Carbon Capture, Utilisation and Storage in Indonesia

Policy brief

International Energy Agency

INTERNATIONAL ENERGY AGENCY

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Key facts

- Indonesia's economic development over the past half-century has been remarkable, with profound impacts on its energy sector.
- The country's young power and industrial assets need clean energy alternatives and energy efficiency measures in order for Indonesia to reach its climate target of net zero emissions by 2060.
- Carbon capture, utilisation and storage (CCUS) can be an important technology to help achieve that goal while advancing energy security and employment outcomes. It is set to play diverse roles in supporting Indonesia's energy transition.
- In March 2023, the Indonesian Ministry of Energy and Mineral Resources (MEMR) finalised Ministerial Regulation MEMR 2/2023, establishing the first CCUS regulatory framework within the Association of Southeast Asian Nations (ASEAN). The regulation sets the stage for upstream oil and gas companies to undertake CCUS activities, including developing CO_2 storage resources.

Key insights

- **MEMR 2/2023 is a promising first step to spark CCUS deployment in Indonesia and could serve as a stepping-stone** for the establishment of other CCUS frameworks across the ASEAN region. Work is already under way in Thailand and Malaysia to create such frameworks.
- **However, MEMR 2/2023 currently has limited scope for CCUS activities beyond the oil and gas sector**. Opportunities exist – particularly in industry, electricity generation and fuel transformation.
- **For CCUS to play its role in Indonesia's decarbonisation, subsequent ministerial regulations will be needed** to create a broader CCUS framework. At least one regulation is now being drafted, focusing on opening up the potential to store captured CO_2 from other countries in cross-border projects.
- **These projects can enable the wider decarbonisation of the ASEAN region**, allowing countries with limited CO_2 storage resources to send their captured CO_2 to countries with more developed storage resources. The same is true for importing or exporting CO_2 outside of the region.
- **Cross-border projects may require regulatory changes to ensure requirements** under the London Protocol are met, as well as robust carbon accounting methodologies to facilitate emissions reduction verification. These efforts could help facilitate the development of CCUS hubs in the region.
- **A review of existing ASEAN platforms for regional energy co-operation is needed** to co-ordinate opportunities in CO_2 transport and storage networks, such as in the next cycle of the ASEAN Plan of Action for Energy Cooperation or through the ASEAN Energy Regulators Network.

The energy sector in Indonesia

Indonesia has been the fourth-fastest growing large economy in the world over the past 50 years, with major implications for its energy sector and emissions.

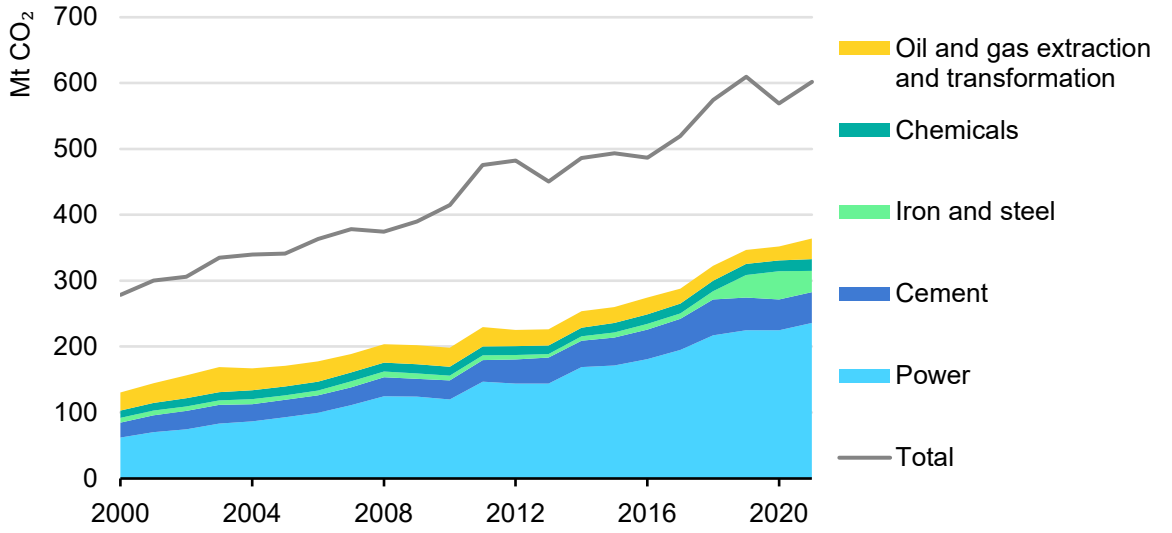
In 2021, Indonesia's total energy sector emissions were around 600 Mt of CO_2, slightly less than those of Korea's energy sector. A little less than half of the emissions were from coal combustion, one-third from oil, and the remainder from natural gas combustion (around 15%) and process emissions (around 5%).

Between 2000 and 2021, total energy supply in the country increased by more than one and a half times, and energy sector CO_2 emissions more than doubled. Much of this growth in energy and related emissions has come from coal, where demand has been driven by the electricity sector. Coal-fired electricity generation increased more than fivefold during this period.

Industry has played a substantial role in Indonesia's growth, and accounts for roughly one-fifth of increased CO_2 emissions over the same period. Again, coal has played a significant role, representing the lion's share of fuels used in the production of steel today.

A large number of power plants and industrial facilities were brought online in the past decade, in particular in power generation, cement, and iron and steel production. Around half the country's total installed capacity for crude steel production was added during the past ten years, and the majority uses the emissions-intensive blast furnace-basic oxygen furnace process route.

Total and selected stationary energy sector emissions sources in Indonesia, 2000-2021



Energy sector emissions more than doubled between 2000 and 2021, with the power sector accounting for half of the growth.

Moving forward, these young power and industrial assets will need clean energy alternatives and energy efficiency measures in order for Indonesia to reach its net zero emissions by 2060 target. Carbon capture, utilisation and storage (CCUS) can be an important technology to help achieve that goal.

Opportunities for CCUS deployment

A growing pipeline of CCUS projects focused on the oil and gas sector

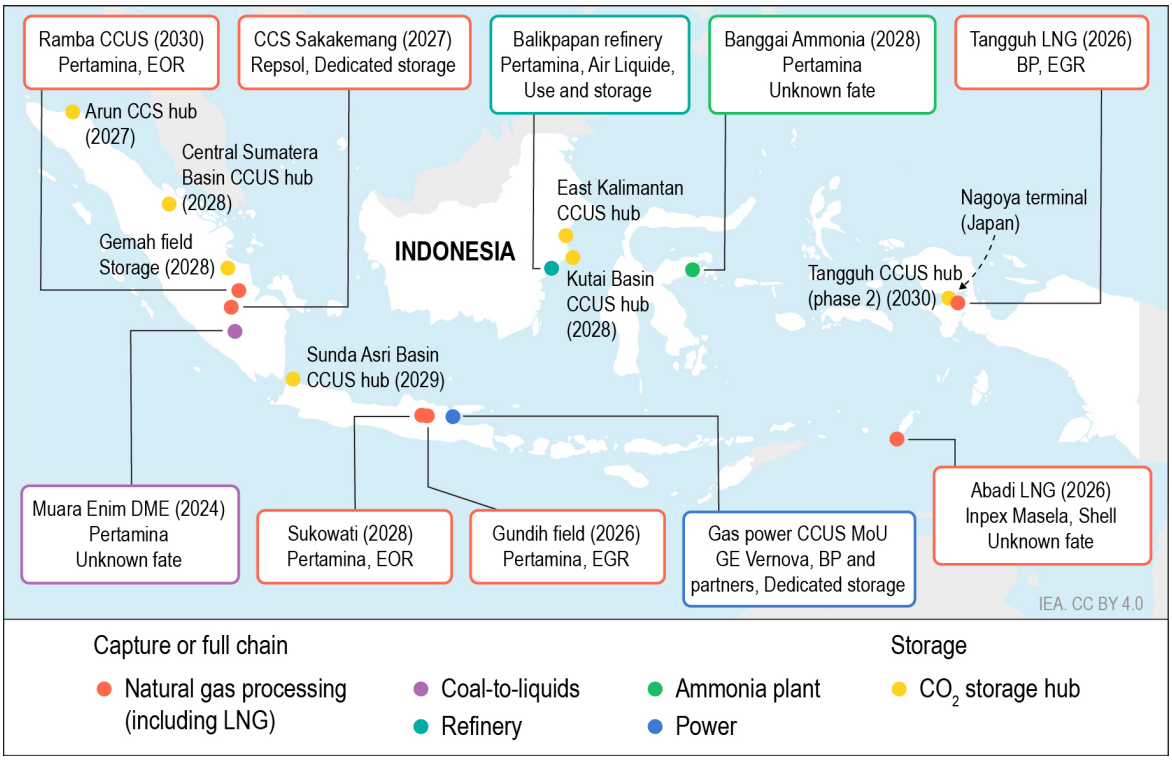
Indonesia is the most advanced economy in Southeast Asia for CCUS, with over 15 projects in development across the CCUS value chain.

Oil and gas companies are heavily involved in CCUS project development in the country. In natural gas processing plants, CO_2 needs to be separated from methane to meet natural gas or liquified natural gas standards. This process results in a highly concentrated (> 98%) CO_2 stream, which makes natural gas processing one of the least-cost applications of CCUS. Six projects involve CO_2 capture at natural gas processing plants, both for existing fields, and for high CO_2 content gas fields which would have otherwise been left unexploited. Once captured, CO_2 can be injected in hydrocarbon fields in operation for enhanced oil (EOR) or gas (EGR) recovery, which is the case for five capture projects out of ten capture projects planned.

CCUS can also be integrated in refineries, though plants vary in scale and configuration, with some high concentration emissions from chemical processes, and a number of lower concentration streams which are more costly to capture. A joint study on implementing capture at the hydrogen production unit at a refinery was announced in 2022.

In addition, oil and gas companies are leveraging their subsurface expertise in the planning of large-scale dedicated storage hubs to store emissions from multiple emitters, including international third-parties, with at least seven dedicated storage hubs in development.

Map of CCUS projects under development in Indonesia, 2023



Notes: LNG = liquefied natural gas; EGR = enhanced gas recovery; EOR = enhanced oil recovery.
Source: IEA (2023), CCUS Projects Database, December 2023.

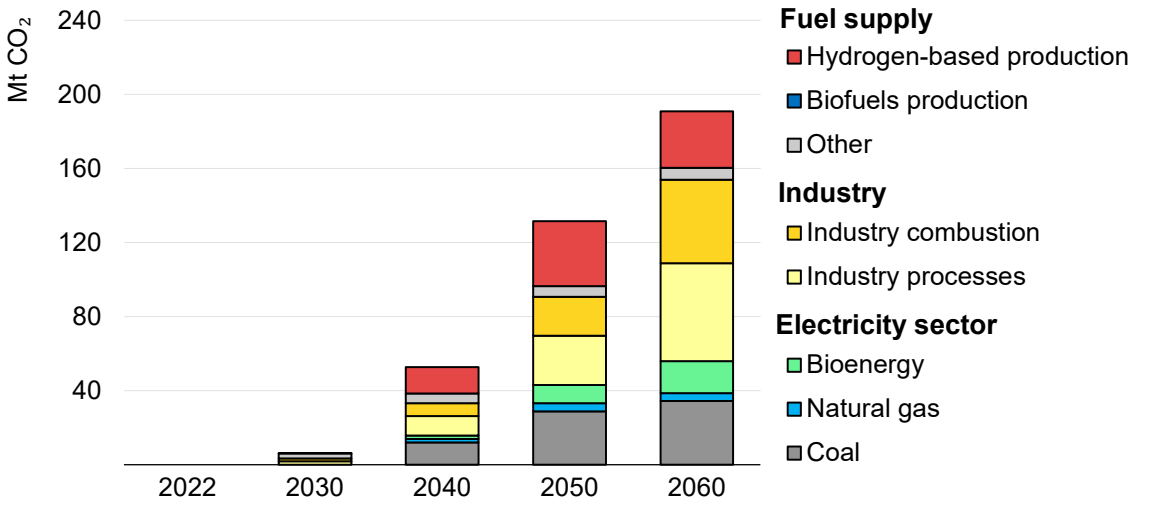
There are ten capture projects in development. While most target enhanced hydrocarbon recovery, several dedicated CO_2 storage hubs are also in development.

Opportunities exist beyond the oil and gas sector

CCUS is set to play important and diverse roles in supporting Indonesia's clean energy transition, in particular in industry, electricity generation and fuel transformation. For Indonesia to meet its carbon neutrality goal by 2060[1], the IEA has assessed CCUS deployment needs to pick up quickly to reach over 6 Mt annually captured in 2030, and around 190 Mt annually in 2060. Projects are currently in development in low-emission ammonia, power, refining, and dedicated storage, reflecting opportunities beyond the oil and gas sector.

[1] Corresponds to the IEA Announced Pledges Scenario (APS), as explored in IEA (2022).

CCUS deployment by sector in the IEA Announced Pledges Scenario, 2022-2060



CCUS is important for curbing CO_2 emissions from the industry and electricity sectors, allowing some existing coal-fired plants to be used as low-emissions options.

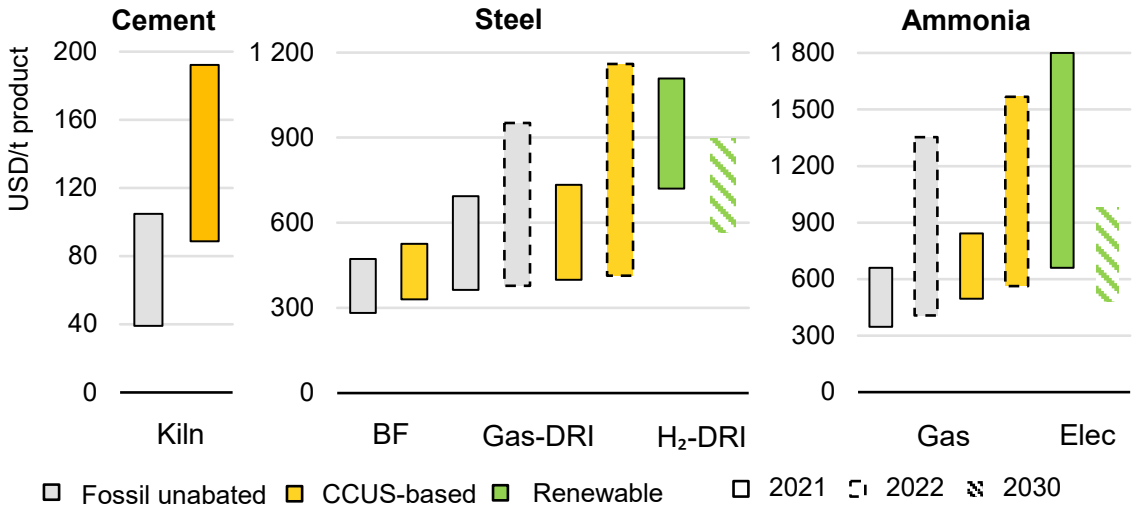
Delivering cost-effective emissions reduction in industry and fuel transformation

Cement production is the largest industrial emitter in Indonesia, with two-thirds of the sector's direct emissions originating from clinker production. In Indonesia, there are around 30 major cement plants with a combined clinker capacity of around 80 Mt per year, which emit around 45 Mt CO_2 per year. CCUS is one of the only technologies available to reduce these process emissions and provide deep emissions reductions for these plants.

In iron and steel production, CCUS can be a cost-effective route to decarbonise where renewable electricity supply or low-emissions hydrogen is limited. There are around six large-scale steel mills with a combined annual production capacity around 15 Mt of crude steel and annual CO_2 emissions of around 30 Mt CO_2.

CCUS can also be a cost-effective solution for low-emissions ammonia production. Japan and Indonesia signed a Memorandum of Co-operation (MoU) in 2022 to collaborate on hydrogen, ammonia, 'carbon recycling' and CCUS. A joint CCUS study on a 0.7 Mt ammonia plant in Central Sulawesi, led by Japanese and Indonesian partners, is currently underway. CCUS can also support the production of low-emissions hydrogen.

Indicative levelised cost of production of selected industry products for different routes, 2022



Notes: CCUS = carbon capture, utilisation and storage. BF = blast furnace; DRI = Direct reduction of Iron; Elec = electrolysis. Costs are shown as a range across all global markets. The costs do not include CO_2 prices or taxes. Costs are shown for the year the technology reaches commercialisation, or for current costs if the technology is already commercial. Source: IEA (2023), CCUS Policies and Business Models: Building a Commercial Market. See page 68.

CCUS is one of the only solutions to decarbonise cement production at scale and can be a cost-effective solution to decarbonise steel and chemicals where alternatives are limited.

Decarbonising a young power generation fleet

CCUS can provide an opportunity to reduce emissions from a young and emissions-intensive power generation fleet. The power sector contributes to over a third of the country's energy sector emissions, the majority of which (85%) come from coal-based generation. The coal fleet is among the youngest in the world, at 13 years old on average, and plants continue to be built.

Retrofitting CCUS is technically feasible on most power generation facilities, but factors such as access to CO_2 transport and storage infrastructure, plant age, capacity, pollution control and boiler design will be important to identify technically viable and least-cost opportunities for CCUS retrofits. (Ultra-) supercritical power plants are better candidates for retrofitting as they have a higher design efficiency and are less likely to require any boiler or turbine upgrades to meet steam conditions for CO_2 capture. Around 20% of Indonesia's coal fleet are supercritical and ultra-supercritical plants, all of which are large-scale and were built in the last decade. Where suitable, these large-scale facilities could serve as anchor projects for developing CO_2 storage hubs.

Biomass fuel switching or co-firing in coal or gas plants can also mitigate power emissions and, when combined with CCS, generate negative emissions.

Key regulatory considerations

The scale-up of CCUS relies on the establishment of legal and regulatory frameworks to ensure the effective stewardship of CCUS activities and the safe and secure storage of CO_2. These frameworks provide an enabling environment for CCUS. More than 20 jurisdictions (subnational, national, or regional) have such frameworks in place for CCUS.

Indonesia's framework is a first-of-a-kind in the region

With the finalisation of the Ministry of Energy and Mineral Resources Regulation Number 2 of 2023 (MEMR 2/2023) in March 2023, Indonesia became the first country in Southeast Asia to put a CCUS framework in place.

MEMR 2/2023 covers many of the areas commonly found in other frameworks which are crucial to ensuring the safe and secure storage of CO_2, such as establishing detailed monitoring and reporting requirements. It also covers several financial and business model considerations that are not commonly found in other frameworks, including potential pathways for a project and its partners to monetise carbon credits.

There are dozens of issues that can affect the legal oversight and regulation of CCUS activities, the majority of which focus on the regulation of CO_2 storage. Indonesia's MEMR 2/2023 covers several of these issues; however, other issues such as one-off legislation for a specific project are not necessarily applicable to Indonesia.

Legal and regulatory issues for CCUS deployment

Category	Issue	Coverage under Indonesia framework
Defining the regulatory scope	Classification and purity of CO_2	Yes
	Ownership and title of CO_2	Unclear
Environmental reviews and permitting	Environmental impact assessment	Yes
	Permitting and authorisation	Yes
	Public engagement and consultation	Yes
Enabling first-mover projects	One-off legislation	N/A
	Preferential approaches and projects	Yes
Ensuring safe and secure storage	Storage resource assessment	Unclear
	Ownership of pore space	Unclear
	Measurement, monitoring (reporting) and verification plans	Yes
	Storage site inspections	Yes
	Operational liabilities and financial security	Yes
	Site closure process	Yes
Addressing long-term storage liabilities	Long-term liability post-site closure	Unclear
	Financial assurances of long-term site stewardship	Yes

Category	Issue	Coverage under Indonesia framework
International and transboundary issues	Regulating cross-border CO_2 transport	Unclear
	Compliance with the London Protocol	Unclear
	Interaction of pressure fronts across international borders	Unclear
	Overlap between multiple frameworks	Unclear
Facilitating CCUS hubs	Access to shared transport infrastructure	Yes
	Facilitating shared storage infrastructure	Yes
Other key and emerging issues	Treatment of CO_2 removal technologies	Yes
	Interaction with other surface and subsurface resources	Unclear
	Transitioning from CO_2-enhanced oil recovery to dedicated storage	Unclear
	CCUS-ready requirements	Unclear

Sources: IEA (2022), CCUS Handbook on Legal and Regulatory Frameworks; Indonesia, Ministry of Energy and Mineral Resources (2023), Ministerial Regulation No.2.

The framework is a strong first step towards deployment, but is narrow in scope

MEMR 2/2023 is rooted in Indonesia's oil and gas framework, and relies on upstream exploration and production companies to spearhead CCUS development and operation. Globally, the oil and gas industry has played major role in the early development of commercial CCUS projects, thanks to its expertise in operating large-scale projects and knowledge of the subsurface.

As a ministerial regulation, MEMR 2/2023 is limited to the jurisdiction of the ministry itself. The regulation states that only oil and gas contractors (i.e. those companies in a production-sharing contract with Indonesia's upstream oil and gas regulators, SKK Migas and BPMA) are allowed to develop CCUS projects.

This narrow scope is due to MEMR 2/2023 being a *regulation*, rather than *legislation*. In other frameworks around the world that are based in (e.g. the CCS Directive in the European Union and the Offshore Petroleum and Greenhouse Gas Storage Act 2006 in Australia), the scope is broader than one sector.

Building out the CCUS framework would require further regulations

To enable CCUS to play its full role in Indonesia's decarbonisation, subsequent ministerial regulations would be needed to expand Indonesia's CCUS framework beyond the oil and gas sector. At a minimum, these regulations should address:

- **The development of CO_2 storage outside of oil and gas working areas**: Under MEMR 2/2023, companies are required to submit their CCUS proposal as part of a development plan associated with oil and gas exploration and production. As such, there is no framework for the development of CO_2 storage resources outside of these working areas. Such

a framework would need to include how CO_2 storage lease areas would be defined, licensed, permitted, monitored and regulated.

- **CCUS activities of non-oil and gas companies**: MEMR 2/2023 allows oil and gas companies within a working area to transport and store CO_2 from emitters outside of the working area (known as "third parties"). This could give CO_2 transport and storage access to emitters that may not have the resources or technical expertise to develop their own CCUS infrastructure, potentially paving the way for the development of CO_2 storage hubs in Indonesia. However, changing business models in the sector are resulting in the emergence of new, specialised players that are offering CO_2 transport and storage as a service to emitters. A regulatory framework for these non-oil and gas companies to participate in CO_2 transport and storage activities is currently lacking.
- **International implications**: Indonesia's large CO_2 storage potential puts it in a strong position to support not only the decarbonisation of the region, but that of countries outside it as well. Discussions with other countries such as Japan on cross-border projects are continuing, and it is important to consider any international implications (such as requirements under the London Protocol) and potential changes to domestic regulations to accommodate CO_2 that is captured in another country.
- **The monetisation of carbon credits from CCUS projects**: MEMR 2/2023 includes economic and revenue considerations for CCUS projects, particularly with regard to monetising carbon credits generated from CCUS projects. It allows the upstream oil and gas sector to trade credits from CCUS projects to meet emissions reduction requirements under Indonesia's recently launched carbon market, and to monetise those credits if the CO_2 is captured from outside the sector. A robust methodology for the generation of CCUS-enabled carbon credits is necessary to ensure CO_2 emissions are reduced in a meaningful way, not only in the oil and gas sector but also in other sector-specific carbon trading regulations.

Indonesia is currently in the process of drafting at least one follow-on regulation to address some of these areas. Any future additional regulations should include a clear definition of the roles and responsibilities of government agencies. MEMR 2/2023 is able to accomplish this requirement because it is set within the existing upstream regulatory regime, but the establishment of new planning, licensing and permitting processes outside of the oil and gas working areas will require similar clarity on government roles. This will rely on internal co-ordination within the MEMR directorates (e.g. oil and gas, electricity, and mineral and coal) and strong cross-government co-ordination with other ministries (e.g. the Ministry of Industry).

Enabling regional deployment

Indonesia's energy and economic circumstances are typical for the region: growing demand for energy within Association of Southeast Asian Nations (ASEAN) member states is overwhelmingly met by fossil fuels. CCUS has the potential to support clean energy transitions in the region, with some countries including CCUS in their net zero emissions plans.

Although no commercial CCUS projects are currently operating in the region, over 20 projects are in various stages of development across the CCUS value chain.

A storage hub for regional and international emissions

Indonesia's potential large CO_2 storage resources could serve as a storage hub for countries in and around the region with limited CO_2 storage resources, such as Singapore, Japan and Korea. Dedicated storage hubs are already in development in the region, targeting the dedicated sequestration of both domestic and international emissions.

Regional storage hubs are already being pursued in other parts of the world, with plans to sequester around 280 Mt CO_2 per year by 2030, mainly in Europe and North America.

Selected storage hubs in development by region, 2023

Region/country	Number of storage hubs in development	Total storage capacity in planning by 2030 (Mt per year)	Total storage capacity in planning (Mt per year)
North America	59	107	192
Europe	29	134	219
Australia and New Zealand	12	14	52
Japan	4	8	8
People's Republic of China	4	6	16
Indonesia	7	(undisclosed)	(undisclosed)
Saudi Arabia	1	9	9
Malaysia	1	2	2
Total	**112**	**279**	**500**

Source: Analysis based on IEA (2023), CCUS Projects Database.

Enhancing regional co-operation and collaboration

The successful deployment of CCUS in the region will depend, in part, on the ability of ASEAN member states to collaborate with one another and with key international stakeholders. Regional frameworks and planning can send the right investment signals and help build on the experience of other countries.

In July 2023, the IEA hosted a joint workshop with MEMR, in collaboration with the ASEAN Centre for Energy, to identify specific opportunities for greater regional collaboration among ASEAN member states. Four core themes emerged: legal and regulatory frameworks, cross-border projects, carbon accounting standards and regional platforms.

Legal and regulatory frameworks provide a starting point for CCUS

Developing comprehensive legal and regulatory frameworks for CCUS typically involves substantial planning and consultation that can take up to several years. Countries with frameworks already in place have started by reviewing existing regulations that affect CCUS activities and identifying any gaps and barriers that could impact deployment. Existing oil and gas frameworks are a typical starting place for many countries.

In Thailand, a regulatory framework is being developed in phases: in the first step, existing oil and gas regulations will be amended to enable upstream companies to perform CCUS activities (just as in MEMR 2/2023). It will also create project-specific regulation to enable the Arthit pilot CCUS project. The second step aims to expand CCUS activities beyond the upstream oil and gas sector and to ensure the economic viability of projects. This will require a specific CCUS regulatory framework.

In Malaysia, which has a robust oil and gas framework, regulators have identified the development of a legal and regulatory framework for CCUS as a key pillar in its National Energy Transition Roadmap. Such a framework will be developed to facilitate CCUS projects, establishing a governance structure that defines roles for relevant ministries, and allowing for the cross-border transport and storage of CO_2.

Phasing in projects can be beneficial for cross-border initiatives

Phased projects can offer valuable opportunities for learning-by-doing that can inform later phases and provide constructive lessons for future cross-border projects involving multiple project partners throughout the CCUS value chain.

Phasing in projects can also enable developers to commence pilot operations while simultaneously starting discussions with other countries and capture facilities for full-scale commercial activities (such as on the requirements and facilities needed at ports, or transport infrastructure needs). For example, phased projects can test the injectivity of CO_2 storage reservoirs under conditions where CO_2 is being transported from multiple places and ships are coming in and out of the storage site.

This approach can also help regulators develop frameworks in phases, as is the case in Thailand, where the first step is focused on enabling pilot projects and the second on large-scale commercial projects. Given that cross-border CCUS projects are novel initiatives, it is important that project developers work with regulators from the start, which could enable the simultaneous development of regulations and technical requirements for projects.

Robust standards are needed to verify emissions reduction

Cross-border projects can allow countries in the ASEAN region with limited CO_2 storage resources to send their captured CO_2 to other countries in the region with more developed storage resources. The same is true for importing or exporting CO_2 outside the region.

However, for a country to claim the emissions reduction from CO_2 storage activities, carbon accounting standards underpinned by robust methodologies are needed. The existence of such standards would allow stakeholders in different countries to collaborate on cross-border projects through the purchasing and selling of credits. For example, Japan and Indonesia are evaluating a cross-border project that would send captured CO_2 from Japan for storage in Indonesia. To verify that this project would contribute to Japan's emissions reduction goals, detailed and standardised methodologies would be needed.

Developing these standards will be crucial to including CCUS projects in international carbon markets, such as those allowed for under Article 6 of the Paris Agreement. Standards are also key to the monetisation of CCUS projects (such as in MEMR 2/2023) in domestic carbon markets.

Standards will need to be tailored to different types of CCUS projects, especially with regards to carbon dioxide removal (CDR) technologies. Emissions reduced from a fossil power plant or industrial facility should have different accounting methodologies from emissions that are removed from the atmosphere. In addition, there is a need for accounting standards to reflect shared infrastructure and CCUS hubs, such as where multiple capture projects are injecting in the same CO_2 storage site.

The first methodologies for claiming carbon credits are emerging through initiatives such as Puro.earth and CCS+. Puro.earth's Puro Standard was the first carbon removal standard for CDR technologies in voluntary carbon markets. The CCS+ Initiative aims to develop methodologies for issuing credits from CCUS activities (including CDR) and make them publicly available under Verra's Verified Carbon Standard.

Regional platforms should be reviewed to enhance collaboration

Under the ASEAN framework, there are several platforms where member states have the opportunity to collaborate on CCUS, principally with regard to the coal sector.

The ASEAN Plan of Action for Energy Cooperation (APEAC) is a ten-year guiding framework for regional energy co-operation, covering seven programme areas, including the clean coal technology programme, where CCUS sits. The ASEAN Forum on Coal (AFOC) is responsible for implementing this programme and co-operation on CCUS.

In order to take advantage of the opportunities for CCUS deployment in sectors beyond coal, an evaluation of existing regional platforms is needed. Expanding ASEAN co-operation on CCUS beyond the coal sector could also open up discussions around the deployment of regional CCUS infrastructure for CO_2 transport and storage. This could start by including regional CO_2 transport and storage as a key consideration in the next APEAC cycle (2026-2035). In this regard, interconnectivity of the region's energy infrastructure, a key focus of the ASEAN Chairmanship under Indonesia, could extend beyond electricity grids and trading to CO_2 transport and storage networks in the region. An evaluation of APEAC's work programmes would be needed to assess whether changes to AFOC would be needed to facilitate an expansion in focus to CCUS networks.

Platforms such as the ASEAN Energy Regulators Network (AERN) may provide another appropriate avenue to expand discussions on CCUS infrastructure and regulations. Currently focused on enhancing regional co-operation on electricity infrastructure, AERN could convene regional regulators working on CCUS to share best practices, harmonise legal and regulatory frameworks in the region, and collaborate on the establishment of shared CCUS infrastructure networks.

Where possible, engaging the private sector on CCUS activities at the regional level could help ensure a co-ordinated roll-out of CCUS projects. This could be done through the ASEAN Council on Petroleum (ASCOPE), whose members are made up of the heads of each ASEAN member state's national oil company. Given the role of ASEAN national oil companies in CCUS projects planned for the region, engaging ASCOPE in a targeted and deliberate manner could help inform other CCUS regional planning discussions at AERN or under APEAC's work programmes.

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