transition technologies.

Transition technologies are assessed based on six essential dimensions to address the critical factors required for a just and orderly transition. These technologies promote climate sustainability while ensuring the reliability and affordability of energy supplies for governments and citizens, thus maintaining social stability. The objective is to achieve a balance among sustainability, reliability, and affordability to ensure social stability.

The characteristics outlined below delineate the contributions of each technology to a just and orderly transition to net-zero emissions:

1. Contribution to energy transition: This process measures the sustainability of the technology by evaluating its efficacy in directly mitigating emissions or facilitating others in doing this, thereby aiding the decarbonization initiatives of projects, enterprises, and economies.
2. Reliability: This parameter assesses the sophistication of the technology. Technologies that are commercially available and can be implemented at scale are deemed more dependable than those in the experimental or pilot stages.

3. Cost: The expense of the technology is crucial in assessing the feasibility of the transition, encompassing both the price of emission reduction for upstream technologies and the enduring energy expenditures linked to power sector technologies.
4. Lock-in Prevention Considerations: Within the ASEAN taxonomy, this element constitutes a component of the risk management tool (RMT). It examines the possible avenues for a technology to evolve towards zero-emission or net-zero emission, notwithstanding the presence of emissions that the technology cannot eradicate.
5. Considerations for Do No Significant Harm: This assesses the potential negative impacts of the technology on many environmental objectives, including ecosystem health, biodiversity, resource resilience, and the circular economy. It also evaluates potential preventive measures, which are incorporated into the RMT requirements within the ASEAN taxonomy.
6. Social Considerations: This paper evaluates the potential adverse societal effects of the technology, like the reduction of employment possibilities or repercussions on local communities.

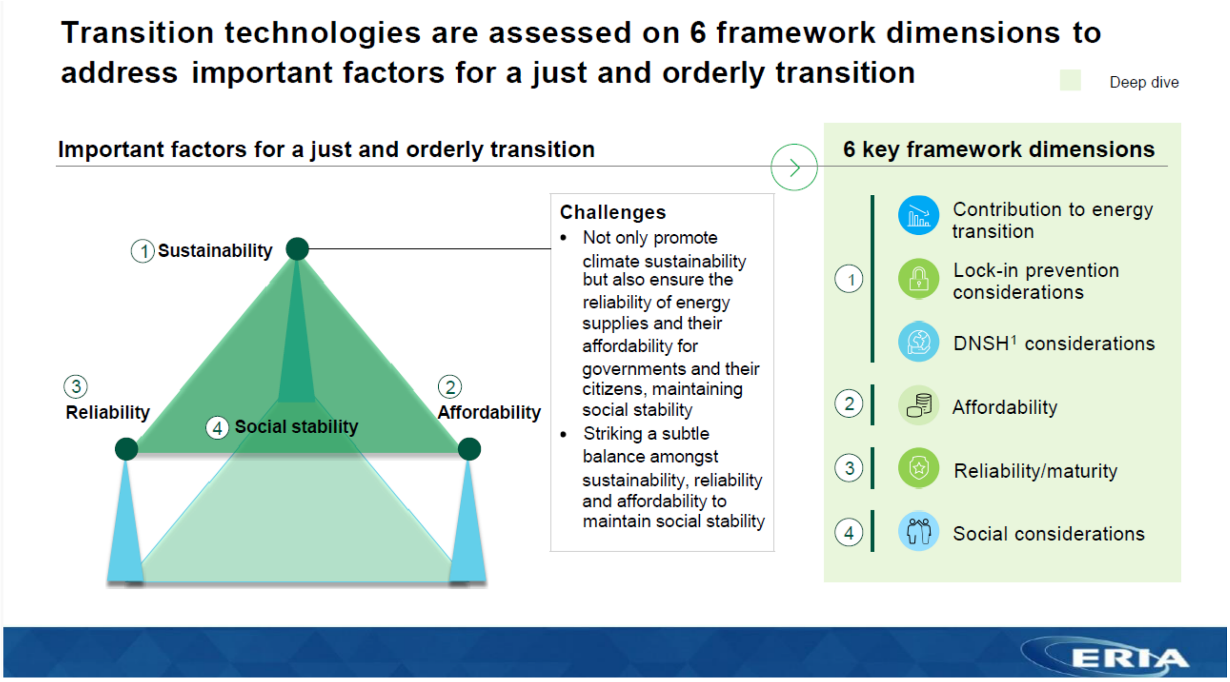

Figure 7: Transition technologies assessed by 6 frameworks

Dr Sidemen further mentioned the revised Technology List and Perspectives for Transition Finance in Asia (TLP) a comprehensive inventory of essential technologies for decarbonisation in broadens its scope to encompass both green and transition technologies across all sectors, including upstream, power, midstream, downstream, and energy end-use, targeting both energy-related and non-energy-related emissions.

In APEC, the energy sector constitutes the predominant source of greenhouse gas emissions, mostly from power and heat generation, succeeded by fuel combustion in transportation, manufacturing, and other sectors. The transition technologies encompasses solutions aimed at mitigating emissions from the upstream, electricity, and cross-sectoral industries. The upstream sector prioritizes technologies that facilitate lower-emission fuels, like biomass, hydrogen, and natural gas, while also focusing on mitigating fugitive emissions from coal. In the energy industry, where coal is a significant pollutant, technologies such as co-firing and CCS are essential, alongside the shift to alternative fuels like biomass and LNG. In industrial sectors, fuel switching and electrification are essential for minimizing energy-intensive processes; however, carbon capture technologies are also crucial for decarbonization. Among the assessed technologies, CCUS is crucial for attaining NZE, especially in challenging sectors hard to abate industries, such as fertilizer, steel, and cement.

The International Energy Agency (IEA) has projected that with the adoption of transition technologies and renewable energy, the role of CCUS in CO2 emission reduction could increase significantly, reaching up to 4.1 gigatons per year by 2050. But the question remains: How can we make CCUS effective?

APEC consists of economies that include technology developers, financiers, and economies incorporating CCUS into domestic plans to achieve NZE.

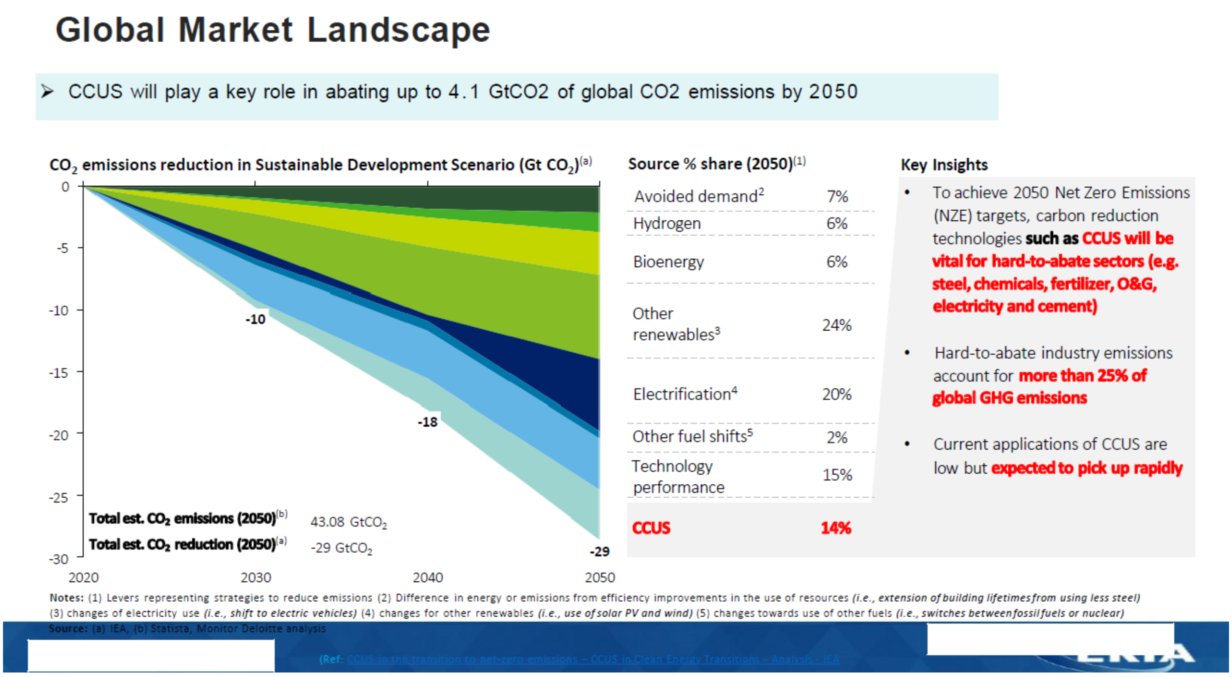

Figure 8: Global Market Landscape

5.2 Technology Deployment

To evaluate technology, we can analyze its learning curve. National Energy Technology Laboratory (NETL) has developed a learning curve for CCS, which illustrates in Figure 9 that as installation capacity, research, and development increase, the cost of the technology will decrease due to improved reliability and efficiency.

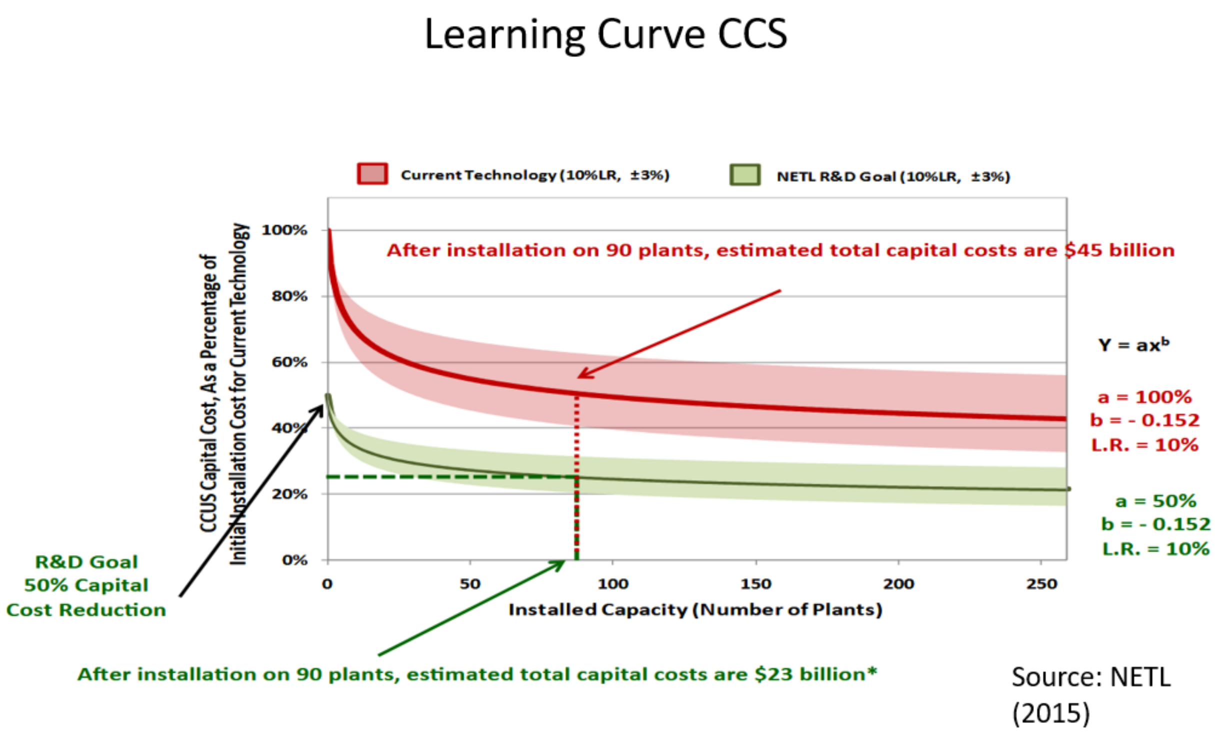

Figure 9: Learning Curve CCS

The concept of CCUS, especially regarding storage, has existed for over five decades, during which significant advancements have occurred in the CCS value chain. Technological advancements, including 3D and 4D seismic assessment tools, have enhanced the precision of storage condition evaluations. Artificial intelligence applications in geology and the oil and gas industries have improved subsurface carbon capture and storage capabilities. Considerable advancements have been achieved in CO_2 capture technology, with research aimed at minimizing energy consumption, reducing costs, and enhancing efficiency. New catalysts have been incorporated into solvents, and advanced membranes and sorbent materials have been developed. In the past ten years, capture technology has decreased energy penalties by over 50% through the reduction of the temperature necessary for reheating amine solvents.

Innovative technologies for CO_2 transportation are under exploration, including a Japanese-engineered vessel that is expected to significantly contribute to international carbon capture and storage projects. Furthermore, efforts are being made to advance undersea transportation through the utilization of submersible and drone technologies.

Existing CCS projects, developed with the technology of their respective periods, have encountered challenges, including subsurface issues related to CO_2 injection. The Snohvit project, operational since 2008, encountered challenges in its initial phase due to an inadequate CO_2 reservoir, which was addressed by choosing an alternative storage site. An Indonesian prototype project similarly faced challenges related to low porosity in the selected reservoir. The Gorgon CCS project has faced challenges in reaching its injection capacity target, attaining 1.5-1.9mt on average per year which is approximately 40-50% of its nameplate capacity of 4mtpa. The Shute Creek facility, among the largest carbon capture plants worldwide, has encountered comparable difficulties in achieving its optimal capture capacity, resulting in a substantial amount of CO_2 emissions being vented instead of stored. The central concern at Shute Creek pertains to its business model, which permits CO_2 to be either sold or vented, contingent upon the demand for enhanced oil recovery (EOR).

Future advancements in CCS will be influenced by technological progress and insights gained from existing projects. The dissemination and commercialization of technology are essential for cost reduction and enhancement of reliability and efficiency. Collaboration among technology developers, project developers, and economies focused on advancing CCS is crucial. Investments by companies such as ExxonMobil and BP in Indonesia, and Chevron in Thailand, along with the collaborative initiatives between Jogmec and Korea, illustrate that advanced technologies and expertise will enhance the implementation of CCS.

5.3 CCS cost the overall value chain.

The efficacy of CCS is contingent upon its comprehensive cost throughout the whole value chain. Dr Sidemen indicates that the costs of CCS in Indonesia vary between USD70 and USD120 per ton of CO_2, with the adoption of CCS increasing electricity prices by USD0.05 to USD0.07 per kWh. Ongoing technological advancements, particularly in CO_2 transportation, may contribute to cost reduction. The belief that CCS is excessively costly, especially in comparison to renewable energy, has impeded its implementation.

The actual expense of CCS is contingent upon elements such as plant location, logistics, infrastructure, and operational necessities, all of which influence the levelized cost of energy (LCOE). Equitable comparisons of technologies, including wind and solar, must consider issues such as energy storage and transmission requirements. The IEA's VALCOE (Value-Adjusted Levelized Cost of Electricity) framework offers a more precise assessment of the costs and advantages of CCS, indicating its economic viability.

Funding CCS is difficult due to its substantial investment demands. Public financing has bolstered existing CCS initiatives in rich economies; however, such funding may be constrained in developing Asia-Pacific economies. Blended finance between the public and private sectors will be essential for the development of CCS projects. Governments can assist by offering incentives, such as tax credits, and modifying their portion of profits via production sharing agreements. Government can enhance the feasibility of CCS finance. Moreover, CO_2 market mechanisms, including the cooperative credit system such as between Indonesia and Japan, Japan and Malaysia can create new funding avenues for CCS in the region.

5.4 The advancement of CCS's regulation

The third key component affecting the advancement of CCS is regulation. Effective regulation emerges from a meticulously designed framework that aligns with the plans of the relevant economies or economies, bolstered by a gap analysis between regulatory objectives and current conditions. This gap analysis is crucial for identifying pertinent frameworks and best practices, choosing suitable options for developing a customized framework, and guaranteeing proper execution. Established frameworks, best practices, and rules can provide essential guidance in the formulation of effective regulations.

Regulations generally conform to two primary models: common law and civil law. Nonetheless, the prevailing trend appears to favor convergence among these methodologies. Regulations can be classified as either public or private. Public rules are formulated and enforced by the government, whereas private regulations are established by professional or industrial groups.

Regulation can also be categorized based on its topic matter: technical, social, or economic. Technical rules pertain to the technical facets of CCS; social regulations encompass permitting, environmental concerns, and safety, while economic regulations involve taxation, incentives, penalties, and credits. In practice, CCS projects frequently engage with many regulatory frameworks.

In general, three elements contribute to effective regulation: institutions, substance, and culture. Culture is very significant in the formulation of legislation.

Private regulation is established by non-state actors, including professional associations and third-party corporations. The implementation is optional and may be incorporated into a contract. Nonetheless, it may also be implemented by governments as compulsory rules. The efficacy of these institutions hinges on the enforcement of power by domestic or transboundary authorities and their collective exercise of authority. For instance, the U.S. government may integrate private regulation with technical regulations, and two ministries or economies might execute a Memorandum of Understanding (MOU) to enhance regulatory efficacy. An illustration of this type of MOU exists between the Netherlands and Norway regarding cross-border CCS initiatives.

Although the discourse surrounding beneficial regulation is straightforward, its implementation might prove to be arduous. Striking a balance between under-regulation and over-regulation is a nuanced endeavor, shaped by the interests of various stakeholders. The requisite regulatory measures for promoting CCS become more evident upon implementation. Should they fail to perform as anticipated, modifications may be required. Public endorsement is essential for CCS initiatives, and the proliferation of social media heightens the likelihood of public dissent. Numerous CCS projects have been suspended due to the inability to secure public approval, including the German RWE project, the Dutch Barendrecht project, and the Polish Bechatow project.

5.5 Key Takeaways and Conclusion

In his keynote address, Dr I Gusti Suarnaya Sidemen underscored the essential importance of CCS technology in attaining NZE, especially in hard to abate industries sectors such as fertilizer, steel, and cement, which encounter considerable decarbonization obstacles. He emphasized the necessity of assessing transition technologies according to criteria such as their role in the energy transition, reliability, cost-effectiveness, avoidance of lock-in, compliance with Do No Significant Harm principles, and societal implications. The objective is to achieve equilibrium among sustainability, reliability, and affordability while maintaining social stability. CCS, particularly in CO_2 sequestration, has progressed significantly over the last fifty years, incorporating technological advancements like 3D/4D seismic instrumentation, artificial intelligence applications, and enhanced CO_2 capture methods.

Technological improvements, collaboration among technology developers, governments, and industry, and innovative CO_2 transportation methods, such as Japanese-engineered vessels, are essential for scaling CCS programs. Nonetheless, the expense constitutes a substantial obstacle, affected by elements such as facility location and infrastructure. Acquiring financing for CCS initiatives is particularly difficult in emerging areas like the APEC. Blended financing approaches that integrate public and private sector initiatives, along with CO_2 market mechanisms such as the Indonesia-Japan cooperative credit system, present novel funding alternatives.

Regulation is essential for the success of CCS, necessitating a meticulously crafted framework that aligns with domestic policies and addresses existing deficiencies. Effective regulation must consider technological, social, and economic considerations, with public acceptance being essential. The efficacy of CCS relies on ongoing innovation, effective finance, and robust regulatory frameworks. Dr Sidemen finished by highlighting the APEC region's capacity to spearhead CCS adoption, hence making substantial contributions to global emissions reduction and sustainability initiatives.

Session 6: Accelerating Cross-border CCS in Asia Pacific

Speaker: ***Ms Hanh Le (ANGEA)***

Ms Hanh Le of the Asia Network for Green Energy and Action (ANGEA) presented the seventh session of the workshop, entitled "Accelerating Cross-Border CCS in the Asia- Pacific." The session examined the notion of CCS, its significance for APEC economies, and the difficulties and opportunities related to its expansion across borders. Le examined how cross-border CCS could augment APEC's decarbonization initiatives by utilizing shared geological storage resources, prospects for cost-sharing, and regional collaboration. The session addressed the technical, financial, and regulatory dimensions of CO_2 transit and storage, highlighting the essential importance of policy harmonization to render CCS a scalable and economically viable solution across the area.

6.1 Cross-border CCS: Concept and Significance for APEC economies

Ms Le commenced by elucidating the notion of cross-border CCS, which entails the capture of CO_2 emissions from high-emission industries in one economy and their transportation to geologically appropriate storage locations in adjacent economies. This paradigm facilitates shared infrastructure, including CO_2 pipelines, storage facilities, and monitoring systems, which could transform regional initiatives to mitigate CO_2 emissions.

She emphasized the importance of cross-border CCS for APEC economies, particularly due to the region's substantial and expanding industrial sectors, which rank among the highest global CO_2 emitters. Industries including steel production, cement manufacture, and coal-fired power generation are crucial for APEC's economic development; however, they are significant contributors to greenhouse gas emissions. In numerous areas, achieving decarbonization by renewable energy or electrification is impracticable. Consequently, CCS technologies, especially cross-border CCS, offer a feasible approach to sustaining industrial activities while substantially reducing emissions.

Ms Le noted that cross-border CCS allows APEC economies to leverage their individual strengths. Certain economies possess extensive geological storage capacities, including offshore storage sites and saline aquifers, whereas others are significant industrial emitters yet lack appropriate storage options. Cross-border CCS enables the region to optimize resources and provide cost-effective, scalable solutions for CO_2 capture and storage.

6.2 Bilateral Agreement Recommendations for Cross-border CCS

Ms Le presented five essential proposals for bilateral agreements in cross-border CCS projects to guarantee clarity, equity, and adaptability. These proposals tackle the intricacies of cross-border CCS by taking into account the varied regulatory regimes, aims, and capabilities of the involved economies.

Clarifying the ownership rights to emission reductions is crucial. The alternatives consist of the capturing economy maintaining all rights, sharing Internationally Transferred Mitigation Outcomes (ITMOs) with the storage economy, or establishing joint ownership. These strategies guarantee mutual advantages from the emission reductions, fostering equity.

Emission Reduction Certification underscores the significance of transparency and data sharing to ensure accurate estimation and validation of emission reductions, allowing both economies to report their reductions in compliance with international norms.

The complexities of cross-border CCS require the development of arbitration bodies to ensure the swift resolution of disputes, hence preserving project momentum.

This concept designates regulatory responsibilities according to international boundaries or designated transfer locations, ensuring clarity in the management of CO_2's environmental effects and safety throughout transportation.

Jurisdictional accountability for leakage is clear measures for managing emissions from leakage during the CCS process ensure equitable and transparent accountability for both parties involved.

6.3 Overview of the Cross-border CCS Study

Ms Le presented a summary of the cross-border CCS study, emphasizing emission reduction units, ownership rights, cross-border transactions, and carbon monitoring, reporting, and verification (MRV). The study aims to tackle the problems and intricacies of cross-border CCS projects and offer advice on their implementation in accordance with international standards and domestic regulatory frameworks.

The study primarily concentrates on the development of emission reduction units, guaranteeing that reductions from cross-border CCS installations are precisely calculated and certified. The paper examines the difficulties of validating these reductions across various jurisdictions, particularly when they are distributed among economies. It examines the legal and operational dimensions of ownership rights, ascertaining whether the capturing economy retains exclusive rights or if both economies share the reductions.

The study underscores the significance of cross-border emission reduction transactions, providing direction for their management and accounting. It emphasizes the necessity for adequate monitoring, reporting, and verification (MRV) to guarantee that carbon captured and sequestered in cross-border CCS initiatives is thoroughly monitored and validated.

6.4 Options for Emission Reduction Ownership Rights

Ms Le proposed three alternatives for the ownership of emission reduction rights in cross-border CCS initiatives (Figure 10):

Single Ownership: The host economy retains exclusive rights to the emission reductions, enabling it to incorporate them into its Nationally Determined Contributions (NDCs). This uncomplicated alternative does not advantage the storage economy, which may perceive itself as marginalized from the ecological benefits.

Single Ownership with Trading: The capturing economy retains the rights but is permitted to generate ITMOs, which may be allocated to the storage economy. This arrangement establishes a financial motivation for the storage economy, although it may not correspond with the goals of the capturing economy.

Joint Ownership: The two economies collaboratively share emission reductions, adhering to a predetermined allocation for attribution reductions to their NDCs. This option enhances equity; however, it poses challenges in managing the risks of double counting and securing international acceptance.

These alternatives provide differing degrees of benefit distribution and adaptability, enabling economies to select the most suitable framework for their particular CCS initiatives.

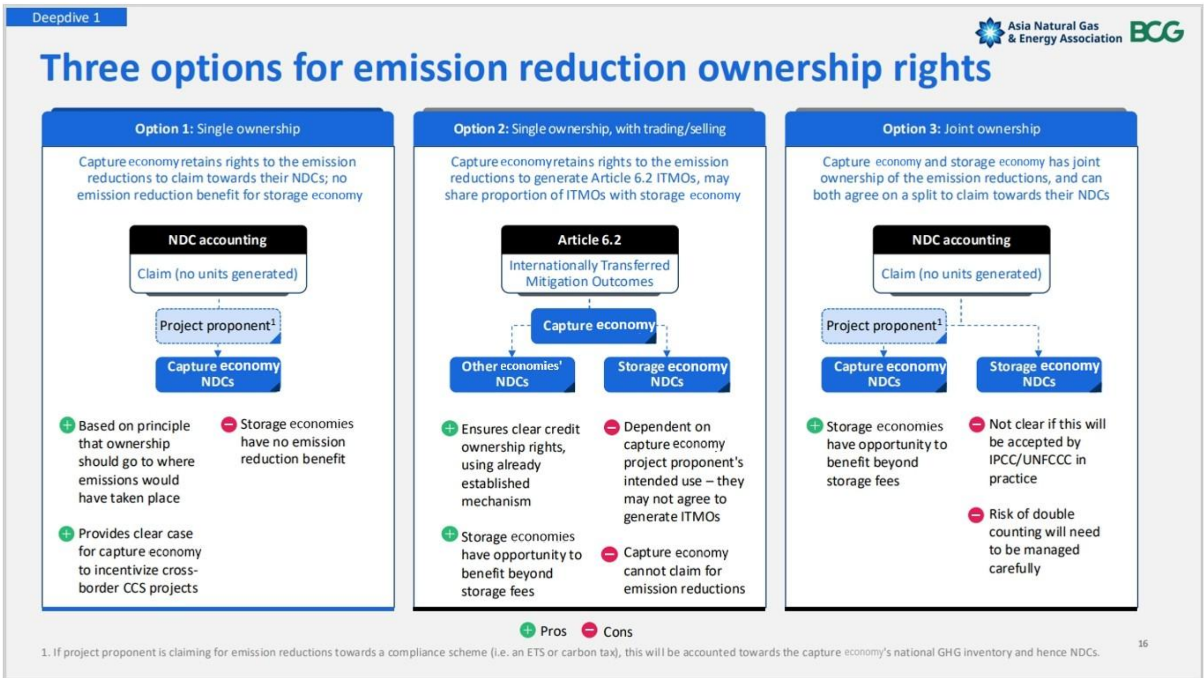

Figure 10: Ownership rights options

6.5 Managing CO_2 Leakage in Cross-border CCS Projects

Ms Le has examined strategies for addressing CO_2 leakage in cross-border CCS projects, specifically at the transfer point—when the accountability for emissions due to leakage transitions from the capturing economy to the storing economy. Leakage is a significant issue in CCS, as it can compromise emission reduction initiatives. Three prospective handover points were examined (Figure 11):

Transfer of Responsibility at the Border: Accountability shifts upon CO_2 entering the storage economy. This solution adheres to IPCC recommendations; nonetheless, it may provide difficulties in monitoring CO_2 movement and tracking emissions at the border.

Transfer of Responsibility at the Receiving Terminal: Accountability shifts upon the arrival of CO_2 at the terminal of the storing economy. This option streamlines operations but may not completely conform to IPCC requirements, and transportation-related leakage may be overlooked.

Responsibility shifts upon the injection of CO_2 into the storage location. This method conforms to MRV criteria but may impose a greater obligation on the capture economy for leakage that transpires prior to injection.

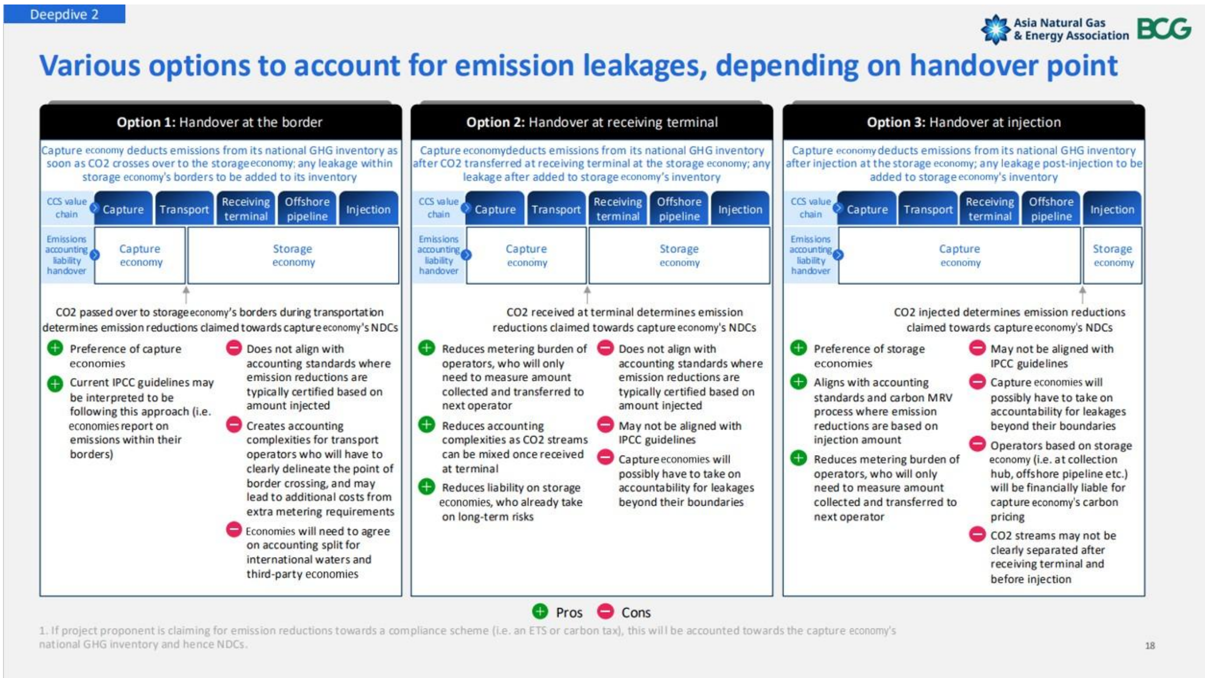

Figure 11: Handover point options

6.6 Key Takeaways and Conclusion

In conclusion, Ms Le's presentation on cross-border CCS underscored the significant potential for APEC economies to collaborate and leverage their complementary capabilities to enhance carbon capture and storage. By tackling essential challenges such as regulatory fragmentation, infrastructure enhancement, and financial investment, APEC economies may surmount obstacles to the extensive adoption of CCS via regional collaboration, policy alignment, and PPPs.

Effective collaboration might position APEC economies as worldwide frontrunners in carbon management, facilitating substantial advancements toward climate objectives while sustaining vital industrial operations with a diminished environmental impact. Cross-border CCS offers a pragmatic, scalable, and economical approach for the reduction of CO_2 emissions, facilitating the region's transition to a sustainable, low-carbon future.

Session 7: Panel Discussion – "State of CCUS Development and Future Directions for CCUS in APEC economies"

Moderator: ***Dr Piya Kerdlap (PXP Sustainability)***

Speakers: ***Mr Shintaro Tabuchi (METI)***

Ms Ju-Min CHENG (MOEA)

Ms Hanh Le (ANGEA)

The last session of the workshop was a panel discussion led by Dr Piya Kerdlap, concentrating on the present status of CCUS development in APEC economies and the prospective trajectories for CCUS implementation throughout the region. The group included prominent experts from Japan; Chinese Taipei; and ANGEA to examine CCUS technologies and investigate the problems and opportunities confronting APEC economies in the expansion of these technologies. The speakers include Mr Shintaro Tabuchi from Japan's Ministry of Economy, Trade, and Industry (METI), Ms Ju-Min Cheng from Chinese Taipei's Ministry of Economic Affairs (MOEA), and Ms Hanh Le from ANGEA. The discourse yielded critical insights about regional collaboration, the technical, legislative, and financial impediments to CCUS implementation, and the prospective framework for CCUS deployment in the APEC area.

7.1 Japan's CCUS Policy

Japan has established a prominent position in advancing CCUS technologies, with Mr Shintaro Tabuchi from the Ministry of Economy, Trade and Industry underscoring the economy's leadership in both research and implementation. Over the past decade, Japan has made substantial investments in CO_2 capture, transportation, and storage technologies, recognizing the urgent need to address high carbon emissions from key industries such as power generation, cement production, and steel manufacture. These sectors, where electrification and renewable energy alone are insufficient for full decarbonization, require innovative solutions like CCUS.

The Japanese government has played an essential role in promoting CCUS technologies, establishing ambitious objectives to collect and sequester CO_2 from major industrial polluters. One of the most notable initiatives is the Tomakomai CCS Demonstration Project, one of the largest of its kind globally, which has demonstrated the commercial viability of CCUS. This project captured CO_2 from coal-fired power reactors and transported it through pipes to offshore storage locations in the North Pacific, serving as a model for other APEC economies.

Japan's policy on CCUS is central to its broader strategy to achieve carbon neutrality by 2050. The economy has recognized that sectors like heavy industry and power generation cannot be fully decarbonized through electrification or hydrogen alone, which is why CCUS has become a critical tool in Japan's climate action plan. Japan's approach to CCUS is comprehensive, involving technological development, regulatory frameworks, business models, and international collaboration to establish a sustainable and scalable carbon management system.

A significant component of Japan's CCUS policy is its focus on technological development, particularly in CCS. Japan has heavily invested in research to improve CCS, especially in subsurface monitoring, numerical simulations, and fiber-optic monitoring to ensure the safety and effectiveness of CO_2 storage. The economy has focused on large-scale demonstration projects such as Tomakomai and Nagaoka, where CO_2 is injected into deep geological formations to test the technology's efficacy and assess its environmental impacts. These projects are crucial for refining the technologies needed for large-scale CCS deployment. Japan is also advancing sophisticated monitoring systems to track CO_2 movement, prevent leaks, and ensure the long-term stability of storage sites. This innovation lays the foundation for Japan's long-term CCS roadmap, which aims to establish a viable business environment for CCS by 2030 and achieve full-scale deployment by 2050, with an annual CO_2 storage capacity of between 120 and 240 million tons.

Integral to Japan's CCS strategy is the development of a robust regulatory framework. The CCS Business Act, passed in May 2024, plays a pivotal role in creating a stable and safe environment for CCS operations in Japan. This legislation outlines regulations for CO_2 capture, transportation, and storage, ensuring businesses comply with stringent safety standards. Furthermore, it facilitates international collaboration by enabling Japan to export CO_2, following the amendment of the London Protocol in 2024. This development not only strengthens Japan's domestic CCS capabilities but also positions it as a global leader in CCUS, promoting the exchange of knowledge and best practices across borders. The CCS Business Act is part of a broader effort to create a comprehensive business model for CCS, covering the entire value chain—from capture to transportation to storage.

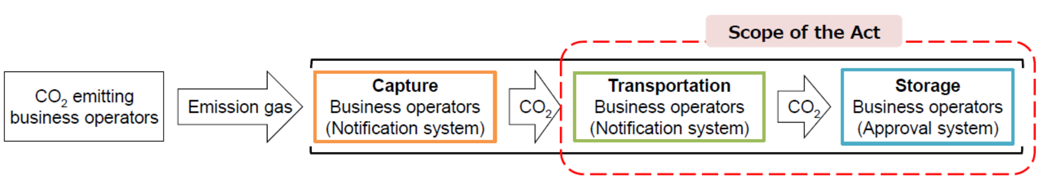

Figure 12: CCS Business Act

The Japanese government plays an essential role in supporting CCS technology deployment through initiatives like the Advanced CCS Program. This program seeks to create cross-sectoral business models for CCS and supports various industries, including thermal power plants, steel manufacturing, cement production, and hydrogen production. Government funding for these projects covers not only CO_2 capture and transport but also the development of storage solutions. This financial support is crucial for reducing the costs associated with CCS, making it more economically viable, and encouraging private-sector investment. Additionally, Japan is allocating significant resources—USD3.9 billion—through the Green Innovation Fund to develop advanced CO_2 capture technologies and carbon recycling processes, such as the production of synthetic fuels and low-carbon cement.

Japan's commitment to Carbon Recycling is another key aspect of its CCUS strategy. The Carbon Recycling Roadmap lays out Japan's goal of commercializing CO_2 utilization technologies by 2050. This roadmap includes developing synthetic fuels, such as sustainable aviation fuel (SAF), and enhancing methane synthesis processes. Japan is also exploring the potential of using CO_2 to produce green LPG and developing new concrete and cement production processes that capture CO_2 emissions. The Japanese government has committed to fostering a vibrant carbon recycling ecosystem, with funding aimed at reducing costs and improving efficiency. Through these efforts, Japan not only seeks to reduce emissions but also to create new industries and economic opportunities by transforming CO_2 into valuable products.

Lastly, Japan's commitment to international cooperation is a vital element of its CCUS strategy. The economy actively participates in international forums such as the Asia CCUS Network Forum and the International Conference on Carbon Recycling, where it shares its technological advancements, policy insights, and best practices with other economies. Japan's participation in these multilateral platforms promotes knowledge exchange and facilitates the global scaling of CCUS technologies. By collaborating with other economies, Japan aims to overcome the technical and financial barriers to CCUS deployment and ensure that these technologies can be scaled rapidly to meet global climate targets.

In conclusion, Japan's approach to CCUS is comprehensive and multifaceted, combining technological innovation, strong regulatory frameworks, significant government support, and international collaboration. These efforts are key to realizing Japan's ambitious carbon neutrality goals and positioning the economy as a leader in global efforts to combat climate change.

7.2 Chinese Taipei's CCUS Strategies and Future Plans

Chinese Taipei, represented by Ms Ju-Min Cheng from the Ministry of Economic Affairs (MOEA), has been making significant strides toward adopting CCUS technologies as part of its strategy to combat climate change. While Chinese Taipei has not yet implemented CCUS on the scale of economies like Japan or Australia, the government has recognized the critical role CCUS can play in reducing carbon emissions from hard-to-abate sectors, particularly those that are energy-intensive, such as power generation, cement production, and chemicals manufacturing. These sectors are key to Chinese Taipei's industrial economy but are also major contributors to the economy's carbon footprint. Chinese Taipei's existing power generation facilities predominantly rely on fossil fuels, including natural gas and coal, making the transition to renewable energy challenging. As a result, CCUS has emerged as a viable solution to mitigate emissions in these industries, where electrification or renewable energy alone is insufficient.

Chinese Taipei's CCUS efforts align with its broader energy transition strategy launched in 2024, which emphasizes enhancing energy efficiency, diversifying renewable energy sources, and fostering international collaboration to accelerate the deployment of new energy technologies. The economy aims to meet ambitious carbon reduction targets for 2030 and 2032, as outlined in its third Nationally Determined Contribution (NDC) announced in 2025. Within this framework, CCUS plays a vital role in decarbonizing Chinese Taipei's energy-intensive sectors and contributing to the domestic goal of achieving net-zero emissions by 2050.

The Chinese Taipei government has initiated several pilot CCS projects to test the feasibility and safety of CO_2 storage. These pilot projects are primarily focused on power generation and industrial sectors. For instance, Chinese Taipei power has begun a pilot project at its Taichung Power Plant, aiming to capture up to 2,000 tons of CO_2 annually. In addition, Chinese Petroleum Corporation (CPC) has launched a project in Miaoli, where CO_2 is being injected into saline aquifers for storage. These projects are crucial for testing the efficiency and safety of CCS technologies and are laying the foundation for future large-scale CCS deployment in Chinese Taipei. The National Science and Technology Council (NSTC) is also heavily involved in assessing suitable geological formations for CO_2 storage. Chinese Taipei's western region, with its stable geological conditions and sedimentary basins, is seen as having significant potential for CO_2 sequestration. Preliminary assessments suggest that the region could safely store up to 46 billion tons of CO_2—a potential that, if verified, could make Chinese Taipei a significant player in global carbon storage efforts.

However, despite the promising geological capacity and technological advancements, several challenges need to be addressed before Chinese Taipei can scale up CCS to meet its climate goals. Public acceptance remains one of the largest hurdles. There are concerns regarding the safety of CO_2 injection and the long-term stability of storage sites. To overcome these challenges, the government is working on enhancing public awareness through transparent communication, emphasizing the safety of CCS technologies, and involving communities in the decision-making process. Public trust and understanding will be key in successfully deploying CCS at the national level.

Another challenge is securing the necessary financial and technical resources for large-scale CCS projects. While Chinese Taipei has made progress through its pilot initiatives, scaling up CCS technologies requires significant investments in infrastructure, technology, and expertise. Chinese Taipei is working closely with international partners to gain insights into best practices, technologies, and funding mechanisms that can help accelerate the deployment of CCS. These partnerships will be crucial as Chinese Taipei aims to build the technical capabilities needed for industrial-scale CCS operations.

Chinese Taipei’s CCS strategy is structured around a clear timeline for deployment, which spans from 2023 to 2050. In the short term (2023-2030), Chinese Taipei will focus on completing experimental projects, including pilot injections and establishing the necessary regulatory frameworks for CCS. During the medium term (2030-2040), the focus will shift to scaling up integrated CCS demonstrations and developing the infrastructure needed to support large-scale CCS operations in industrial sectors. The long term (2040-2050) will see the deployment of CCS technologies for energy and industrial applications, including large-scale offshore storage operations.

Ultimately, the success of Chinese Taipei's CCS efforts will depend on continued government support, technological innovation, public engagement, and international collaboration. The economy’s CCS strategy is not only a crucial component of its broader energy transition plan but also a model for other economies in the Asia-Pacific region. Through ongoing research, public outreach, and the development of a strong regulatory and business framework, Chinese Taipei is positioning itself as a future leader in CCUS technologies. With continued investment and collaboration, Chinese Taipei’s CCS initiatives can play a pivotal role in helping the nation meet its carbon reduction goals and contribute to global efforts to combat climate change.

7.3 Panel Discussion

The panel discussion on CCUS offered significant insights into the critical elements, problems, and prospects related to these technologies. Specialists from various locations articulated their viewpoints, emphasizing the essential components of the success of CCUS projects, public perception, and the economic factors associated with the expansion of these technologies. A primary topic of discussion was the significance of integrity in CCUS systems. Ms Hanh Le underscored that although all elements of CCUS—capture, transport, and storage—are essential, the integrity of CO_2 injection and storage is of utmost importance. The secure storage of CO_2 and the prevention of leakage immediately affect the safety and efficacy of the entire process, therefore influencing public confidence and the success of the project.

Ms Ju-Min Cheng emphasized that public approval is crucial for the success of CCUS initiatives, particularly in densely populated regions, such as Chinese Taipei. She emphasized that fostering public awareness and comprehension of the technology is crucial for obtaining social license to operate, necessitating significant outreach and educational initiatives to enhance public perception. A persistent issue in the discourse was the necessity of effective public communication, with Ms Le contending that CO_2 should be redefined as a resource for decarbonization and industrial use rather than as trash. Altering the story to highlight economic advantages, such as job creation and technological progress, may enhance public acceptability. Transparency was emphasized as a crucial element, necessitating public comprehension of emissions tracking, leak management, and implemented safety protocols.

Economically, although the deployment of CCUS technologies entails considerable expenses, there are enormous prospects for the emergence of new industries and employment development. Nonetheless, achieving financial viability for CCUS in enterprises presents a problem, necessitating governmental assistance, carbon pricing strategies, and industry incentives. Mr Shintaro Tabuchi highlighted the financial challenge, emphasizing that the substantial investment required for CCS infrastructure necessitates clear legislative frameworks and sustained government support to encourage private sector investment.

The panel addressed the significance of global cooperation in the advancement of CCUS technologies. Mr Tabuchi provided insights into Japan's achievements in large-scale CCS projects and how its experience may serve as a paradigm for other economies in the region. Disseminating knowledge, optimal practices, and insights gained would facilitate the expedited implementation of CCUS technologies worldwide. The panel recommended that further seminars concentrate on public communication techniques, prioritizing public engagement and the mitigation of safety and environmental issues. The development of innovative business models for CCUS was another focal point, aimed at aligning with diverse legislative and financial environments across regions, ensuring adaptation to local requirements and promoting private sector engagement. The panelists indicated a need to investigate cost reduction measures, as decreasing the expenses associated with capturing, transporting, and storing CO2 is crucial for the expansion of CCUS technology.

In conclusion, the panel discussion underscored the intricacies of CCUS initiatives and the necessity for collaborative efforts across multiple sectors to guarantee their success. CCUS has various obstacles, including the preservation of technological integrity, management of public perception, and acquisition of financing; however, it also holds considerable promise for climate change mitigation. Ongoing collaboration, clear communication, and supporting policies will be essential for integrating CCUS into global decarbonization initiatives. The continuing advancement of this technology necessitates global collaboration and collective expertise to fully realize its potential.

7.4 Key Takeaways and Conclusion

The principal conclusion from the panel discussion on CCUS is that the effective implementation and expansion of CCUS technologies hinge on addressing several interconnected factors, including technological reliability, public perception, and economic viability. Preserving the integrity of CO_2 injection and storage systems is a critical aspect. Securing CO_2 storage, minimizing leakage, and resolving transportation issues are critical to the success of any CCUS operation. Moreover, public acceptance is essential, particularly in highly populated areas where skepticism about new technologies is prevalent. Public communication initiatives are essential for cultivating trust, and reframing CO_2 as a useful resource for decarbonization instead of trash can enhance attitudes.

The economic viability of CCUS poses difficulties owing to the substantial upfront expenses associated with the deployment of these technologies. Nonetheless, significant prospects exist for employment development, industrial expansion, and revenue enhancement via governmental incentives. Transparent policy frameworks and ongoing support are essential to render CCUS financially attractive to private investors. Moreover, global collaboration is needed. Through the dissemination of knowledge and exemplary practices, economies can accelerate the use of CCUS technologies. Effective CCUS projects require continuous collaboration, transparency, and substantial financial and policy support to attain global decarbonization objectives.

Based on the workshop insights, the subsequent proposals are proposed:

1. Harmonize regulatory frameworks: APEC economies must align their regulatory policies regarding CCUS to facilitate coherent and efficient cross-border implementation. Standard laws for CO_2 transport and storage can alleviate legal and technological obstacles, promoting cross-border cooperation.
2. Allocate resources for infrastructure: APEC economies must invest in the development of critical infrastructure, including CO_2 transport pipes and storage facilities, to effectively expand CCUS technologies. Regional collaboration will facilitate the sharing of infrastructure expenses, enhancing the viability of individual economies' participation in extensive CCUS initiatives.
3. Financial incentives and support: Governments ought to provide financial incentives, including subsidies, tax credits, and carbon pricing mechanisms, to improve the economic feasibility of CCUS technologies. These incentives will draw private sector investment, which is crucial for mitigating the substantial capital expenses linked to CCUS implementation.
4. Augment knowledge exchange: Continuous knowledge dissemination and capacity-building programs within APEC economies are essential to guarantee that all members access best practices and technology innovations. Studying successful CCUS initiatives in other locations helps expedite implementation within the APEC region.
5. Foster PPPs: Collaboration between the public and private sectors is essential for addressing the financial and operational problems associated with growing CCUS. Governments can

facilitate collaboration by offering stable policy frameworks and financial support, while the private sector can propel innovation and technical advancement.

By implementing these recommendations, APEC economies can surmount obstacles to CCUS deployment, advance domestic climate objectives, and aid in the global struggle against climate change. Effective regional cooperation and the advancement of CCUS technology will facilitate the attainment of the SDGs and foster a sustainable, low-carbon future for the region.

Session 8: Conclusion

The APEC Workshop on CCUS Deployment and Development for Sustainable Development Goals emphasized critical methods and obstacles concerning the extensive use of CCUS technologies throughout APEC economies. The workshop brings together stakeholders, experts, and policymakers to examine the critical function of CCUS in alleviating climate change, especially for sectors that are challenging to decarbonize, like cement, steel, and chemical manufacturing. CCUS is considered a crucial mechanism for attaining net-zero emissions, facilitating the capture and secure sequestration of CO_2 from industrial sources.

A key conclusion from the debates was the necessity for regional cooperation among APEC economies to surmount current technical, regulatory, and budgetary obstacles. Numerous APEC economies encounter obstacles, including the elevated expenses of CCUS technology, disjointed regulatory frameworks, and inadequate infrastructure for CO_2 transit and storage. These challenges impede economies from executing extensive CCUS initiatives, and cooperation within APEC can assist in overcoming these barriers. The creation of cross-border storage networks, collaborative CO_2 pipelines, and standardized regulatory frameworks were considered essential methods for advancing CCUS implementation throughout the area.

A major technical difficulty addressed was the substantial expense associated with CO_2 capture technology and the requisite infrastructure for transporting and storing captured CO_2. Notwithstanding continuous progress in these domains, including the advancement of direct air capture technology and enhanced geological storage methods, the capital investments necessary for these initiatives remain excessively large. Governments and private investors must collaborate to establish financial incentives, subsidies, and funding channels that alleviate the economic strain on industries. PPPs were highlighted as a vital strategy for distributing financial risks and facilitating the ongoing advancement of CCUS technologies.

A significant topic discussed at the workshop was regulatory fragmentation, which hinders the execution of cross-border CCUS activities. APEC economies possess varied domestic legislation regarding CO_2 collecting, storage, and transportation, complicating the establishment of universal standards for cross-border initiatives. Experts advised APEC economies to develop synchronized regulatory frameworks to guarantee uniform safety standards, delineate long-term liability, and facilitate international cooperation in CO_2 transit and storage. This regulatory consistency is crucial for establishing the legal certainty required to attract private investments in CCUS projects.

The financial framework for CCUS was a primary subject of discourse. A significant obstacle to extensive implementation is the absence of definitive carbon price frameworks across APEC members. In the absence of a stable and substantial carbon price, CCUS technologies are unable to compete successfully with alternative emissions reduction strategies, including renewable energy and enhancements in energy efficiency. The workshop participants advocated for enhanced carbon pricing mechanisms, like elevated carbon taxes or emission trading systems (ETS), to increase the cost of CO_2 emissions and provide financial incentives for firms to engage in CCUS solutions.

Public engagement and education were recognized as critical components for the effective implementation of CCUS. Local communities frequently articulate apprehensions regarding the safety and environmental ramifications of geological CO_2 storage, particularly in densely populated regions. To foster public trust, governments and industry leaders must guarantee transparency, conduct educational initiatives, and deliver explicit information regarding the advantages and safety protocols related to CCUS technologies.

The session underscored the essential function of CCUS in attaining sustainable development and climate objectives for APEC economies. Regional collaboration, regulatory harmonization, financial incentives, and public involvement were recognized as crucial for surmounting the existing obstacles to

CCUS implementation. By emphasizing these measures and cultivating PPPs, APEC economies may expedite the implementation of CCUS technology, diminish CO_2 emissions, and spearhead the worldwide shift toward a low-carbon economy. By fostering improved collaboration and utilizing shared infrastructure, APEC may establish itself as a leader in CCUS implementation, serving as a global exemplar for climate action.

Appendix A: Agenda

AGENDA

Capacity building role on CCUS deployment and development

in APEC economies for Sustainable Development Goals

Venue: Pullman Bangkok King Power, Bangkok, Thailand
Eternity room, G floor

25-26 March 2025

DAY 1: TUESDAY, 25 MARCH 2025

TIME	DAY 1
09:00 (30 min)	**Welcome Address by Host (Thailand)** ● Speaker: ○ Mr Warakorn Brahmopala (Director General of Department of Mineral Fuels) ○ Mr Patpicha Ratanapreechachai (Project Overseer) ● Introduction to the workshop's objectives and vision ● Highlighting the importance of CCUS in the APEC region ● Photo group
09:30 (60 min)	**Keynote Speech (9:30 – 10:30):** *"The Role of CCUS in Achieving Net-Zero Targets"* ● Speaker: Alex Zapantis (GCCSI) ● Overview of global CCUS technologies, trends, future prospects, and the role of CCUS in achieving net-zero targets
10:30 (15 min)	BREAK
10:45 (75 min)	**Panel Discussion (10:45 – 12:00):** *"Global CCUS Landscape and Opportunities for APEC"* ● Moderator: Piya Kerdlap ● Speakers: ○ Danuwas Lambasara (PTTEP) ○ Vitaly Osokin (Chevron) ○ Somnath Kansabanik (Rystad) ● Assessing the current global CCUS landscape, opportunities, and potential in APEC economies ● Q&A

12:00 (90 min)	LUNCH
TIME	**DAY 1**
13.30 (60 min)	**Presentation 1 Technical Session (13:30 - 14:30):** *"Geological Storage of CO_2: Technical Advances and Challenges"* ● Speaker: Juan ZHOU (CERI) ● Presentation on state-of-the-art technologies and challenges in assessing geological formations for CO_2 storage in APEC economies. ● Q&A
14:30 (30 min)	BREAK
15:00 (60 min)	**Presentation 2 Policy and Regulation Session (15:00 - 16:00):** *"Regulatory Frameworks for CCUS: Best Practices and Challenges"* ● Speakers: Pedro Van Meurs ● Discussion on the development of international standards and regulations for CCUS deployment, as well as the legal barriers to cross-border CO_2 trading and carbon pricing. ● Q&A
16:00 (60 min)	**Summary of discussions and key takeaways**
18:00	**Welcome Dinner**
20:00	**END OF DAY 1**

DAY 2: WEDNESDAY, 26 MARCH 2025

TIME	DAY 2
09:00 (60 min)	**Keynote Speech 1 (9:00 – 10:00):** *"Energy Transition, with particular emphasis on low-carbon technologies"* ● Speaker: I Gusti Suarnaya Sidemen (ERIA) ● Discussion on carbon capture and storage (CCUS) policies, incentive measures, and other initiatives that can support the achievement of energy transition goals in the region

10:00 (30 min)	BREAK
TIME	**DAY 2**
10:30 (60 min)	**Presentation 1 (10:30– 11:30):** *"Accelerating Cross-border CCS in Asia Pacific"* ● Speaker: Hanh Le (ANGEA) ● Exploring how international partnerships can accelerate CCS projects through harmonized policy frameworks for cross-border CO_2 trading, addressing policy alignment challenges, permitting processes, and legal frameworks to facilitate seamless CCS operations across borders ● Q&A
11:30 (120 min)	LUNCH
13:30 (90 min)	**Panel Discussion (13:30– 15:00):** *"State of CCUS Development and Future Directions for CCUS in APEC economies"* ● Moderator: Piya Kerdlap ● Speakers: ○ Shintaro Tabuchi (METI) ○ Ju-Min CHENG (MOEA) ○ Hanh Le (ANGEA) ● Discussing current projects, challenges, and regional collaboration efforts in the development of CCUS ● Identifying challenges, opportunities, and pathways for CCUS deployment in APEC economies ● Q&A
15:00 (30 min)	BREAK
15:30 (15min)	**Summary of discussions and key takeaways**
15:45 (30 min)	**Closing Remarks (15:45 - 16:15):** ● Speaker: Mr Supawich Chaingam (Director of Mineral Fuels Management Division, DMF)
16:15	**Networking Session (16:15 - 17:00):**

(45 min)	Informal networking for participants to discuss collaboration opportunities further.
17:00	**END OF DAY 2**