Report

Bridging Ambition and Action: Malaysia's CCUS Journey

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The report *Bridging Ambition and Action: Malaysia's CCUS Journey* was developed by the **ASEAN Centre for Energy (ACE)** to explore the fiscal and regulatory landscape of CCUS in Malaysia, including ongoing projects, CCUS hub initiatives, key stakeholders, and the barriers and recommendations to advance the country's CCUS development.

This report was developed under the overall guidance and supervision of Dato' Ir. Ts. Razib Dawood, Executive Director of ACE. The development was led by Lintang Ambar Pramesti, with contributions from Aldilla Noor Rakhiemah, Muhammad Anis Zhafran Al Anwary, Bayu Jamalullael, Dwina Mahira Nahdi, Muhammad Zaidan, and Suwanto.

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Executive Summary

Carbon Capture, Utilisation and Storage (CCUS) is pivotal to Malaysia's climate strategy, as outlined in the National Energy Transition Roadmap (NETR). The roadmap identifies CCUS as a flagship technology essential for reducing emissions in hard-to-abate sectors and achieving net-zero targets by 2050.

To position itself as a regional leader in carbon capture and storage, Malaysia is advancing three pioneering initiatives: Kasawari, Lang Lebah, and BIGST. These projects aim to develop multiple storage hubs by 2030, significantly contributing to the country's climate goals.

A major milestone in Malaysia's CCUS journey was achieved in 2025 with the official enactment of the CCUS Act 2025 (Act 870), following royal assent from His Majesty Sultan Ibrahim, King of Malaysia. This landmark legislation provides the first comprehensive federal legal framework for CCUS in Malaysia, enabling greater regulatory clarity and investor confidence.

At the subnational level, Sarawak took early leadership by establishing its own regulatory framework through the Land Code (Carbon Storage) Rules in 2022, making it the first state in Malaysia to legislate for carbon storage activities.

Efforts are underway to align perspectives between federal and state authorities on CCUS regulations. Additionally, Malaysia is supportive of a harmonised regional framework for ASEAN, and engaging in international agreements to facilitate the smooth transportation of CO_2 across borders, reinforcing the country's commitment to cross-border CCS initiatives.

Image Source: Bay Bisdak's Images

South-East Asia's Energy Landscape: Trends and Projections

The Intergovernmental Panel on Climate Change (IPCC) has emphasised the urgent need for rapid and significant reductions in CO_2 and other greenhouse gas emissions to prevent global temperatures from exceeding the 1.5°C and 2°C limits set by the Paris Agreement [1]. Achieving net-zero emissions is crucial to slowing the rate of unprecedented global warming, particularly in regions with growing energy demands and a heavy reliance on fossil fuels.

South-East Asia, with its rapidly expanding economies, has long depended on fossil fuels as a primary energy source. By 2025, fossil fuels are expected to still account for approximately 76% of the region's total primary energy supply [2]. In Malaysia, this reliance is even more pronounced, with fossil fuels making up 96.6% of the country's energy supply and accounting for 84% of its electricity generation in 2023 [2].

Energy-related emissions in the region exceed 2,000 Mt CO_2-eq in 2023, and are projected to rise to over 5,000 Mt CO_2-eq by mid-century [3]. These emissions are predominantly driven by electricity generation (51%), industry (18%), and transportation (18%). In Malaysia, carbon emissions reached 291 million tons of CO_2 in 2022, reflecting the scale of the challenge [4]. Recognising the urgency of GHG emission reduction, nine out of 10 ASEAN Member States (AMS), including Malaysia, have committed to achieving carbon neutrality or net zero emissions [3], with Malaysia setting a target for net zero by 2050 [5].

To address these challenges, Malaysia is increasingly looking to CCUS technologies as one of the important tools [5]. CCUS has the potential to play a pivotal role in this balance, helping Malaysia achieve its net-zero goals by reducing carbon emissions, especially in hard-to-abate sectors. Additionally, the utilisation of captured CO_2 can stimulate the development of new industries, driving green growth and enhancing Malaysia's climate resilience [6].

Image Source: Pexels

CCUS: A Key Enabler for Malaysia's Net-Zero Ambitions

Malaysia's commitment to addressing climate change is evident in its updated Nationally Determined Contribution (NDC) [7], submitted in July 2021, which aims to reduce carbon intensity by 45% against GDP by 2030, as compared to 2005 levels. This enhanced ambition is supported by key policy frameworks, such as the 12th Malaysia Plan, the National Energy Policy (NEP) 2022-2040, and the National Energy Transition Roadmap (NETR).

The 12th Malaysia Plan (2021-2025) [5] reinforces the country's climate commitment by outlining a pathway toward long-term carbon neutrality. Aligned with the Prime Minister's vision of a low-carbon Malaysia by 2040 [8], with the potential to achieve net-zero GHG emissions [6] by as early as 2050. To achieve a 45% emissions reduction by 2030, it promotes enabling instruments such as carbon pricing to attract investment in green technologies, including CCUS.

As part of Malaysia's CCUS development, a regulatory framework has been established to govern national implementation and ensure compliance with international protocols, including transboundary CO_2 movement. A dedicated unit will be formed to oversee the planning, execution, and monitoring of CCUS activities. Over the next three decades, the CCUS industry is expected to attract investments ranging from US$200 billion to US$250 billion, creating an average of 200,000 jobs annually.

Malaysia's National Energy Policy (NEP) 2022-2040 [9] is a critical component of the country's climate strategy, recognising the pivotal role of CCUS in the transition towards a low-carbon economy. It underscores CCUS as a key technology for reducing GHG emissions, particularly from the oil and gas sector, which is essential for meeting the growing demand for sustainable energy production.

The policy highlights the importance of advancing CCUS technologies to extend the lifespan of Malaysia's indigenous oil and gas resources, while ensuring economic and environmental sustainability. It also promotes the integration of digital tools, such as data analytics, AI, and machine learning, to enhance operational efficiency and effectiveness. This strategic approach aims to boost value creation and cost competitiveness in the domestic oil and gas sector.

The New Industrial Master Plan 2030 (NIMP 2030) has made decarbonisation of the manufacturing sector a key Mission [10]. Under Mission 3: Push for Net Zero, CCUS is recognised as a potential solution for carbon abatement, particularly for the hard-to-abate sectors. CCUS is also regarded as a new growth sector which will bring about high economic benefits.

The National Energy Transition Roadmap (NETR) [6] provides a comprehensive framework for achieving Malaysia's ambitious climate targets, with CCUS is identified as one of six critical energy transition levers within this roadmap. Specifically, "CCS for Industry" is designated as a flagship project, underscoring its significance in reducing GHG emissions by an additional 5%, equating to 4.1 Mt CO_2-eq per capita.

The NETR sets ambitious CCUS targets, including the development of three hubs by 2030—two in Peninsular Malaysia and one in Sarawak—with a combined storage capacity of up to 15 Mtpa. By 2050, this is expected to expand to 40–80 Mtpa across three major hubs. The roadmap highlights CCUS as a driver of job creation, GDP growth, and industrial competitiveness. To support deployment, it calls for a strong policy and regulatory framework, including provisions for transboundary carbon movement.

Policy and Investment Framework

Budget 2023: Fiscal Incentives for Carbon Capture

The Malaysian government, recognising the pivotal role of Carbon Capture and Storage (CCS) technology in reducing GHG emissions, introduced a series of tax incentives in the 2023 Budget, to stimulate investment and participation in CCS activities. These incentives are designed to support companies that undertake in-house CCS activities, provide CCS services, or utilise CCS services, thereby fostering a robust CCS ecosystem in Malaysia [11].

Investment Tax Allowance (ITA):

One of the cornerstone incentives is the Investment Tax Allowance (ITA), which provides companies engaged in in-house CCS activities, or those offering CCS services, with a 100% allowance on qualifying capital expenditure. This allowance is available for a period of 10 years and can be offset against up to 100% of the company's statutory income, significantly reducing the tax burden and encouraging sustained investment in CCS infrastructure.

Import Duty and Sales Tax Exemption:

To further ease the financial barriers associated with CCS technology, the government has introduced an exemption from import duty and sales tax on equipment specifically used for CCS activities. This exemption is available from 1 January 2023, until 31 December 2027, making it more cost-effective for companies to acquire the necessary technology and thereby accelerating the adoption of CCS.

Tax Exemption on Statutory Income:

For companies providing CCS services, the budget offers a 70% exemption on statutory income derived from these services. This exemption is applicable for a 10-year period, providing a significant financial incentive for companies to enter the CCS market and actively contribute to Malaysia's climate goals.

Tax Deductions for Pre-Commencement Expenses and Service Fees:

Companies undertaking in-house CCS activities are permitted to deduct allowable pre-commencement expenses within five years from the date of initiating operations. Moreover, companies using CCS services can benefit from tax deductions on the fees incurred for these services, making the integration of CCS into their operations more financially viable.

Building the Legal Foundation: Storage Rights and Regulations

In Sarawak, Malaysia, the **2022 Land Code (Carbon Storage) Rules** governs carbon storage. This legal framework establishes guidelines for developing and managing carbon storage sites in both onshore and offshore areas, with a particular focus on storage licenses and permits.

Additionally, the **2023 Environment (Reduction of Greenhouse Gases Emission) Ordinance** complements this framework, by managing cross-sectoral carbon emissions in a variety of sectors, including oil and gas, energy, and others designated by the relevant authorities. This ordinance includes carbon storage as one of the carbon emissions reduction efforts. These two regulations are specific to the Sarawak region, having been enacted by the Sarawak government.

The 2022 Land Code (Carbon Storage) Rules

These rules authorise specific land areas in Sarawak to be used for storing "scheduled gases," such as atmospheric CO_2 and other greenhouse gases, which play a critical role in climate change mitigation. The regulations apply to petroleum operators, industrial companies, and non-residents who wish to store these gases, regardless of where the gases are sourced. Storage can occur in designated sites, including:

- **Abandoned petroleum sites**: Locations where petroleum production has ceased for more than 12 months, and no economically viable petroleum remains, either onshore or offshore.
- **Deep saline aquifers**: Underground layers of salty water suitable for safely holding greenhouse gases.
- **Coal seams**: Layers of coal that may be used for gas storage.
- **Other areas**: Additional onshore or offshore sites deemed suitable and safe for gas storage, as determined by the relevant authority.

Operators must first obtain a storage license to begin carbon storage operations. As stated in Section 32B (1) of the Land Code, this license is essential for engaging in carbon storage activities. After securing a storage license, operators need to apply for a storage permit specifically allowing the storage of scheduled gases on that land. This permit is available only to those who already hold a storage license.

For example, if an operator wants to repurpose an abandoned petroleum production site for carbon storage, they must first decommission their site following these steps:

1. **Notify the Director**: The operator must inform the Director of the abandonment and complete the decommissioning process within 12 months. If the site is part of an active production hub, the Director may allow for a delay in abandonment.
2. **Submit a Decommissioning Plan**: Operators must present a plan for approval and complete the decommissioning before handing over the site. They remain liable for any remaining issues and must cover all decommissioning costs. If they fail to comply, the Authority can appoint another party to handle the decommissioning and recover expenses.
3. **Site Handover and Future Access**: Once the site is handed over, operators can no longer access it without written consent. Although the site can be licensed for carbon storage, operators do not automatically gain rights to this license or permit.

Then, an operator must apply for a storage license to develop the land for carbon storage operations by following these steps:

1. **Complete the Application**: Fill out the application form and include all required documents:
    a. **For Onshore Land:** Provide a locality map certified by a licensed surveyor, an area plan for the potential storage site, audited financial statements for the last two financial years, and any additional documents requested by the Director.
    b. **For Offshore Land:** Submit a locality map that shows the location, including coordinates and approximate size, along with audited financial statements for the last two years and any other documents requested by the Director.
2. **Verification Process**: The submitted information will undergo a verification process, which may include providing additional requested information and a site inspection.
3. **Authority Review**: The authority will review the site's suitability, as well as the applicant's technical competence, financial stability and reliability. The authority has the discretion to approve or reject the application based on safety, suitability and public interest.
4. **Appeals**: If the application is rejected, applicants can appeal to the Majlis Mesyuarat Kerajaan Negeri, and the decision will be final.

The license will be registered and distributed to relevant authorities. Licensees can appoint qualified individuals as storage operators, but these appointments must be registered with the Superintendent. Licenses are non-transferable without written authorisation from the authority, and transferring controlling shares in a company that holds a license is considered a transfer of the license itself. In the event of a license transfer, any active storage permits under the former license will automatically be transferred to the new licensee under terms and conditions determined by the Authority.

Storage operators are responsible for the monitoring, maintenance, and safety of the storage site. They must report any damages or incidents, and the authority may require corrective actions. Licensees are accountable for ensuring compliance with all laws and license conditions by all parties involved, and they are liable for any damages caused by failures or negligence of associated parties. Regular reports on the site's condition, gas quantities, and incidents are required from storage operators, and the authority has the right to inspect storage sites.

In the case of any breach, the authority can revoke the license, giving the licensee an opportunity to respond. If revoked, the licensee must return the license and settle any outstanding dues. Upon expiration or revocation, a new license may be issued to another party, to ensure safe and continuous operation of the storage sites.

After obtaining the storage license, the operator (now referred to as the licensee) must apply for a storage permit to begin storage activities. The application process includes the following steps:

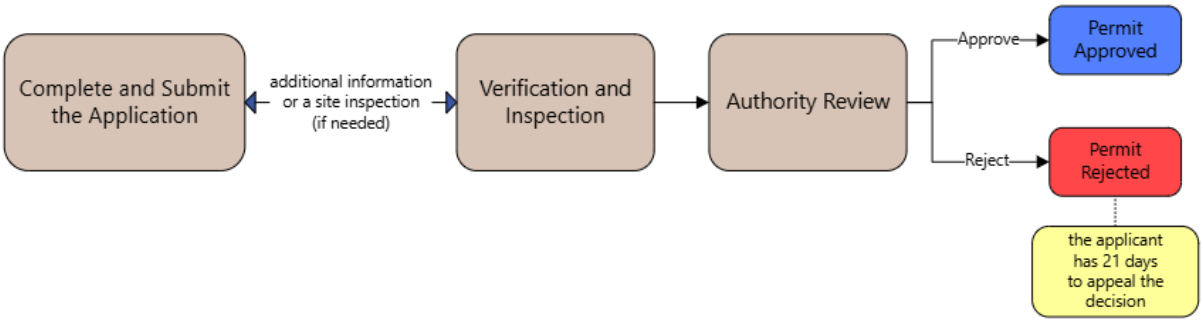

Figure 1: Process for Obtaining a Storage Permit for Carbon Storage Activities (Source: Authors)

1. **Complete and Submit the Application**: The licensee submits a comprehensive storage development plan to the Director, including:
    a. Names and addresses of storage users, license holder, and storage operator.
    b. A copy of the carbon storage license for the area.
    c. Details about the gases to be stored: quantity, start date of injection, injection rates/pressures, and gas composition.
    d. Proposed site capacity, preventive measures, monitoring and maintenance plans, and evidence of financial resources.
    e. Additional requirements:
        i. For onshore storage: A locality map from a licensed surveyor, an approved geological report, and information on any decommissioned petroleum sites, if applicable.
        ii. For offshore storage: A locality map with coordinates, an approved geological report, and a decommissioning plan with an undertaking to remove structures if necessary.
2. **Verification and Inspection**: The Director will verify the submitted application and may request additional information or conduct a site inspection if needed.
3. **Authority Review**: The Director will submit a report with the application for the Authority's review and decision.
4. **Permit Approval**: The Authority will approve the permit if the site is deemed suitable and safe, and the applicant is competent and financially secure.
5. **Appeal Process**: If the application is rejected, the applicant has 21 days to appeal the decision.

Upon approval, the Superintendent will issue the permit, outlining terms and conditions, and registering it. The permit will specify the location, nature and quantity of gases, operational requirements, monitoring plans, reporting obligations, closure conditions, and financial security provisions. Any changes to the permit must be approved by the Authority. Breaching permit terms, experiencing leaks, or encountering unsafe conditions may result in revocation of the permit, with the licensee receiving written notice and an opportunity to respond. The operator remains responsible for monitoring the site and containing any gas leaks until the site is safely closed or a new permit is issued.

When closing storage sites, the licensee must seek Authority approval and follow established post-closure plans. These plans include ongoing monitoring and corrective measures until the storage permit is terminated. The Authority may require financial contributions to cover post-closure costs, and permits can be terminated once all closure criteria are satisfied. Storage users remain liable for any outstanding debts, fees, or corrective actions until full closure is achieved. Costs incurred by the Authority due to user negligence can be recovered as civil debts.

The Environment (Reduction of Greenhouse Gases Emission) Ordinance, 2023

Another regulation enacted by the state government in Sarawak, titled the Environment (Reduction of Greenhouse Gases Emission) Ordinance, 2023. As required in its provisions, the ordinance shall be read as part of the Land Code (Carbon Storage) Rules, 2022, when dealing with decarbonisation in Sarawak.

This ordinance introduces a rigorous framework for managing cross-sectoral carbon emissions, including oil and gas, energy, and other sectors determined by the authorised institution (*Majlis Mesyuarat Kerajaan Negeri*). It outlines extensive requirements and guidelines designed to regulate and encourage the reduction of greenhouse gases.

According to **Article 6** of the ordinance, individuals and entities involved in economic activities on land or water, and in forest areas within Sarawak are required to submit a comprehensive carbon emission report within 90 days of registration. This report must conform to the most recent Greenhouse Gas Protocol standards or other approved reporting frameworks. The report should include:

- The GHG emission levels based on the scope set by the Board;
- Efforts to implement low-carbon solutions to meet prescribed emission thresholds;
- The quantity of greenhouse gases captured and stored, if applicable; and
- Any additional information as required by the Controller.

The Controller also has the power to require these reports to be verified by an accredited external auditor. Non-compliance, including failure to submit a report or submitting false information, may result in substantial penalties, including fines of up to 50,000 Malaysia Ringgit (MYR), imprisonment for up to one year, or both.

Article 9 outlines provisions for facilities not included in the scheduled economic sectors, to undertake voluntary greenhouse gas mitigation measures. Facilities that produce carbon emissions can seek to mitigate, reduce, abate, or **capture and store** these gases, to apply for Carbon Credit Units. Before initiating any such activities, facility owners or operators must notify the Board using a prescribed form. This notification must describe:

- The emission-generating process;
- The volume of gases intended for reduction or **capture**;
- The methods for emission reduction or abatement; and
- Storage sites for captured CO_2, and transport methods.

Activities may only commence once the prescribed form has been submitted to the Controller. Facilities must also provide annual reports on the utilisation and application of **captured gases**. These reports may be subject to verification by an accredited external auditor and, for Carbon Credit Units, by a Carbon Standard Administrator.

This ordinance underscores Sarawak's dedication to stringent environmental regulations, aiming to substantially reduce GHG emissions and foster sustainable practices, one of which is by means of CCS implementation (carbon utilisation is not specifically addressed by this legislation).

The Carbon Capture, Utilization and Storage Act 2025 (CCUS Act 2025)

The CCUS Act 2025 (Act 870) marks Malaysia's first national-level legal framework governing the capture, transportation and permanent storage of CO_2 [12]. The Bill was passed by both Houses of Parliament in March 2025, following royal assent by His Majesty Sultan Ibrahim, King of Malaysia, on 22 July 2025 and officially enacted into CCUS Act 2025 or Act 870 on 1 August 2025. The Act applies to Peninsular Malaysia and the Federal Territory of Labuan, but does not extend to the states of Sabah and Sarawak, which operate under separate legal jurisdictions [13].

To support the implementation of the Act, a dedicated Malaysia CCUS Agency will be established. This agency will comprise a Chairperson, the Secretary General of the responsible Ministry (likely the Ministry of Economy), the Director General of the Department of Environment, and up to six additional members appointed by the Minister.

The Agency will be tasked with overseeing, regulating, and promoting CCUS activities across the value chain. Its responsibilities include issuing permits, managing resources and funding mechanisms, advising the government, and ensuring compliance with the provisions of the Act. Additionally, the Agency may appoint a technically competent entity to advise on specialised areas, provided the entity demonstrates sufficient knowledge, skill, and experience in CCUS-related fields.

In general, the Act permits CO_2 captured both within and outside of Malaysia to be transported or imported for permanent storage at designated offshore or onshore sites in Malaysia. However, each stage of the CCUS value chain—capture, transport/import, storage assessment, and permanent storage—requires compliance with prescribed technical and environmental standards, and must obtain the relevant certificates and permits from the Agency.

Alongside the submission of documentation, operators are required to pay fees to obtain:

- Import permit
- Storage assessment (offshore & onshore)
- Storing license (offshore & onshore)

In addition, for each tonne of CO_2 injected into offshore storage, operators must pay a rate-based injection levy to the government. The details of how the Act regulates each stage of the CCUS value chain are presented in the table below.

The CCUS Act 2025 (Act 870) also establishes a **Post-Closure Stewardship Fund,** which will be administered and controlled by the CCUS Agency. The fund is financed through government allocations, injection levies collected from offshore storage operators, and earnings from investments, including interest income. Its primary function is to cover costs associated with post-closure monitoring and remediation of CO_2 storage sites.

However, subject to ministerial approval, returns from fund investments may also be used to support the broader development of Malaysia's CCUS industry. The Agency is authorised to invest any unused portions of the fund, but such investments require prior approval from both the Minister and the Minister of Finance. To ensure transparency and accountability, the Agency must maintain proper financial records, prepare annual audited statements, and report regularly to the Minister.

Table 1 Directions on CCUS activities based on the CCUS Act 2025 (Act 870)

	Capture	Transport	Import	Utilisation	Storage	Closure and post-closure
CO_2 handling	For domestic CO_2 capture activity	By road, rail, water, pipeline, or other means	• Importing for permanent storage purposes from outside Malaysia • By road, rail, water, pipeline, or other means	• Captured domestically • Prohibited to use imported CO_2 for permanent storage purpose	Offshore or onshore storage site	To get the closure certificate, operators shall fulfil these obligations: • Monitor and report monitoring results to the agency • Doing corrective, remediation, or other prescribed activities The obligations will be transferred to the government after: • A prescribed period has lapsed after the closure certificate was issued • Other prescribed conditions in the closure certificate have been fulfilled
Requirement	Own or operate any carbon capture installation	• Compliance with any other written laws related to transportation • Compliance with the **prudent CCUS practices**	• Compliance with the **Stream Acceptance Criteria** • Compliance with the import permit	-	• Compliance with the **Stream Acceptance Criteria** • Fulfil the **operational obligations of the storage operator**	
Application needed (to the Agency)	Registration	Registration	Import permit	Registration	Storage assessment permit and license	Closure certificate, Transfer of Obligation Certificate
Required Payment (Fee)	-	-	Fee for import permit	-	• Fee for assessment permit • Fee for storage license • Injection levy for offshore storage activity	-

Table 2 Information on Prudent CCUS Practices, Stream Acceptance Criteria, and Obligation for Storage Operator in CCUS Act 2025 (Act 870)

Prudent CCUS Practices	CO_2 Stream Acceptance Criteria	Operational Obligation of Storage Operator

These refer to methods, measures, and standards commonly adopted by the global CCUS industry at the relevant time. They include:
• Requirements set by the Minister after consultation with a competent technical entity,
• Guidelines issued by the competent technical entity, and
• Standards from recognised national or international bodies.
These practices represent the expected level of care and performance in conducting CCUS activities safely and responsibly.
	To be accepted for transport and storage under the CCUS Act 2025 (Act 870), a CO_2 stream must meet the following conditions:
	• **Composition**: Must consist overwhelmingly of CO_2 and comply with prudent CCUS practices. No waste or other substances may be intentionally added.
	• **Incidental Substances**: May contain trace substances that are unavoidably associated with capture, provided they:
	  ○ Do not pose significant risk to storage site or transport infrastructure integrity,
	  ○ Do not endanger human health or the environment,
	  ○ Do not breach any applicable Malaysian laws.
	• **Record-Keeping**: Operators are required to maintain accurate records of the quantity and composition of each CO_2 stream.
		Under the CCUS Act 2025 (Act 870), licensed storage operators are require to:
		• Provide relevant information to assess their compliance with the offshore storage license conditions
		• Conduct monitoring of the storage complex and its surrounding environment, and prepare monitoring plan
		• Implement corrective and remediation measures in the event of any leakage or significant irregularity.
		• Submit monitoring reports and related findings to the CCUS Agency in accordance with regulatory requirements.

From Vision to Reality: Groundbreaking CCS Projects

Malaysia is making significant strides in CCS technologies, with three major projects leading the charge. These initiatives—Kasawari, Lang Lebah, and BIGST—are critical components of the country's efforts to reduce carbon emissions and promote sustainable energy production. Each project involves advanced technology and extensive collaboration, positioning Malaysia as a key player in the global CCS arena.

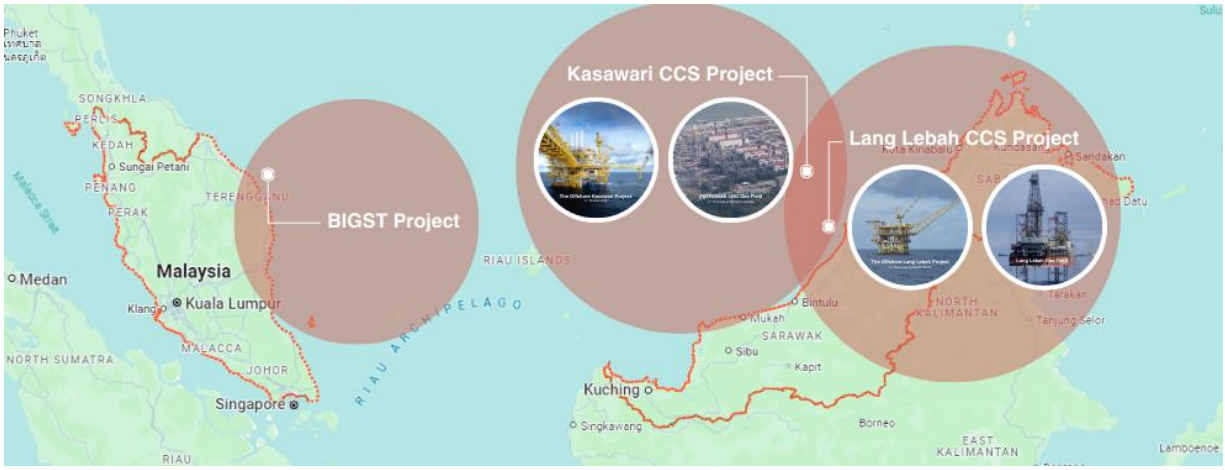

Figure 2: CCS Projects in Malaysia (Source: Authors)

Table 3: Summary of CCS Projects in Malaysia

Project	Kasawari	Lang Lebah	BIGST
Entity	PETRONAS Carigali	PTTEP, KUFPEC, PETRONAS Carigali	JX Nippon (now ENEOS Explora), PETRONAS Carigali
Overview	Commercial operation starts in 2025	Expected to begin in 2028	No specified schedule yet
	Capturing 3.3 Mtpa CO_2 from high CO_2 content of 30% to 40% in the SK316 block, offshore from Sarawak	Depleted gas wells in the Golok gas field, located offshore Sarawak	Bujang, Inas, Guling, Sepat, and Tujoh (BIGST) gas fields, located offshore Kerteh, Terengganu
	All gas processing and CO_2 recompression offshore on a dedicated platform	CO_2 sourced from high CO_2 gas fields	CO_2 Sourced from high CO_2 ranging from 28% to 80%
Status	Towards investment decision	FID delayed until at least 2026	Collaboration agreement signed in 2022

Source: [14], [15], [16]

The **Kasawari CCS Project**, led by PETRONAS Carigali, is located off the coast of Sarawak, approximately 200 kilometres from Bintulu. As Malaysia's first offshore carbon capture initiative, it aims to capture up to 3.3 million tonnes of CO_2 annually from natural gas production, and is tentatively scheduled to have the first injection by the end of 2029 or early 2030.

The project, installed at a water-depth of 108 meters, will deploy energy-efficient gas turbines and PETRONAS' proprietary membrane technology to minimise emissions [17]. With key contractors like MMHE, NPCC and Baker Hughes, this project will be one of the largest offshore CCS efforts globally [18].

The Kasawari CCS Project stands out as one of Malaysia's most ambitious carbon capture initiatives. The project is part of the broader Kasawari Phase II development, which focuses on capturing and storing CO_2 emissions from natural gas production—a major source of greenhouse gases in the Eastern Malaysia region.

To enhance the efficiency and sustainability of the operation, PETRONAS plans to employ PGT25 and PGT25+ gas turbines, featuring Dry Low Emission Technology, which minimises nitrogen oxide emissions. Additionally, PETRONAS will deploy its proprietary PN2 Hollow Fibre Membrane and Cryomin cryogenic distillation technology, specifically designed for high CO_2 concentrations [19].

The development of the Kasawari CCS Project is supported by key contractors, such as Malaysia Marine and Heavy Engineering (MMHE), the National Petroleum Construction Company (NPCC), and Baker Hughes. MMHE is responsible for Engineering, Procurement, Construction, Installation, and Commissioning (EPCIC) services, while Baker Hughes will provide the necessary carbon dioxide compression equipment. McDermott will handle the offshore installation of the pipeline and platform jacket.

Figure 3: Kasawari CCS Project (Source: offshore-technology.com)

The **Lang Lebah CCS Project** is closely tied to the Lang Lebah gas field, which is located about 90 kilometres off the coast of Miri, Sarawak. The field holds an estimated 5 trillion cubic feet of gas, and production is expected to begin by 2027, with a goal of producing 1 billion cubic feet of gas per day. This project will manage the high levels of carbon dioxide and hydrogen sulphide present in the gas. The captured CO_2 will be stored in the depleted Golok Field [20].

Lang Lebah CCS Project is situated in Block SK410B. The development of the Lang Lebah Field is meticulously planned to address both resource extraction and environmental sustainability. The extracted gas will be transported via pipeline to an onshore processing facility located in the Petchem Industrial Park in Tanjung Kidurong, Bintulu, Sarawak. Technip Energies was awarded the Front-End Engineering Design (FEED) contract for this facility in October 2022, which will handle the carbon capture, compression, and transportation processes.

The offshore component of the Lang Lebah CCS Project includes two jacket-based wellhead platforms, a central processing platform, a flare platform, two bridges, and a 42-inch subsea trunkline, supported by a network of intra-field pipelines. The FEED contract for these offshore facilities was awarded to Perunding Ranhill Worley in July 2022 [21]. This extensive infrastructure will ensure the effective management of the CO_2 captured during gas production, contributing to Malaysia's broader carbon reduction goals.

As part of the Sarawak Integrated Sour Gas Evacuation System (SISGES), the Lang Lebah CCS Project is instrumental in expediting the development of untapped sour gas resources off the coast of Sarawak [21]. The project aligns with PTTEP's strategy to decarbonise the energy sector and achieve Net Zero emissions by 2050.

Figure 4: Lang Lebah CCS Project (Source: offshore-technology.com)

The **BIGST CCS Project** represents a pioneering collaboration between JX Nippon Oil & Gas Exploration Corporation and its subsidiary, JX Nippon Oil and Gas Exploration (BIGST) Sdn. Bhd., under a Production Sharing Contract (PSC) with PETRONAS and PETRONAS Carigali Sdn. Bhd. This project marks a significant milestone as the first CCS project in Peninsular Malaysia.

The project focuses on developing the offshore Bujang, Inas, Guling, Sepat, and Tujoh gas fields. These fields hold around 4 trillion standard cubic feet of gas, but have been challenging to develop due to high CO_2 concentrations [14]. By incorporating CCS technology, the project will separate and inject CO_2 into a depleted gas field, following the model set by the Petra Nova CCS project in Texas [22].

Mapping Future Potential: Malaysia as An CCS Hub

Malaysia is strategically positioning itself as a pivotal player in CCS/CCUS within the region, with significant targets outlined in the National Energy Transition Roadmap (NETR) [23]. The NETR sets ambitious goals for CCUS development over the coming decades, reflecting Malaysia's commitment to achieving its Net Zero Carbon Emissions (NZCE) targets, and contributing to regional decarbonisation efforts.

By 2030, Malaysia aims to develop three CCUS hubs: two in Peninsular Malaysia and one in Sarawak. These hubs will collectively have a storage capacity of up to 15 million tonnes per annum (Mtpa). By 2040, the roadmap envisions the establishment of one additional carbon capture hub, expanding the total storage capacity to between 15 Mtpa and 40 Mtpa. Looking ahead to 2050, Malaysia plans to develop three more carbon capture hubs, with a total storage capacity projected to reach between 40 Mtpa and 80 Mtpa.

Collaborative studies, including those led by PETRONAS, have identified key clusters for CCS development to achieve Malaysia's ambitious targets. These clusters are designed to efficiently capture, process, and store CO_2 from various industrial sources, including both domestic and foreign emissions. The proposed clusters are:

- **Northern Cluster (Peninsular Malaysia)**: Centred around Kerteh, a prominent industrial area known for its petrochemical industries. This cluster will capture industrial CO_2 emissions at the Kerteh Hub. The CO_2 will be transported to the Kerteh Terminal, which will also receive CO_2 from international sources via liquefied CO_2 (LCO_2) carrier ships. All captured CO_2, both domestic and foreign, will then be transported by pipeline to an offshore storage site.
- **Southern Cluster (Peninsular Malaysia)**: Based in Kuantan, a major port city and logistics hub. This cluster will manage CO_2 from industrial emitters sent to the Kuantan Terminal. Similar to the Northern Cluster, this terminal will also accept foreign CO_2 via LCO_2 carrier ships, and the CO_2 will be transported by pipeline to an offshore storage site.
- **Eastern Cluster (Sarawak)**: Located in Bintulu, a significant centre for the energy sector, particularly in natural gas production. This cluster will capture and process CO_2 at the Bintulu Hub. The CO_2 will be sent to the Bintulu Terminal, which will accommodate both domestic and foreign CO_2 from LCO_2 carrier ships. The CO_2 will then be transported via pipeline to an offshore storage site. PETRONAS' flagship project, the Kasawari CCS Project, might be part of this cluster.

Innovation Ecosystem: Key Players and Partnerships

In Malaysia, the development of CCS is supported by public sector entities, private companies, and academic institutions. The involvement of these entities can be categorised into three main groups: Climate Change and Energy Transition Strategy, Research and Development (R&D), and Business Development [19].

Climate Change and Energy Transition Strategy

Malaysia's climate change and energy transition strategies are guided by the National Strategy for Climate Change, such as the Nationally Determined Contributions (NDC), developed by the Ministry of Natural Resources and Environmental Sustainability (*Kementerian Sumber Asli dan Kelestarian Alam*). Additionally, the National Strategy for Energy Transition is formulated by the Ministry of Energy Transition and Water Transformation (*Kementerian Peralihan Tenaga dan Transformasi Air* - PETRA). These strategies emphasise the importance of reducing greenhouse gas emissions and transitioning to sustainable energy sources, making CCS/CCUS a critical component in achieving these goals.

Research and Development (R&D)

CCS research and development are primarily supported by the Malaysian Science and Technology Information Centre (MASTIC) [25], a key department under the Ministry of Science, Technology, and Innovation (MOSTI). MASTIC's role is to collect, manage, and disseminate strategic information related to science, technology, and innovation (STI) activities in Malaysia.

In the academic sector, Universiti Teknologi PETRONAS (UTP) makes significant contributions through its Institute of Contaminant Management (ICM) [26], which conducts R&D for CCS. One of their focus areas is CO_2 separation, managed by the CO_2 Research Centre (CO_2RES) [27], which develops absorption systems and membrane materials [28].

A notable innovation in Malaysia's CCS landscape is PETRONAS' [29] Membrane Contactor (MBC) technology, which addresses many challenges faced by traditional CCS systems. The MBC technology features a compact design that increases the mass transfer area by more than 20 times, reducing the system's height by 75% and weight by 40%, whilst also cutting solvent usage by 25%. This modular and scalable technology simplifies operations and is versatile enough to work with various solvents, making it adaptable to different market needs [30].

The MBC technology excels in CO_2 separation, achieving a capture efficiency of over 95%, which significantly reduces solvent usage and energy consumption during regeneration. PETRONAS has also integrated cost-effective design enhancements, such as shorter columns and improved solvent circulation, further lowering the costs associated with CO_2 capture [30].

The Ministry of Investment, Trade, and Industry (MITI) of Malaysia is spearheading the implementation of the National Carbon Capture (NCC) Project, a flagship initiative under Mission 3 of the NIMP 2030. This project utilises PETRONAS' MBC technology to develop a carbon capture pilot plant for high-emitting industries as part of building a domestic CCUS ecosystem.

Regulatory Agency

CCUS activities in Peninsular Malaysia and Federal Territory Labuan will be govern under the CCUS Act 2025 (Act 870). The Act establishes Malaysia CCUS Agency as the regulatory body to administer the Act.

In the State of Sarawak, both the Economic Design Unit (UPEN) Sarawak and the Ministry of Energy and Sustainability, through Petroleum Sarawak (PETROS) [31], regulate onshore oil and gas resources and oversee the state-owned oil and gas company.

In the State of Sabah, the delegation of UPEN, through Sabah Maju Jaya (SMJ) [27], is responsible for similar functions. State-owned companies like PETRONAS, PETROS, and SMJ are actively involved in CCS projects, often in collaboration with private companies and other entities through Memorandums of Understanding (MoUs).

Utilisation Catalysing New High-Growth High-Value Economy

Malaysia's pathway to net zero must deploy both CCS and CCU. While geological storage is essential, CO_2 utilisation (CCU) creates monetisable demand by converting captured CO_2 into products and services, which in turn may lower the cost of capturing carbon. The International Energy Agency (IEA) classifies CO_2 utilisation into six application families: construction materials (carbonated aggregates/concrete); synthetic fuels (e-fuels, methanol); chemicals (CO, syngas, formic acid); polymers; carbon additives (e.g., nanotubes, carbon black); and ingredients (e.g., single-cell proteins, lipids).

Globally, CO_2 use is around 230 $MtCO_2$/year, dominated by urea (~130 Mt) and Enhanced Oil Recovery (~80 Mt); New utilisation pathways in the production of CO_2-based synthetic fuels, chemicals and building aggregates could reach just under 15 $MtCO_2$/year by 2030, including ~8 $MtCO_2$/year to synthetic fuels [33].

Malaysia is placing considerable focus on utilising captured CO_2 as part of completing the CCUS cycle. The aim is to turn captured CO_2 into commercially valuable products—focusing on bio-based materials, CO_2-enriched agriculture, and synthetic fuels—applications that can generate near-term market value while advancing Malaysia's long-term low-carbon industrial transition, and at the same time strengthen the technical expertise, infrastructure, and market linkages required for future large-scale deployment.

This approach enables tangible economic returns, strengthens capabilities in CO_2 capture and conversion, and ensures that utilisation becomes one of the core drivers of Malaysia's low-carbon, high-value economy.

Tenaga Nasional Berhad (TNB) is at the forefront of developing innovative carbon capture and utilisation (CCU) projects, implementing integrated solutions to reduce emissions from Malaysia's thermal power plants—one of the key challenges in the transition to a low-carbon future.

In line with its net zero emissions goal, TNB aims for advanced CCU technologies to contribute 30% towards reducing its emissions intensity by 2050. The strategy focuses on two primary pathways: carbon capture, using advanced bio-based and chemical systems for efficient CO_2 absorption, and carbon utilisation, applying biological and hydrogenation processes to transform captured CO_2 into high-value products as shown in **Figure 5**.

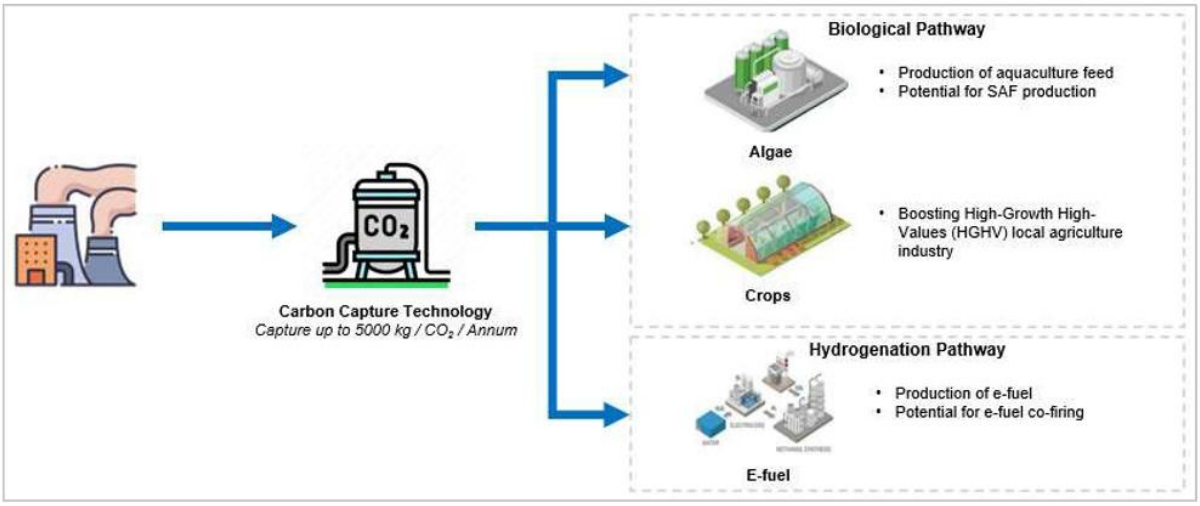

Figure 5: Conceptual Solution for Carbon Capture and Utilization [34]

Since 2011, TNB has carried out numerous CCU initiatives. These efforts focus on capturing CO_2 from large point sources, then converting it into high-value products through biological and chemical pathways, supporting both decarbonisation and economic diversification. The key initiatives are:

- **Project Bloom (Bio-CCU) –** Centred on a microalgae bio-CCU pilot, this project demonstrates the direct capture and utilisation of CO_2 from actual flue gas into outdoor algae photobioreactor systems. Using local marine microalgae strains in a 4,500 L setup, it achieves CO_2 fixation rates of up to 2.3 g/L, generating biomass for high-value products such as proteins, lipids, pigments, and specialty chemicals. The initiative also builds local expertise through training modules on mass cultivation, monitoring, and downstream processing, establishing a strong foundation for future scale-up[35].
- **Project Dragon**: initiated in June 2024 at the Jimah East Power (JEP) coal-fired power plant, is a key CCU pilot capturing up to 5,000 kg of CO_2 annually using innovative amine solvent-based technology. The captured CO_2 is utilised through multiple pathways: CO_2-enriched agriculture (including high-value crops like dragon fruit—the inspiration for the project's name—and chillies in greenhouse trials, as shown in **Figure 7**), microalgae cultivation to support the High Growth High Value (HGHV) agriculture industry, and potential hydrogenation to produce e-fuels such as methane and methanol. This multi-track approach supports early commercial applications while building the technical expertise, infrastructure, and market readiness needed for future hydrogen-enabled chemical production [36].

Figure 6: Photobioreactor system for Bio-CCU [37]

Figure 7: Improved yield of crops with enriched CO_2 [38]

Overcoming Implementation Barriers

Cross-Border CO_2 Transport: London Protocol Compliance

As Malaysia progresses in its efforts to establish CCS hubs that may involve storing CO_2 from foreign sources through cross-border transport, the country faces significant challenges in complying with international maritime regulations, particularly the London Protocol.

The London Protocol, which evolved from the 1972 London Convention, was introduced in 1996 to modernise global efforts in preventing marine pollution. It implemented a comprehensive ban on marine dumping, allowing only a select list of materials to be disposed of at sea under stringent conditions.

One key development under this protocol was the 2006 amendment that permitted the disposal of CO_2 in sub-seabed geological formations, a crucial step for the implementation of CCS technology [39].

However, Malaysia is not a signatory to the London Protocol, which creates potential complications when engaging in cross-border CO_2 transport projects with countries that are Contracting Parties. The legal framework governing these activities under the Protocol is complex and includes a significant amendment to Article 6, made in 2009.

The amendment was specifically designed to address the legalities of transboundary CO_2 transport for storage purposes. It stipulated that CO_2 exports could be conducted if governed by bilateral or multilateral agreements, with clear delineation and allocation of permitting responsibilities that align with the Protocol's environmental protection standards [39].

Despite its importance, the 2009 amendment has faced considerable difficulties in gaining widespread acceptance. To date, only ten countries—Norway, United Kingdom, Netherlands, Iran, Finland, Estonia, Sweden, Belgium, Denmark, and Korea—have ratified it [40].

For the amendment to become fully applicable, it requires ratification by two-thirds of the 53 Contracting Parties, equating to 35 ratifications. This high threshold has stalled the amendment's implementation, leaving CO_2 exports under the more restrictive original framework of the Protocol.

In response to the slow ratification process, the London Protocol introduced provisional application of the 2009 amendment starting in 2019, allowing Contracting Parties to implement the amendment before its formal entry into force [41].

For Malaysia, not being a party to the London Protocol poses significant challenges. When dealing with other countries that have ratified the Protocol and the 2009 amendment, Malaysia could face legal and regulatory barriers, particularly if these countries require compliance with Protocol standards as part of any CO_2 cross-border project. This could hinder Malaysia's ambitions to become a regional CCS hub, especially if it intends to import and store CO_2 from countries that are Protocol signatories.

Moreover, the 2009 amendment mandates that any agreements or arrangements between exporting and receiving countries must include provisions equivalent to the Protocol's standards, particularly when involving non-Contracting Parties. This further complicates Malaysia's position, as the country would need to either comply with these stringent requirements, or risk being excluded from potential CCS collaborations with Protocol member states.

East Malaysian States: Regulatory Harmonisation

On the domestic front, the development of CCUS technology in Malaysia has entered a new phase following the enactment of the CCUS Act 2025 (Act 870). On 21 May 2024, Malaysia's Ministry of Economy presented a memorandum for a standalone CCUS Bill to the Cabinet. Finally, in 2025, the Act is enacted after passing the legislation. It establishes a comprehensive legal framework for CCUS, covering the entire value chain—from carbon capture to transportation, utilisation, and storage [42].

The Act is designed to ensure cohesive implementation, attract significant investments, and effectively manage associated risks and liabilities. It will be administered by the newly established Malaysia CCUS Agency, supported by a technically competent entity to ensure effective management and oversight [43]. In parallel, Malaysia is pursuing Bilateral Agreements with the aim of positioning the country as a regional CCUS hub, offering integrated CCUS solutions for industries in the Asia Pacific region [30].

Importantly, the jurisdiction of the CCUS Act 2025 (Act 870) is limited to Peninsular Malaysia and the Federal Territory of Labuan, a specification that helped address earlier concerns raised by the states of Sabah and Sarawak. These states—both possessing substantial autonomy over their natural resources—had previously expressed strong reservations, concerned that the legislation might infringe upon their constitutional rights to manage and control such resources.

Sabah and Sarawak, having joined Malaysia under the Malaysia Agreement 1963 (MA63), enjoy special constitutional provisions that distinguish them from other states. Over time, both states have voiced grievances regarding perceived erosions of this autonomy, especially in relation to indigenous land rights and natural resource governance [32].

Historically, Sabah and Sarawak have emphasised their sovereignty over resource management, particularly regarding their oil and gas reserves, which are crucial to their economies. The CCUS Act 2025 (Act 870) centralisation of control was raising some concerns that it could undermine their revenue streams and decision-making authority.

The contention is rooted in a broader context of historical and political tensions, with the federal system often viewed as disregarding the special provisions and guarantees afforded to these states [33].

To address these concerns, the Ministry of Economy, had assured Sarawak that the federal legislation would respect state boundaries and ongoing dialogues under the MA63 platform [34]. He stated that while discussions regarding federal-state boundary interpretations remain ongoing, the CCUS legislative framework would reflect any consensus reached.

The Minister further noted that the framework was developed with guidance from the Attorney General's Chambers, particularly in relation to jurisdictional boundaries as defined by the Continental Shelf Act 1966, the Exclusive Economic Zone Act 1984, and the Territorial Sea Act 2012 [35]. This statement was made in response to calls from Sarawak Premier Tan Sri Abang Johari Openg for clarification on boundary-related issues.

Sarawak has maintained that the federal CCUS Act 2025 (Act 870) does not apply within its jurisdiction, reiterating that any carbon storage projects in its territory must be regulated under state law. This stance is supported by the Sarawak (Alteration of Boundaries) Order 1954 and its interpretation of the Continental Shelf Act 1966, which the state views as granting it authority over its continental shelf and subsoil.

Sarawak officials have further argued that the Continental Shelf Act, originally extended to the state under an emergency ordinance, may no longer be valid following the lapse of that ordinance [36].

Proactively, Sarawak introduced its own legal framework through the Land Code (Carbon Storage) Rules 2022, which comprehensively governs the use of land for carbon storage—both onshore and offshore. This pioneering state legislation underscores Sarawak's commitment to maintaining full regulatory control over carbon storage activities within its borders.

Sarawak's position, presented during the National Energy Council meeting and met without objection, reinforces its sovereign regulatory stance and its determination to manage carbon storage activities independently of the federal framework [36].

Sabah has expressed similar reservations. Deputy Chief Minister Datuk Seri Dr. Jeffrey Kitingan questioned the necessity of the federal CCUS Act 2025 (Act 870) for Sabah, citing the state's jurisdiction over land and forestry matters. Sabah's engagement in carbon management is reflected in initiatives like the Nature Carbon Agreement (NCA), which seeks to monetise carbon credits while conserving its tropical forests.

Sabah leaders have stressed the importance of maintaining autonomy over carbon-related resources and have warned that the federal law could conflict with Sabah's constitutionally enshrined powers [37].

The divergence in perspectives between the federal government and the states of Sabah and Sarawak presents an ongoing challenge to Malaysia's ambition of implementing a unified national CCUS policy. Without full alignment, there may be delays and legal uncertainty—particularly for CCUS projects involving cross-border CO_2 transport and storage, where jurisdictional clarity is essential. This is particularly significant given that Sabah and Sarawak house much of Malaysia's energy infrastructure and possess key offshore oil and gas fields, such as the Kasawari and Lang Lebah projects—prime candidates for carbon storage [38].

The regulatory uncertainty stemming from such situation might create additional challenges for private sector stakeholders, industries, and investors considering investments in CCUS development in these regions. Ambiguities in the legal framework could affect investment decisions, as potential investors may be cautious about committing resources amid unclear regulatory conditions.

This could impact the progress and scale of CCUS projects, which are crucial for achieving Malaysia's carbon reduction objectives. However, the situation is addressed excellently as the CCUS Act 2025 (Act 870) excludes Sabah and Sarawak, thus giving the two region full authority to lead the development of CCUS industry within their area.

As Malaysia proceeds with CCUS development, building trust and strong collaboration by fostering cooperative frameworks that balance federal objectives with state autonomy remains a key priority. Resolving any jurisdictional tensions will be critical to the success of Malaysia's broader carbon reduction strategy.

Way Forward: Accelerating the Progress

A multifaceted approach is necessary to address the challenges Malaysia faces in complying with the London Protocol, particularly regarding cross-border CO_2 transport. Bilateral agreements will be the main instrument to govern the conduct for both Parties of the cross border CCUS activities, subject to each Party's international obligation.

In this context, ASEAN Member States could benefit from developing a coordinated regional strategy, including a dedicated regional protocol on CCS and cross-border CO_2 transport. Such a framework could integrate rigorous technical and environmental standards, supported by robust financial and legal mechanisms. Aligning with these international norms would not only help Malaysia mitigate legal and regulatory risks, but also strengthen its strategic positioning as a regional CCS hub, thereby enhancing the effectiveness of carbon management efforts across Southeast Asia.

With the enactment of the Malaysia CCUS Act 2025 (Act 870), the country is now positioned to move toward greater harmonisation of CCS regulations with both regional and international standards. This progress must be pursued in accordance within the ambit of the said Act.

Looking ahead, the development of detailed subsidiary regulations under the CCUS Act 2025 (Act 870) is highly anticipated. These regulations will be critical to clarify many of the "prescribed" elements outlined in the Act and to ensure that potential operators can participate in a clear, consistent, and compliant manner. Such regulatory clarity will be vital for advancing the entire CCUS value chain in Malaysia and for building a credible and investment-friendly environment for large-scale CCS deployment. This would bring Malaysia one step closer towards the vision of becoming the CCUS leader in the region.

Image Source: Canva

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