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Feasibility Study on a CCS Pilot Project in Indonesia

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Feasibility Study on a CCS Pilot Project in Indonesia

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Preface

The Asia CCUS Network (ACN) was officially established in 2021, with ERIA serving as its secretariat. As a platform for all stakeholders in carbon capture, utilisation, and storage (CCUS), the ACN is committed to advancing its mission through three key initiatives:

1. Knowledge Sharing: Hosting regular online conferences featuring experts on the latest and most relevant CCS/CCUS topics in Asia and globally.
2. Research Studies: Focusing on carbon capture, transportation, and storage, with a particular emphasis on addressing cost-related challenges.
3. Capacity Building: Conducting training programmes to estimate carbon storage capacity in collaboration with organisations like the United States Geological Survey (USGS) and the Japan Organization for Metals and Energy Security (JOGMEC).

The ACN is guided by a clear vision and roadmap, which includes the initiation of a CCS pilot project after 2025 and the application of CCUS technology to contribute to decarbonisation in Asia from 2030 onwards. As part of this effort, ERIA has undertaken a feasibility study to identify a suitable CCS pilot project site within the Association of Southeast Asian Nations (ASEAN) region. The study assesses CO_2 emissions from coal power plants, evaluates CCS costs (including CO_2 capture, transport, and storage), and examines the regulatory framework and necessary incentives to support such projects.

Existing reports and research highlight significant potential for CO_2 storage in ASEAN countries, particularly Indonesia and Malaysia. Injecting CO_2 into deep saline aquifers in these countries could potentially accommodate CO_2 from outside ASEAN, such as from Japan and the Republic of Korea, by leveraging cost-reduction mechanisms like the Joint Crediting Mechanism. To facilitate this, establishing a CCS value chain or network across Asia will be essential. This will require coordination on cross-border CO_2 transportation, regional regulations, and robust measurement, reporting, and verification systems.

This report aims to support the development of appropriate CCS business regulations for ASEAN and the broader East Asia Summit region, enabling sustainable and collaborative decarbonisation efforts.

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The project members express their gratitude for the support provided by ERIA and its professional team. Their insights, particularly on geological resources in Indonesia, have been invaluable to the development of this report.

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List of Abbreviations and Acronyms

ADB	Asian Development Bank
AMS	ASEAN Member State
Art.	Article
ASEAN	Association of Southeast Asian Nations
ASR	Abandonment and Site Restoration
BECCS	Bioenergy with Carbon Capture and Storage
CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation, and Storage
CDM	Clean Development Mechanism
CO_2	Carbon Dioxide
CoE	Centre of Excellence
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
DACCS	Direct Air Carbon Capture and Storage
DFI	Development Finance Institution
DNSH	Do No Significant Harm
EIA	Environmental Impact Assessment
EO	Environmental Objective
EOR	Enhanced Oil Recovery
EPC	Engineering, Procurement, and Construction
ERIA	Economic Research Institute for ASEAN and East Asia
ESMAP	Energy Sector Management Assistance Program
ETA	Energy Transition Accelerator
ETS	Emission Trading System
FCA	Finance Conduct Authority
FF	Foundation Framework

FTP	First Tranche Petroleum
GCF	Green Climate Fund
IEA	International Energy Agency
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power producer
JCM	Joint Crediting Mechanism
MDB	Multilateral Development Bank
MEMR	Ministry of Energy and Mineral Resources
MOEF	Ministry of Environment and Forestry
MRV	Measurement, Reporting, and Verification
MSME	Micro, Small, and Medium-sized Enterprise
MUFG	Mitsubishi UFJ
NAPs	National Adaptation Plans
NDC	Nationally Determined Contribution
NEK	Nilai Ekonomi Karbon (Carbon Economic Value)
NETL	National Energy Technology Laboratory
NZE	Net Zero Emissions
O&M	Operation and Maintenance
OJK	Otoritas Jasa Keuangan (Indonesian Financial Services Authority)
OPEX	Operating Expense
PLN	Perusahaan Listrik Negara (State Electricity Company)
PR	Presidential Regulation
PS	Plus Standard
PSC	Production Sharing Contract
PT-SMI	PT Sarana Multi Infrastruktur
SCALE	Scaling Climate Action by Lowering Emissions
SPE-GRK	Sertifikat Pengurangan Emisi - Gas Rumah Kaca (Carbon Credit in Indonesia)

SPV	Special Purpose Vehicle
SRN PPI	Sistem Registrasi Nasional Pengendalian Perubahan Iklim (National Registration System for Climate Change Control)
TA	Technical Assistance
TKBI	Buku Taksonomi untuk Keuangan Berkelanjutan Indonesia (Indonesia Taxonomy for Sustainable Finance)
TNA	Technology Needs Assessment
TRL	Technology Readiness Level
TSC	Technical Screening Criteria
T-VER	Thailand Voluntary Emission Reduction Program
UN	United Nations
UNEP	United Nation Environment Programme
UNEPCCC	United Nations Environment Programme Copenhagen Climate Centre
UNFCCC	United Nations Framework Convention on Climate Change
USC Coal	Ultra-supercritical coal
ZEP	Zero Emissions Platform
ZTI	Zona Target Injeksi (Injection Target Zone)

Executive Summary

The Asia CCUS Network: Advancing CCS Projects in ASEAN

Organised by ERIA, the Asia CCUS Network aims to implement a pilot carbon capture and storage (CCS) project in the Association of Southeast Asian Nations (ASEAN) after 2025, with the goal of commencing commercial operations after 2030. This study seeks to identify a potential coal power plant for capturing carbon dioxide (CO_2) and to assess the associated costs, regulatory challenges, and strategies for capturing, transferring, and storing CO_2 within ASEAN, with a particular focus on Indonesia.

Key Findings on CO_2 Emissions and CCS Potential

As outlined in Chapter 1, CO_2 emissions from coal power plants in key ASEAN countries – Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam – remain significantly high. The study identifies 16 power stations (comprising 40 units) with substantial CO_2 emission potential beyond 2030, particularly those with a minimum generation capacity of 600 megawatts (MW) per unit and long remaining lifetimes. These power stations collectively emit an estimated 168 million tonnes of CO_2 annually.

To mitigate emissions from coal-fired power plants while maintaining energy security and economic sustainability, CCS emerges as a viable option. Considering the proximity to geological storage sites, a specific coal-fired power plant in Indonesia has been selected for further feasibility analysis. As demonstrated in Chapter 2, the estimated CCS cost across the entire value chain – capture, transport, and storage – amounts to US$71 per tonne of CO_2. Total capture costs for large power stations can reach tens of billions of dollars, highlighting the challenges of making CCS projects financially viable in the absence of high carbon pricing.

Regulatory and Financial Challenges in Indonesia

Chapters 3 and 4 reveal that while Indonesia has made progress in developing CCS regulations – such as ministerial and presidential decrees – significant gaps remain. Key non-technical barriers include the absence of provisions for first-mover projects, limited financial resources, and the lack of ratification of the London Protocol, which would enable CO_2 trade with other countries. These factors hinder the feasibility of offering CO_2 storage services and advancing CCS deployment.

Recommended Business and Financing Models

Given Indonesia's current situation, where CCS projects are not yet commercialised and financing options are limited, Chapter 5 recommends a full-chain business model for early-stage projects. Under this model, a consortium would provide CO_2 capture, transport, and storage services to power generation companies in exchange for a service fee. Over time, transitioning to a hub-and-cluster model – with dedicated service providers for each part of the value chain – is essential. This shift would align with the development of regulatory frameworks and support the long-term growth of CCS projects.

To address the critical barriers of insufficient incentives and financial resources, Chapter 6 explores a blended finance approach. This model utilises anchor funding from international mechanisms such as the Green Climate Fund, enabling additional financial contributions from private sources through debt and equity investments.

Carbon market mechanisms, such as the Joint Crediting Mechanism between Indonesia and Japan, are also expected to attract public and private investment. Technical assistance accompanying these financial mechanisms would further enhance capacity-building efforts.

A Pathway to Regional Decarbonisation

As detailed in subsequent chapters, blended finance and technical assistance from international sources are crucial to supplement local efforts in facilitating CCS projects. These models will not only support regulatory and business development but also accelerate the deployment of CCS technologies. The establishment of a regional hub-and-cluster model will be vital for maximising greenhouse gas (GHG) reduction benefits and achieving ASEAN's decarbonisation goals.

Chapter 1

Mapping and Estimation of CO_2 Emissions from Coal Power Plants in ASEAN

To estimate the cost of CCS, two promising plants were selected based on the following process. Firstly, estimations were made on emissions from power plants in each ASEAN country. Secondly, a mapping exercise was conducted on the emissions in the top 5 emitting countries. The study selected 16 candidate plants based on the following evaluation indicators:

- Power plants that started operation recently were selected. Due to their relatively long remaining lifespans, they are unlikely to be decommissioned during the CCS operation period, and the accumulative amount of CO_2 captured during the CCS operation period is expected to be high.
- Power plants with more than 600 MW of capacity per unit (more than 1,200 MW in total) were selected, as larger capacities will result in larger CO_2 emissions, allowing economies of scale to work and lower construction costs for the capture unit.

Thirdly, the locations of the candidate plants were mapped again, and two promising plants were selected for CCS cost estimation based on the evaluation indicators. The final selection was made based on the following characteristics:

(i) Proximity to the coast. By enabling the use of offshore storage, an opportunity can be increased by accepting CO_2 not only from power plants but also from overseas through cross-border transport.

(ii) Proximity to a potential basin. Developing a storage site near the power plant can contribute to reducing construction costs.

(iii) Size of total capacity. If the total capacity is large, CO_2 emissions are also large, so economies of scale can work to reduce the construction cost of the CCS system.

Details of the power plant selection process will be further discussed in later subsections.

1. List of Existing Coal Power Plants in Key ASEAN Countries (Indonesia, Malaysia Thailand, and Viet Nam) based on Pre-existing Studies

This study estimates emissions from coal-fired power plants in 10 ASEAN countries as shown in Table 1.1.

The top five emitting countries were Indonesia, Malaysia, the Philippines, Thailand, and Viet Nam. The study maps the emissions from power plants in these five countries.

Table 1.1. Emissions from Plants in 10 ASEAN Countries

	Total Emissions from Plants (tCO_2/year)
Brunei Darussalam	1,212,798
Cambodia	7,745,370
Indonesia	275,920,384
Lao PDR	10,352,885
Malaysia	100,455,753
Myanmar	1,047,417
Philippines	82,186,063
Singapore	0
Thailand	38,230,525
Viet Nam	148,984,151

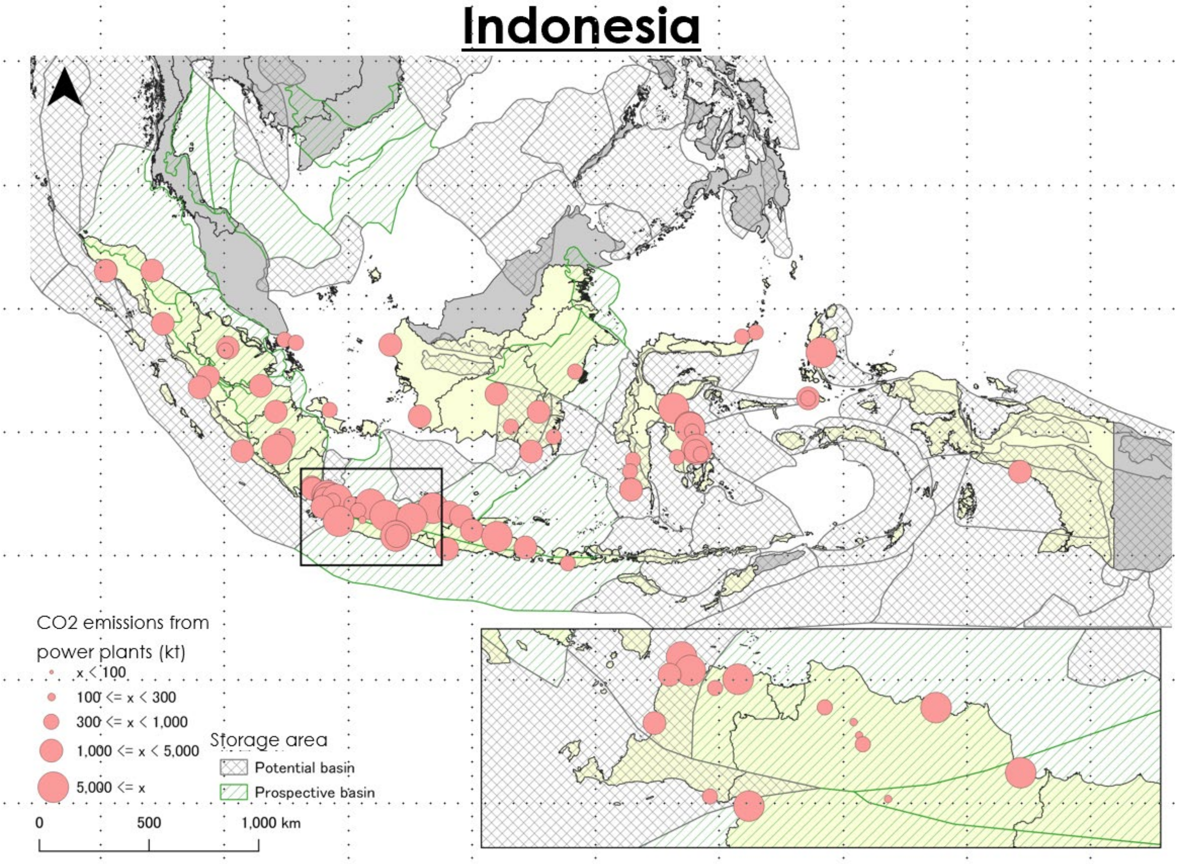
Source: Created by Mitsubishi Research Institute, plant information cited from Global Energy Monitor.

2. Mapping of All the Identified Coal Power Plants in the ASEAN Region

2.1. Indonesia

Indonesia is home to numerous coal-fired power plants. As shown in Figure 1.1, Power plants are concentrated especially in the western coastal areas of Java.

Figure 1.1. Coal-fired Power Plants in Indonesia

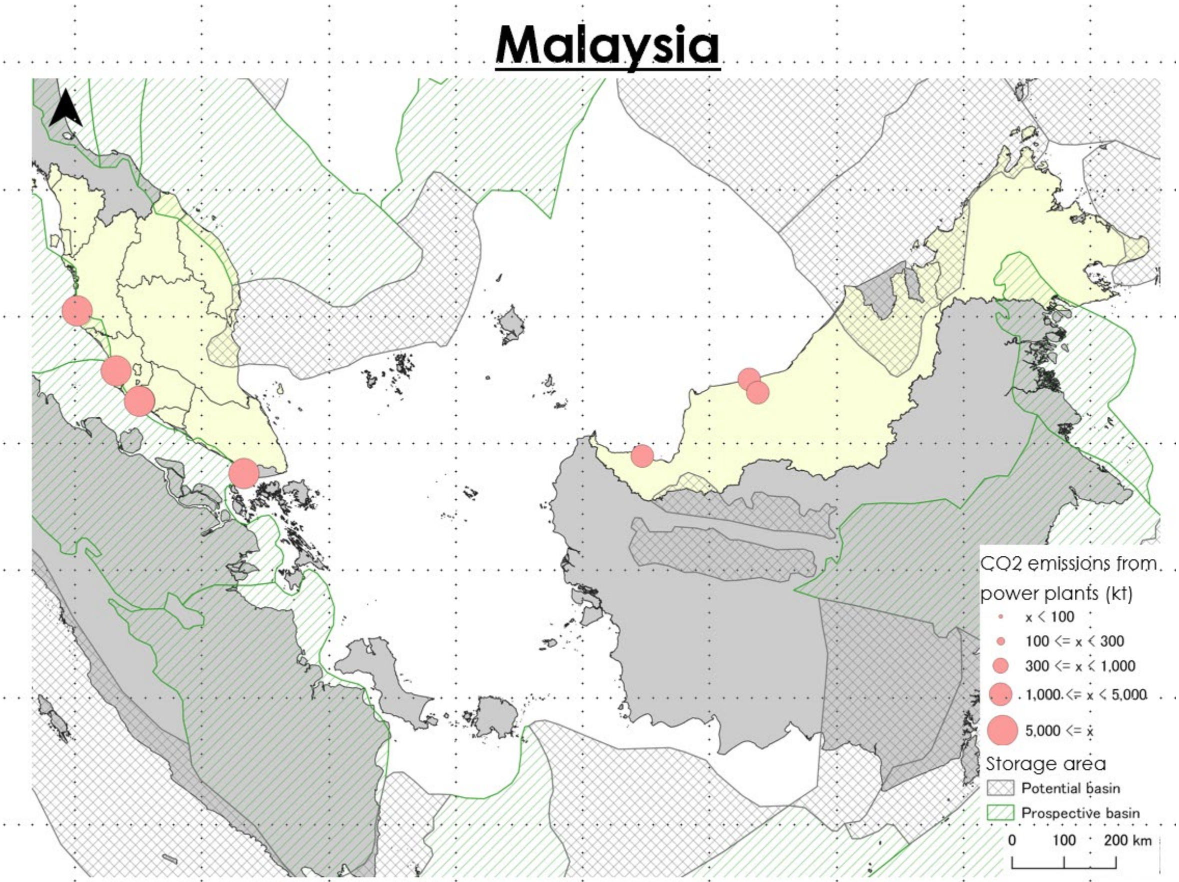


Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

2.2. Malaysia

Malaysia has relatively few coal-fired power plants. As shown in Figure 1.2, although the power plants with high emissions are located along the coast of the Malay Peninsula.

Figure 1.2. Power Plants in Malaysia

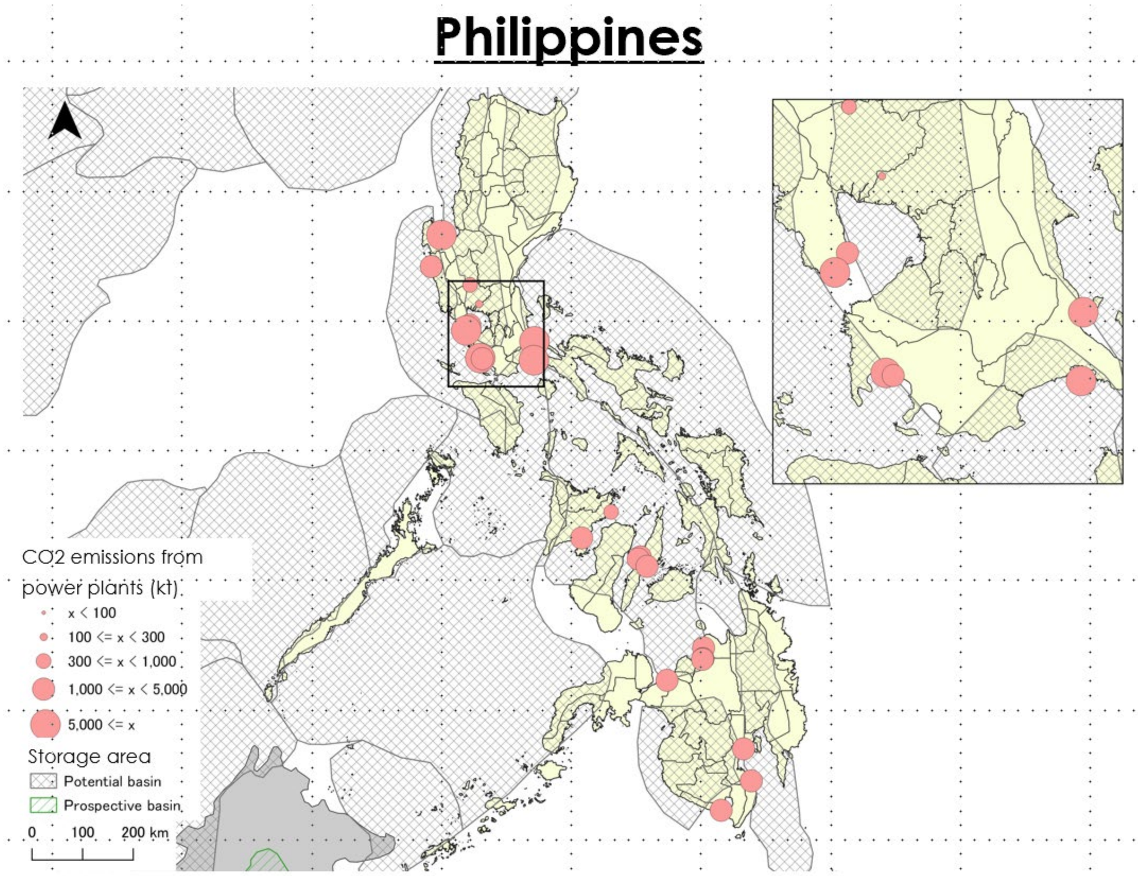


Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

2.3. Philippines

The Philippines has relatively few coal-fired power plants. Additionally, power plants with high emissions are located in Southern Luzon Island, as shown in Figure 1.3.

Figure 1.3. Power Plants in the Philippines

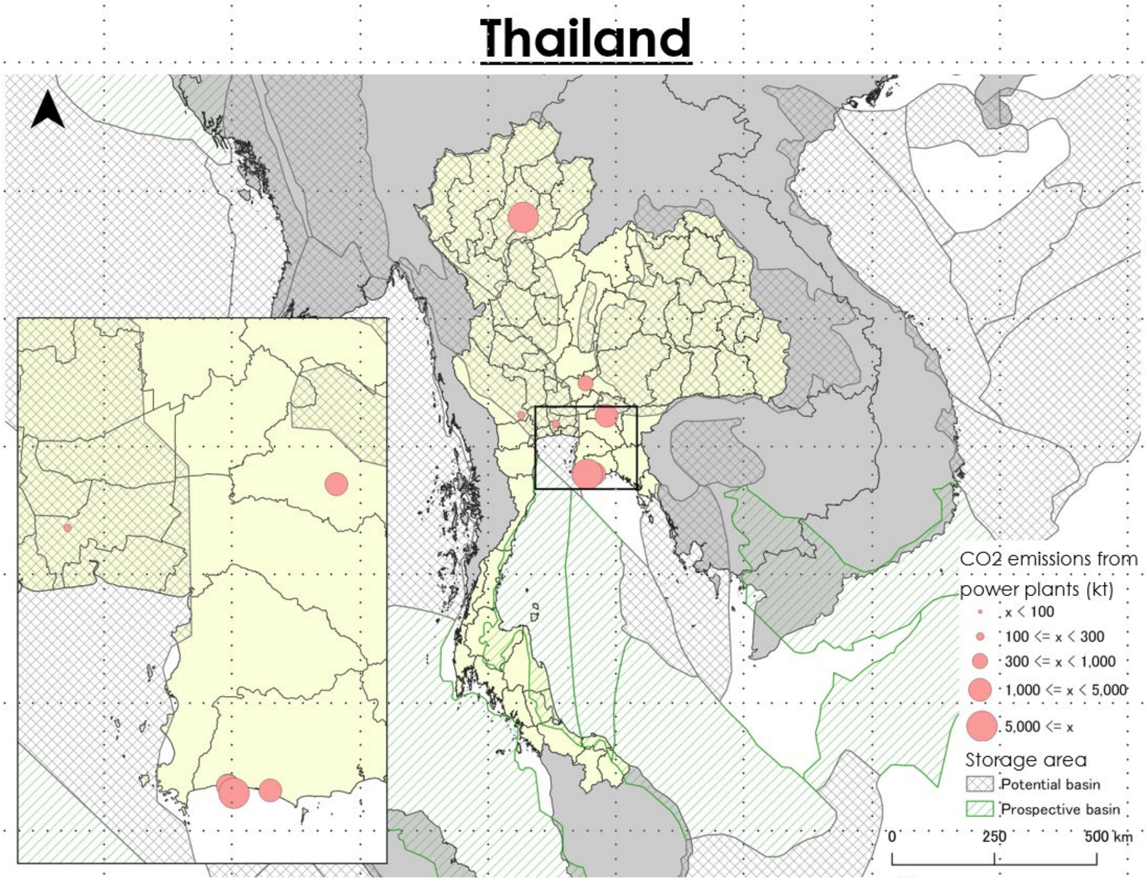


Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

2.4. Thailand

Thailand also has relatively few coal-fired power plants. Additionally, power plants with high emissions are located in northern Thailand and along the coast of the Gulf of Thailand, as shown in Figure 1.4.

Figure 1.4. Power Plants in Thailand

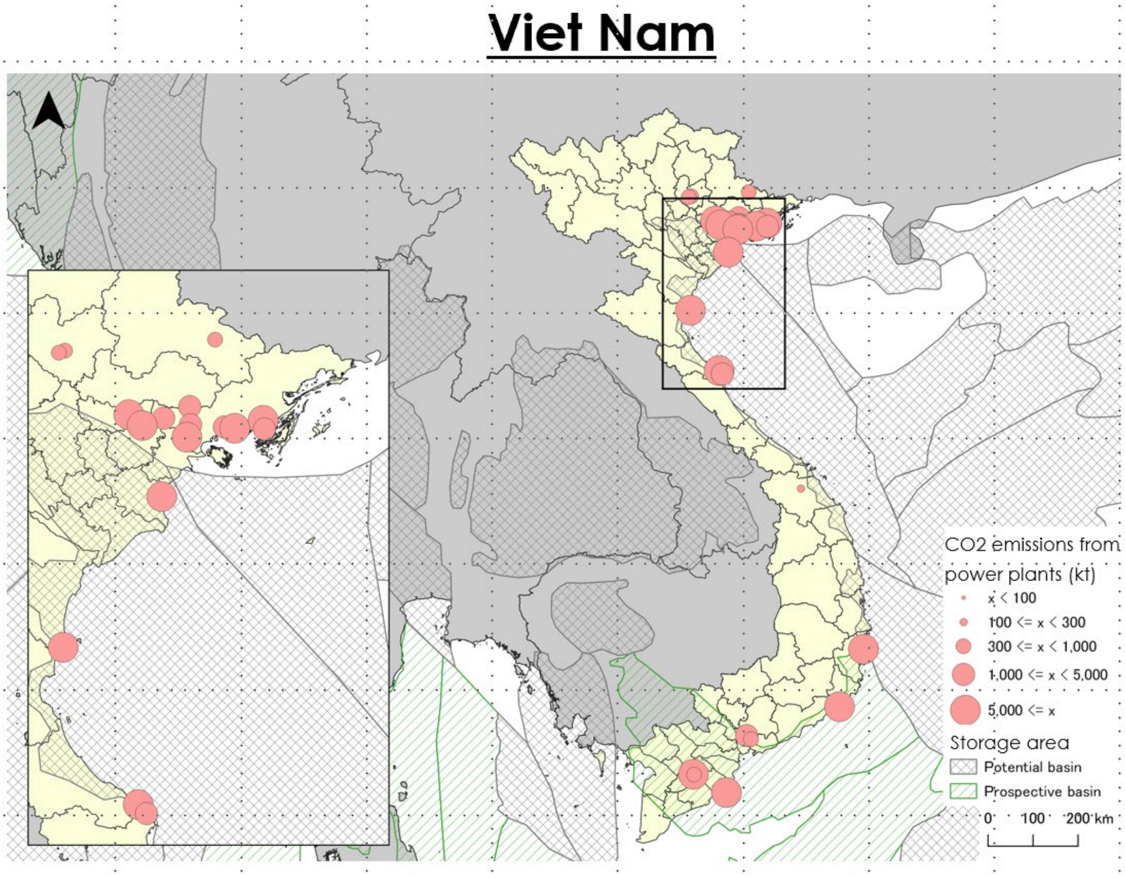


Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

2.5. Viet Nam

Viet Nam has numerous coal-fired power plants. The power plants with high emissions are concentrated along the coast near Hanoi or in the southern coastal regions of Viet

Figure 1.5. Power Plants in Viet Nam



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Box 1.1. Method for the Estimation of CO_2 Emissions
The calculation of the CO_2 emissions for each unit of the power plants is conducted as follows:
Emissions per unit = (a: Capacity of the unit) x (b: CO_2 emissions per capacity for each country)
b = (c: Total emissions of each country in 2017) / (d: Total capacity of each country in 2017)
c = (e: Total power generation of power plants in each country) x (f: Emission factor)

f = (g: Total amount of coal used by power plants in each country) x (h: Emission factor of sub-bituminous coal) x (i: Total power generation of power plants in each country)

* The values of (i) and (e) are different. The reason for using (i) is to ensure the accuracy of (f) by using the same source for (g) and (i).

Table 1.2. Method for the Estimation of CO_2 Emissions

No.	Parameter	Unit	Source/Equation
a	Capacity of the unit	MW	Global Energy Monitor [1]
b	CO_2 emissions per capacity for each country	tCO_2/MW	c/d
c	Total emissions of each country in 2017	tCO_2	e×f
d	Total capacity of each country in 2017	MW	World Research Institute [2]
e	Total power generation of power plants in each country	kWh	World Research Institute [2]
f	Emission factor	tCO_2/kWh	g×h×i
g	Total amount of coal used by power plants in each country	MTOE (converted to TJ)	IEA [3]
h	Emission factor of sub-bituminous coal	kg/TJ	IPCC [4]
i	Total power generation of power plants in each country	kWh	IEA [3]

Sources: [1] Global Energy Monitor (n.d.).
[2] World Research Institute (n.d.).
[3] IEA (2019).
[4] IPCC (2026).

3. Calculation of Estimated Power Generation, Coal Consumption, and CO_2 Emissions for Each Coal Power Plant by 2030

3.1. Selection of Candidate Coal Power Plants

Sixteen candidate plants were selected from the top five emitting countries identified from the mapping exercise conducted in Section 2 and based on the following evaluation indicators mentioned in the opening section of Chapter 1. The list of 16 selected power plants is shown in Table 1.3.

Table 1.3. Candidate Plants

Country (number of power stations)	Plant		Capacity (MW)	CO_2 Emissions (kt-CO_2/year)	Coal Consumption (kt/year)	Start Year
Indonesia (4)	Bangko Tengah Power Station	Unit 1	660	3,638	1,710	2023
		Unit 2	660	3,638	1,710	2023
	Jawa-7 Power Station	Unit 1	991	5,463	2,568	2019
		Unit 2	991	5,463	2,568	2020
	Tanjung Jati B Power Station	Unit 5	1,000	5,513	2,591	2022
		Unit 6	1,000	5,513	2,591	2022
	Central Java Power Project	Unit 1	950	5,237	2,462	2022
		Unit 2	950	5,237	2,462	2022
Malaysia (2)	Jimah East Power Station	Unit 1	1,000	7,564	3,556	2019
		Unit 2	1,000	7,564	3,556	2019
	Manjung Power Station	Unit 5	1,000	7,564	3,556	2017
		Unit 4	1,000	7,564	3,556	2015
Philippines (1)	Dinginin Power Station	Unit 1	668	4,600	2,162	2022
		Unit 2	668	4,600	2,162	2022
Thailand (2)	Mae Moh Power Station	Unit 4 (replacement)	655	4,080	1,918	2019
		Unit 5 (replacement)	655	4,080	1,918	2019
		Unit 6 (replacement)	655	4,080	1,918	2019

Country (number of power stations)	Plant		Capacity (MW)	CO_2 Emissions (kt-CO_2/year)	Coal Consumption (kt/year)	Start Year
		Unit 7 (replacement)	655	4,080	1,918	2019
	Map Tah BLCP Power Station	Unit 1	717	4,466	2,099	2007
		Unit 2	717	4,466	2,099	2006
Viet Nam (7)	Hai Duong Thermal Power Plant	Unit 1	600	3,027	1,423	2020
		Unit 2	600	3,027	1,423	2021
	Thai Binh Power Center	Unit 2-1	600	3,027	1,423	2023
		Unit 2-2	600	3,027	1,423	2023
	Nghi Son Power Station	Phase 2 Unit 1	660	3,638	1,710	2022
		Phase 2 Unit 2	660	3,638	1,710	2022
	Van Phong Power Station	Phase 1 Unit 1	716	3,612	1,698	2023
		Phase 1 Unit 2	716	3,612	1,698	2023
	Vinh Tan Power Station	Phase 1 Unit 1	600	3,027	1,423	2018
		Phase 1 Unit 2	600	3,027	1,423	2019

Country (number of power stations)	Plant		Capacity (MW)	CO_2 Emissions (kt-CO_2/year)	Coal Consumption (kt/year)	Start Year
		Phase 4 Unit 1	600	3,027	1,423	2017
		Phase 4 Unit 2	600	3,027	1,423	2018
		Phase 4 Extension	600	3,027	1,423	2019
	Song Hau Thermal Power Plant	Unit 1-1	600	3,027	1,423	2021
		Unit 1-2	600	3,027	1,423	2022
	Duyen Hai Power Generation Complex	Unit 2-1	600	3,027	1,423	2017
		Unit 2-2	600	3,027	1,423	2017
		Unit3-1	623	3,140	1,476	2017
		Unit 3-2	623	3,140	1,476	2017
		Unit3 Extension	688	3,471	1,631	2020
Total		-	-	168,012	78,978	-

Source: Created by Mitsubishi Research Institute, power plant information cited from Global Energy Monitor.

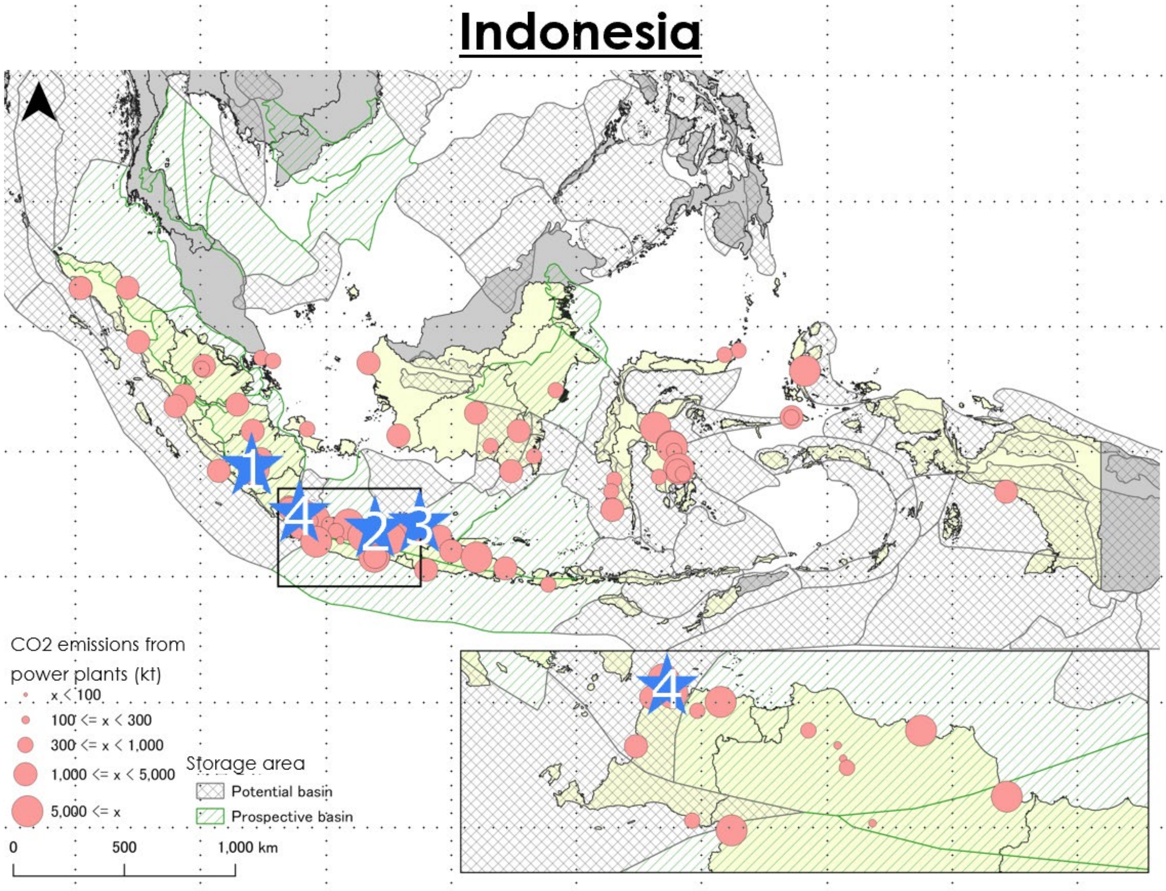
3.2. Comparison of the identified CO_2 sources with storage potential in the key countries (Indonesia, Malaysia, Thailand, and Viet Nam)

The 16 candidate plants mentioned in Section 3.1 were mapped for further assessment together with the locations of prospective and potential basins as shown in Figure 6–Figure 10. Prospective basins are defined here as basins with some existing data showing capacity for CO_2 storage including oil and gas facilities while potential basins include basins showing possibility of CO_2 storage in more general sense.

3.2.1. Indonesia

Indonesia is home to numerous coal-fired power plants. Additionally, power plants with high CO_2 emissions are predominantly located along the coast of Java Island. Potential basins are located near the coastal power plants, Tanjung Jati B Power Station and Jawa-7 Power Station. The power plants and storage sites in Indonesia are shown in Figure 1.6 and Table 1.4.

Figure 1.6. Power Plants in Indonesia



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.4. Power Plants and Storage Sites in Indonesia

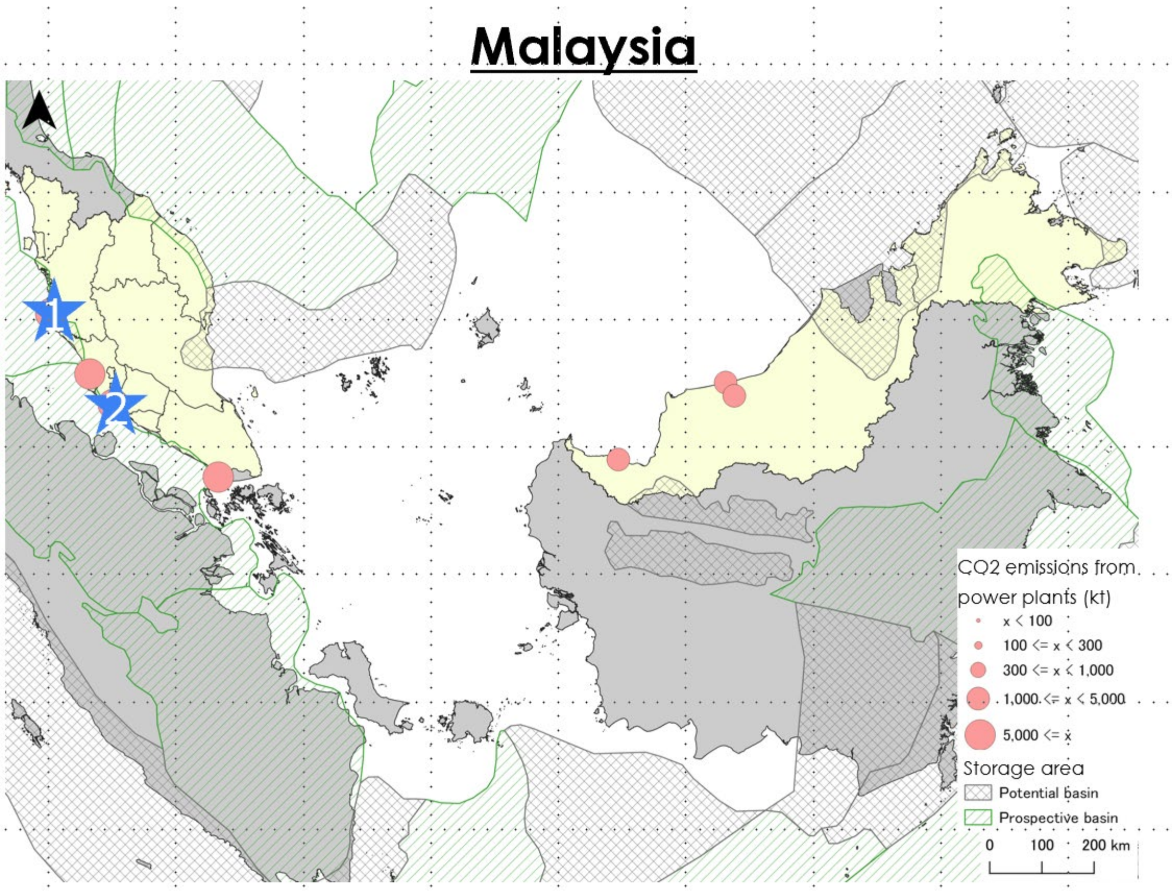
No.	Power Plant	Storage Site
1	Bangko Tengah Power Station	Prospective basin
2	Central Java Power Station	Prospective basin
3	Tanjung Jati B Power Station	Potential basin
4	Jawa-7 Power Station	Potential basin

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

3.2.2. Malaysia

Malaysia has relatively few coal-fired power plants. Although the power plants with high emissions are located along the coast of the Malay Peninsula, only prospective basins are found in the surrounding areas. The power plants and storage sites in Malaysia are shown in Figure 1.7 and Table 1.5.

Figure 1.7. Power Plants in Malaysia



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.5. Power Plants and Storage Sites in Malaysia

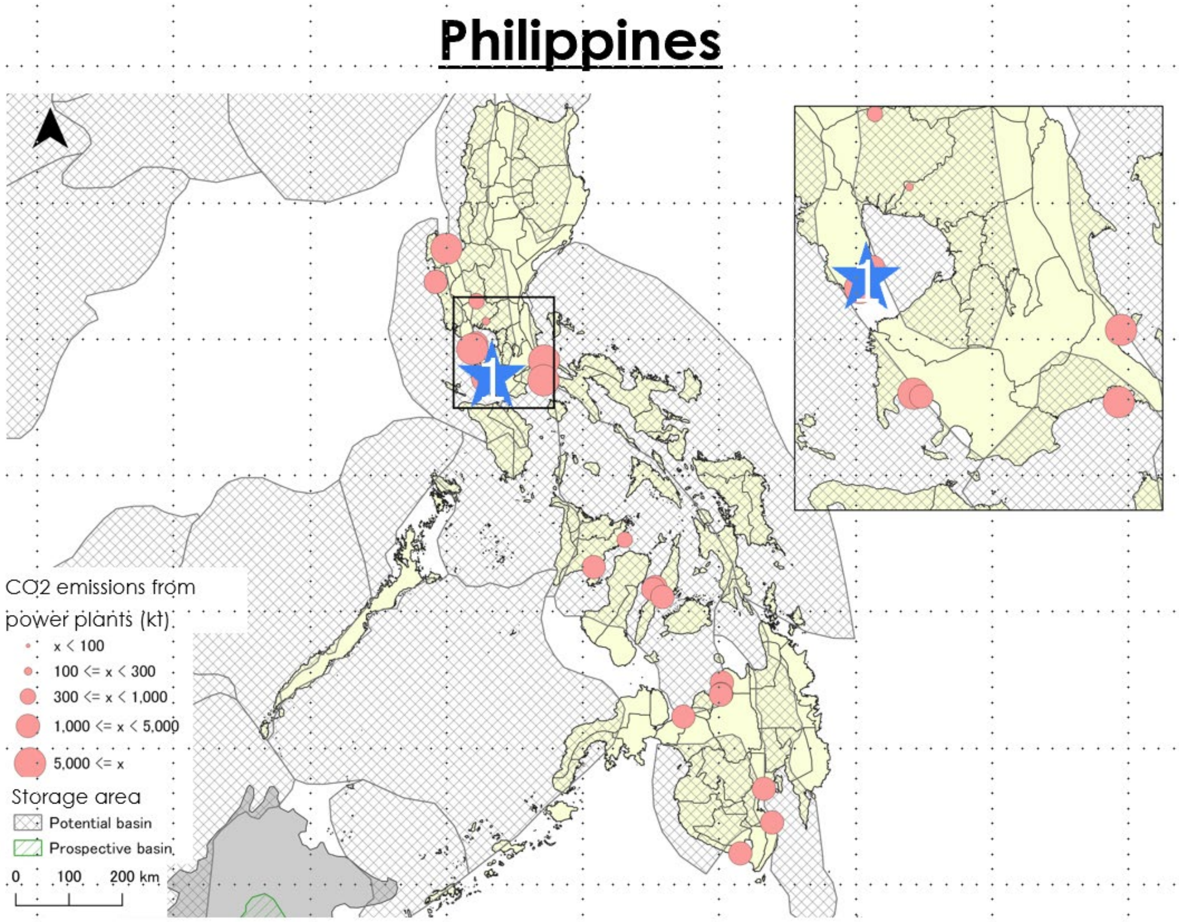
No.	Power Plant	Storage Site
1	Manjung Power Station	Prospective basin
2	Jimah East Power Station	Prospective basin

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

3.2.3. Philippines

The Philippines has relatively few coal-fired power plants. Additionally, power plants with high emissions are located in the Bataan Peninsula. However, whilst there are storage sites around Luzon Island, there are no storage sites along the Bataan Peninsula. The power plants and storage sites in the Philippines are shown in Figure 1.8 and Table 1.6.

Figure 1.8. Power Plants in the Philippines



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.6. Power Plant and Storage Site in the Philippines

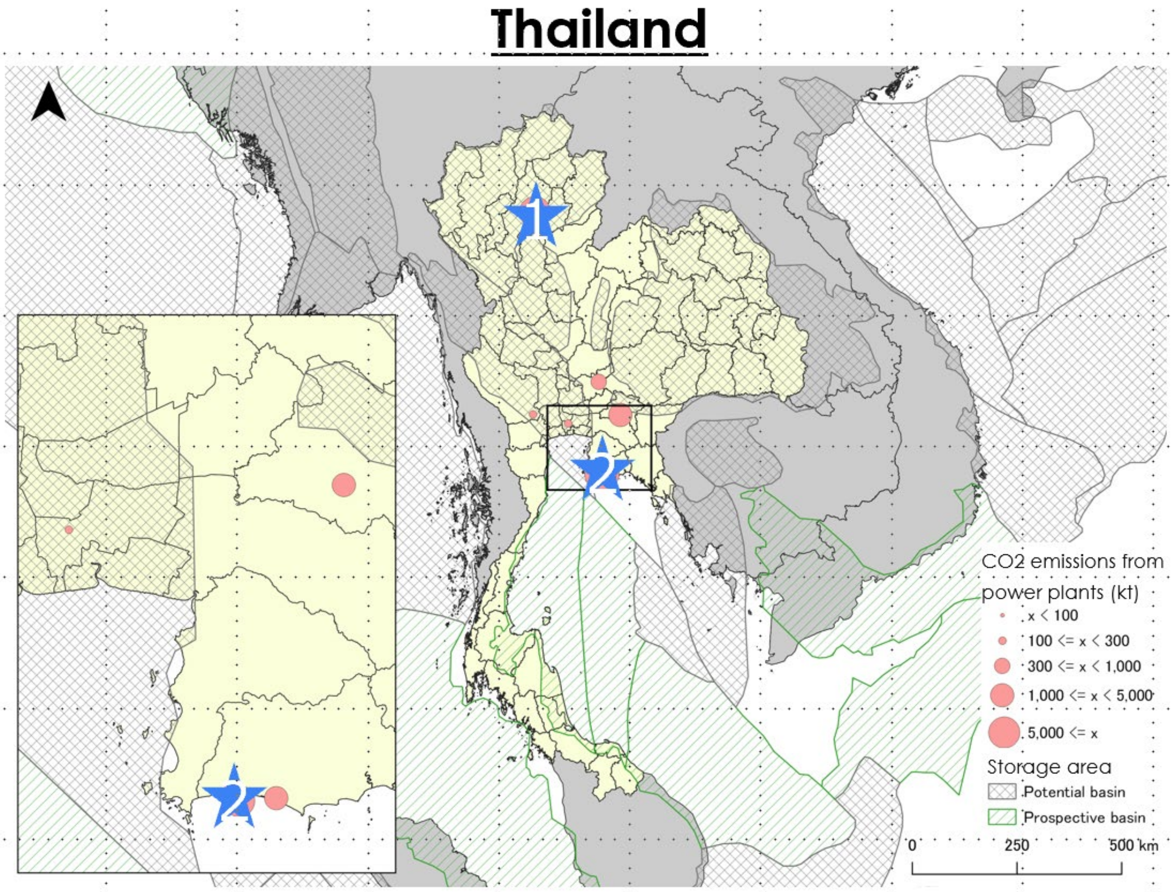
No.	Power Plant	Storage Site
1	Dinginin Power Station	N/A (potential basin nearby)

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

3.2.4. Thailand

Thailand has relatively few coal-fired power plants. Additionally, power plants with high emissions are located in northern Thailand and along the coast of the Gulf of Thailand. However, there are no storage sites along the coast of the Gulf of Thailand. Moreover, although there is a potential basin around the power plants in northern Thailand, it is challenging to find storage sites due to the inland location. The power plants and storage sites in Thailand are shown in Figure 1.9 and Table 1.7.

Figure 1.9. Power Plants in Thailand



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.7. Power Plants and Storage Sites in Thailand

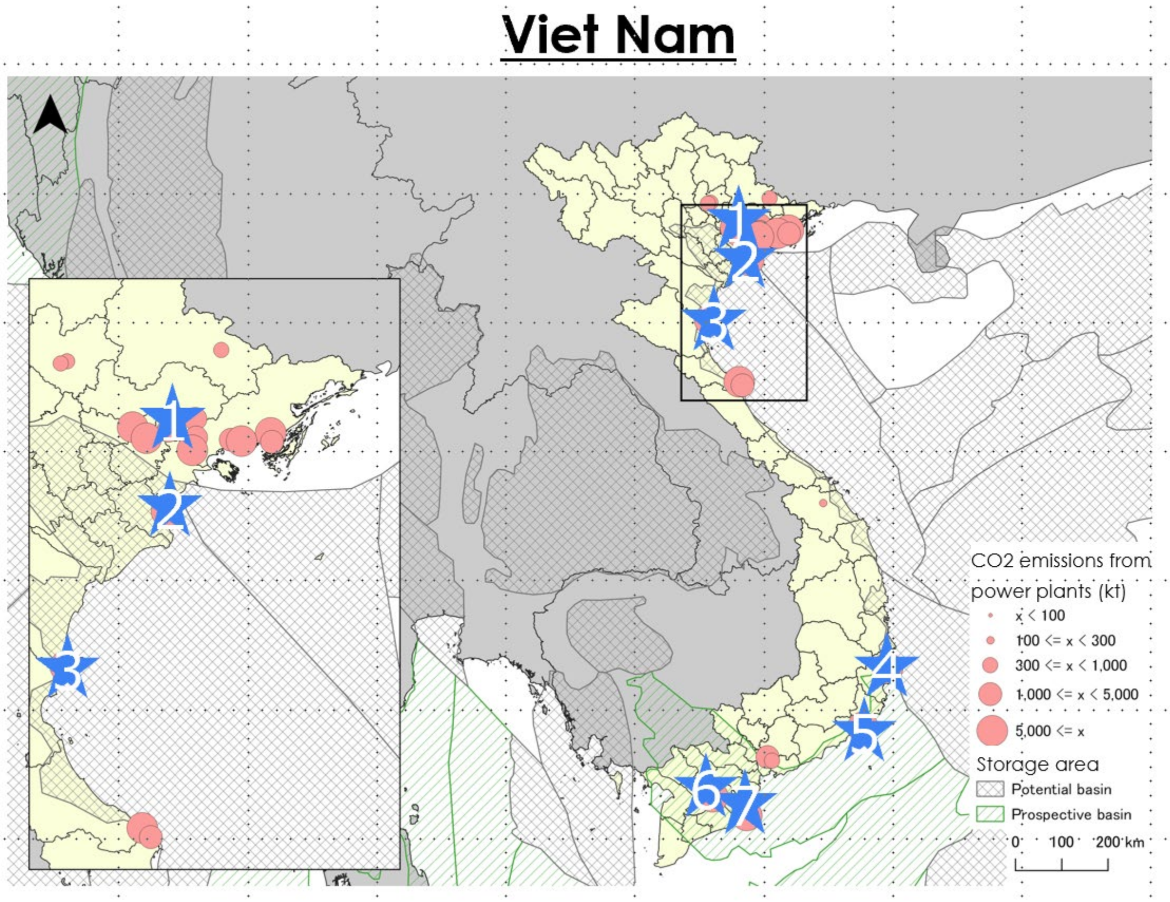
No.	Power Plant	Storage Site
1	Mae Moh Power Station	Potential basin
2	Map Ta Phut BLCP Power Station	N/A

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

3.2.5. Viet Nam

Viet Nam has numerous coal-fired power plants. The power plants with high emissions are concentrated along the coast near Hanoi or in the southern coastal regions of the country. Potential basins are located near three coastal power plants. The power plants and storage sites in Viet Nam are shown in Figure 1.10 and Table 1.8.

Figure 1.10. Power Plants in Viet Nam



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.8. Power Plants and Storage Sites in Viet Nam

No.	Power Plant	Storage Site
1	Hai Duong Thermal Power Plant	N/A
2	Thai Binh Power Center	Potential basin
3	Nghi Son Power Station	Potential basin
4	Van Phong Power Station	Potential basin
5	Vinh Tan Power Station	Prospective basin
6	Song Hau Thermal Power Plant	Prospective basin
7	Duyen Hai Power Generation Complex	Prospective basin

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

1) Selection of promising plants

As demonstrated in Table 1.9, the 16 candidate plants selected in the previous sub-section were narrowed down to two promising plants that are particularly suitable as CCS storage targets based on the following characteristics as mentioned in the opening section of this chapter.

(i) Proximity to the coast. By enabling the use of offshore storage, opportunities can be expanded by accepting CO_2 not only from power plants but also from overseas through cross-border transport.

(ii) Proximity to a potential or prospective basin. Developing a storage site near the power plant can contribute to reducing construction costs.

(iii) Size of the total capacity. If the total capacity is large, CO_2 emissions are also large, so economies of scale can work to reduce the construction cost of the CCS system.

Table 1.9. Sixteen Candidate Plants and Two Promising Plants

Country	Plant	Site	Storage Potential	Capacity
Indonesia	Bangko Tengah Power Station	Onshore	Prospective basin	660 MW x 2
	Central Java Power Station	**Offshore**	Prospective basin	950 MW x 2
	Tanjung Jati B Power Station*	**Offshore**	Potential basin	1,000 MW x 2
	Jawa-7 Power Station	**Offshore**	Potential basin	991 MW x 2
Malaysia	Manjung Power Station	**Offshore**	Prospective basin	1,000 MW x 2
	Jimah East Power Station	**Offshore**	Prospective basin	1,000 MW x 2
Philippines	Dinginin Power Station	**Offshore**	N/A (potential basin nearby)	668 MW x 2
Thailand	Mae Moh Power Station	Onshore	Potential basin	655 MW x 4
	Map Ta Phut BLCP Power Station	**Offshore**	N/A	717 MW x 2
Viet Nam	Hai Duong Thermal Power Plant	Onshore	N/A	600 MW x 2
	Thai Binh Power Center	**Offshore**	Potential basin	600 MW x 2
	Nghi Son Power Station	**Offshore**	Potential basin	660 MW x 2
	Van Phong Power Station	**Offshore**	Potential basin	716 MW x 2
	Vinh Tan Power Station	**Offshore**	Prospective basin	600 MW x 5
	Song Hau Thermal Power Plant	Onshore	Prospective basin	600 MW x 2
	Duyen Hai Power Generation Complex	**Offshore**	Prospective basin	600 MW x 2 / 623 MW x 2 / 688 MW x 1

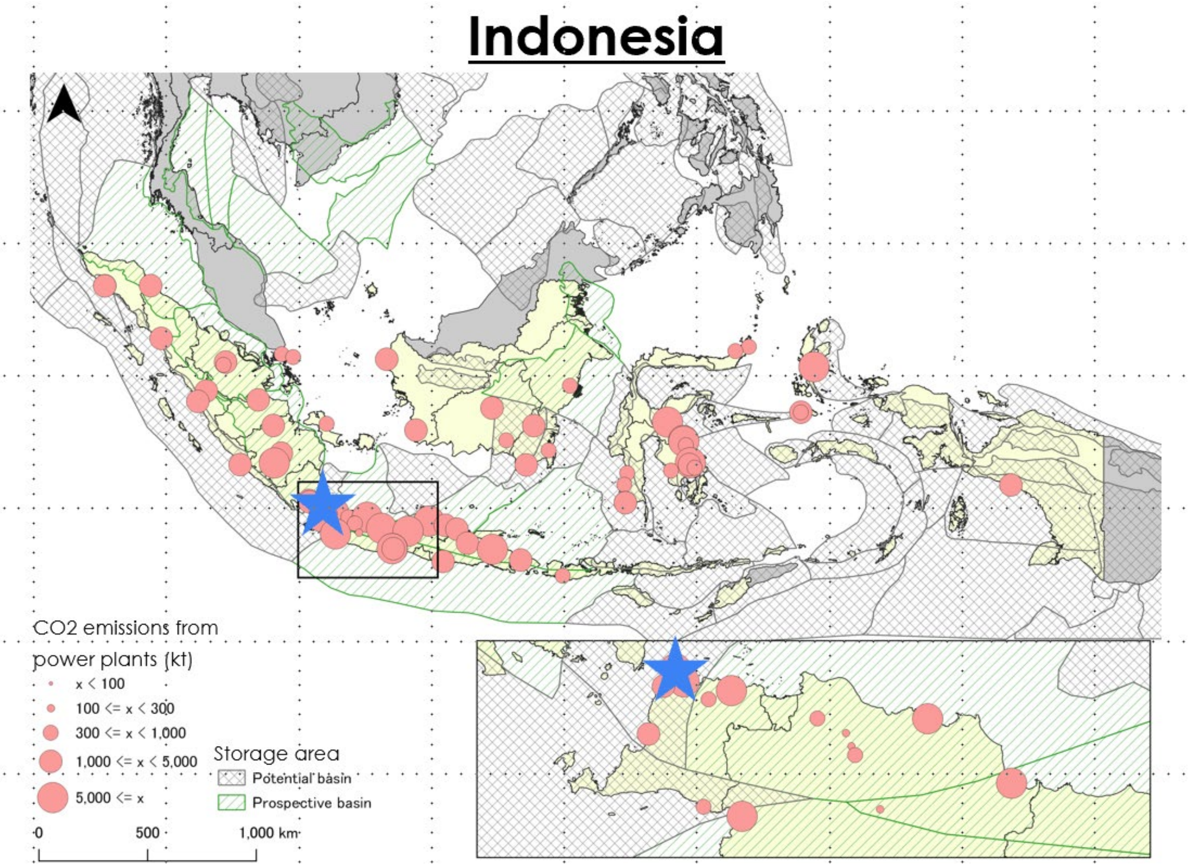
* Tanjung power station was beyond the scope of the study because it has already been surveyed by ERIA.
Note: The promising plants are indicated in red.
Source: Mitsubishi Research Institute.

2) Selection of promising power plants for CCS cost estimation

The details of the two promising power plants selected in the previous sub-section are as follows.

The first selection, Jawa-7 Power Station, is a high-emission facility located along the coast of Java Island, with a potential basin situated offshore nearby as shown in Figure 1.11 and Table 1.10.

Figure 1.11. Location of Java-7 Power Station in Indonesia



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

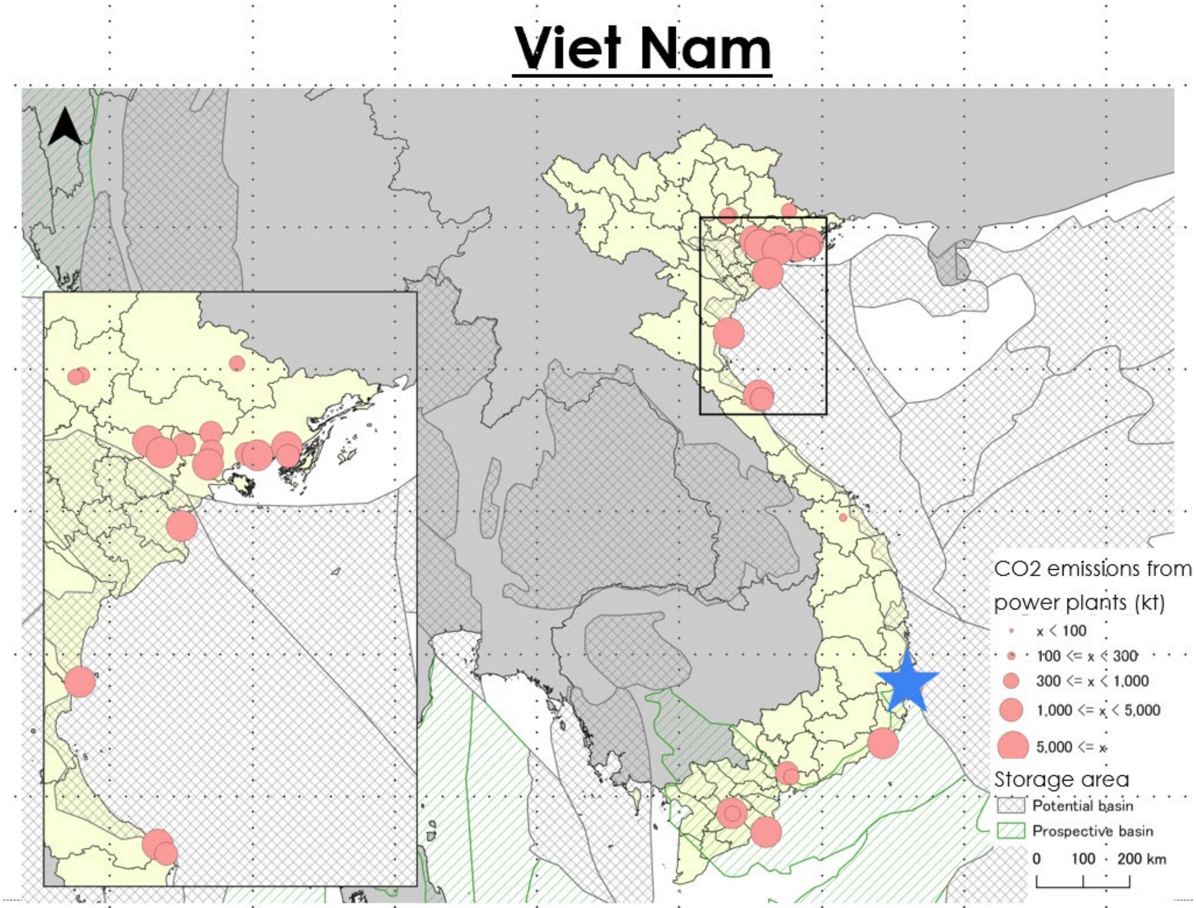
Table 1.10. Details of Jawa-7 Power Plant in Indonesia

Details	Jawa-7 Power Plant
Capacity	991 MW × 2
Country factor	75.9 (US: 99.2)
Type of power plant	Ultra super-critical (USC) coal
Type of capture technology	Chemical absorption (amine)
Capture efficiency	90%
Estimated CO_2 emissions	10.92 $MtCO_2$/y
Captured CO_2	9.83 $MtCO_2$/y
Pipeline length	50 km
Storage site	Offshore (potential basin)
Well depth	2,000 m
Project lifespan	25 years

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor, country factor information cited from Japan Machinery Center for Trade and Investment (2023).

The second selection, Van Phong Power Plant, is a high-emission facility located on the southern coast of Viet Nam, with a potential nearby basin situated offshore as shown in Figure 1.12 and Table 1.11.

Figure 1.12. Location of Van Phong Power Station in Viet Nam



Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

Table 1.11. Details of Van Phong Power Plant in Viet Nam

Details	Van Phong Power Plant
Capacity	716 MW × 2
Country factor	70.4 (US: 99.2)
Type of power plant	Ultra super-critical (USC) coal
Type of capture technology	Chemical absorption (amine)
Capture efficiency	90%
Estimated CO_2 emissions	7.22 $MtCO_2/y$
Captured CO_2	6.50 $MtCO_2/y$
Pipeline length	50 km
Storage site	Offshore (potential basin)
Well depth	2,000 m
Project lifespan	25 years

Source: Created by Mitsubishi Research Institute, storage information cited from Global Energy Monitor.

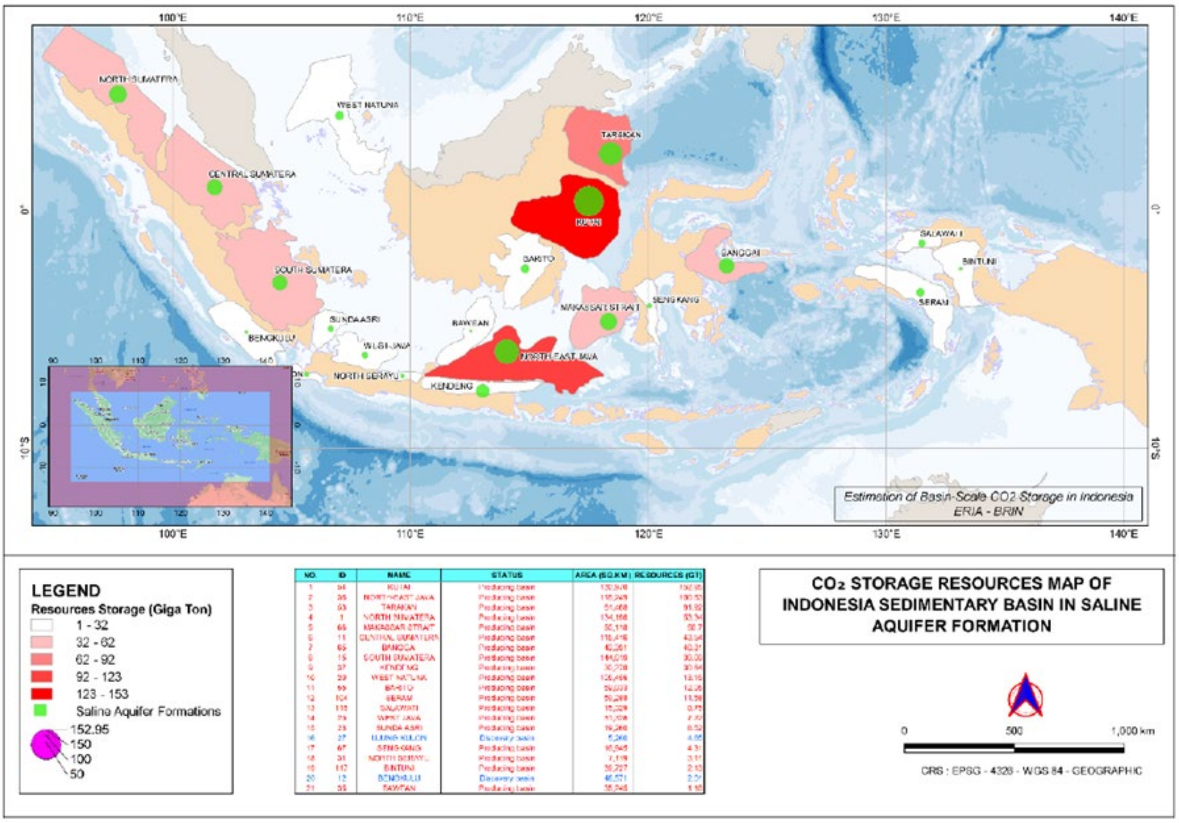
Chapter 2

CCS Cost Estimation Based on the Selection of the Pilot CCS Project

1. Reasons for the Selection of the Power Plants for the Feasibility Study

In Chapter 1, Jawa-7 Power Station and Van Phong Power Station were selected as promising plants. For the feasibility study (FS), the plant with the more detailed basin data, Jawa-7 Power Plant, was selected as the cost estimation can be conducted with a higher level of certainty. For Jawa-7 Power Plant, detailed reservoir data are obtained from Global Energy Monitor and the ERIA Study on Basins, as indicated in Figure 2.1.

Figure 2.1. Distribution of CO_2 Storage Resources in the Assessed Deep Saline Aquifers Across Sedimentary Basins of Indonesia



Source: ERIA, 'Estimation of Basin-Scale CO_2 Storage in Indonesia'.

2. Potential basins for the power plant subject to the FS

The ERIA Study on Basins identifies basins with sufficient data to estimate the CO_2 storage in deep saline aquifers as potential storage sites in Indonesia.

Amongst the basins covered in the ERIA Study on Basins, two offshore storage basins near the Jawa-7 Power Plant with two highly mature reservoirs were selected for the FS as indicated in Table 2.1.

Table 2.1. CO_2 Storage Resource Estimation for Deep Saline Aquifers by Basin

No	BASIN ID	BASIN NAME	BASIN STATUS	FORMATION	LITHOLOGY	CO2 STORAGE RESOURCES		
						Kg	Gigatonne(Gt)	
1	54	KUTAI	Producing basin	Balikpapan	Sandstone	1.5295E+14	152.95	152.95
2	36	NORTH EAST JAVA	Producing basin	Ngrayong	Sandstone	1.0083E+14	100.83	100.83
3	53	TARAKAN	Producing basin	Tarakan Fm	Sandstone	9.1920E+13	91.92	91.92
4	1	NORTH SUMATERA	Producing basin	Baong	Sandstone	4.2654E+13	42.65	53.34
			Producing basin	Keutapang	Sandstone	1.0683E+13	10.68	
5	66	MAKASSAR STRAIT	Producing basin	Lower Tanjung	Sandstone	2.5657E+13	25.66	50.70
			Producing basin	Berai	Limestone	2.5041E+13	25.04	
6	11	CENTRAL SUMATERA	Producing basin	Menggala	Sandstone	2.8296E+13	28.30	43.54
			Producing basin	Bekasap	Sandstone	1.5246E+13	15.25	
7	65	BANGGAI	Producing basin	Minahaki	Limestone	3.2400E+13	32.40	40.31
			Producing basin	Tomori	Limestone	7.9079E+12	7.91	
8	15	SOUTH SUMATERA	Producing basin	Talang Akar	Sandstone	2.4633E+13	24.63	39.69
			Producing basin	Baturaja	Carbonate	1.5054E+13	15.05	
9	37	KENDENG	Producing basin	Ngimbang	Sandstone	2.1133E+12	2.11	30.64
			Producing basin	Kujung	Limestone	2.5268E+13	25.27	
			Producing basin	Rancak	Limestone	3.2602E+12	3.26	
10	20	WEST NATUNA	Producing basin	Lower Gabus	Sandstone	1.3152E+13	13.15	13.15
11	55	BARITO	Producing basin	Lower Tanjung Fm	Sandstone	1.2052E+13	12.05	12.05
12	104	SERAM	Producing basin	Manusela Fm	Limestone	1.1581E+13	11.58	11.58
13	115	SALAWATI	Producing basin	Kais	Limestone	8.7547E+12	8.75	8.75
14	25	WEST JAVA	Producing basin	Upper Cibulakan	Sandstone	5.0705E+12	5.07	7.22
				Baturaja	Carbonate	2.1540E+12	2.15	
15	23	SUNDA ASRI	Producing basin	Baturaja	Limestone	2.7382E+12	2.74	6.52
			Producing basin	Talangakar	Sandstone	3.7864E+12	3.79	
16	27	UJUNG KULON	Discovery basin	Rajamandala	Sandstone	4.6466E+12	4.65	4.65
17	67	SENGKANG	Producing basin	Tacipi	Limestone	4.3091E+12	4.31	4.31
18	31	NORTH SERAYU	Producing basin	Halang Fm	Sandstone	3.1101E+12	3.11	3.11
19	117	BINTUNI	Producing basin	L.Kambelangan	Sandstone	2.1323E+12	2.13	2.13
20	12	BENGKULU	Discovery basin	Lemau Fm	Limestone	2.0138E+12	2.01	2.91
21	35	BAWEAN	Producing basin	Kujung	Limestone	1.1609E+12	1.16	1.16
		Total CO_2 Storage Resources				**6.8057E+14**	**680.57**	**680.57**

Source: Created by MRI based on ERIA, 'Estimation of Basin-Scale CO_2 Storage in Indonesia'.

Figure 2.2. Potential Basins for the Feasibility Study

Source: Map: HERE WeGo (wego.here.com) .(IPC licence number: [PL1702])
Additional data: Created by Mitsubishi Research Institute, storage site information cited from ERIA.

Whilst the Sunda Asri Basin is closer to the Jawa-7 Power Plant, it has a deeper storage depth. The emissions from the Jawa-7 Power Plant are about 10 Mt/yr, so it is possible to fill both basins even with 40 years of operation. The producing basin in the ERIA materials was recognised as synonymous with the potential basin in this study.

Table 2.2. Details of the Potential Basins Near Jawa-7 Power Plant

Details	Sunda Asri Basin
Basin status*	Producing basin
Distance from Jawa-7 Power Plant	160 km
Well depth*	900 m
CO_2 storage resources*	6.52 Gt

Table 2.2. *Continued*

Contents	West Java Basin
Basin Status*	Producing basin
Distance form Jawa-7 Power Plant	230 km
Well depth*	780 m
CO_2 storage resources*	7.22 Gt

Source: * Data sourced from ERIA, 'Estimation of Basin-Scale CO_2 Storage in Indonesia'.

3. Cost Estimation Results based on the FS

Calculations were performed for four patterns of the system: two potential basin sites, Sunda Asri and West Java; and two transportation methods, pipelines and ships. Where the reference values are derived from past values, they are converted to 2023 values using the Plant Cost Index, whilst the values derived from international sources are converted to Indonesian values using the Location Factor.

The results of the cost calculations reveal that pipeline transportation is cost effective because the potential basins are only about 200 km from Jawa-7 Power Plant. Whilst the Sunda Asri basin is farther away from Jawa-7 Power Plant, the storage depth is shallower. Therefore, the cost of storage is lower, resulting in a total cost advantage. Due to the lower transportation cost for Sunda Asri, the details of the cost estimation will be presented for the case of Sunda Asri hereafter.

Table 2.3. Results of the CCS Cost Calculation

(2023 US$/t-$CO_2$)

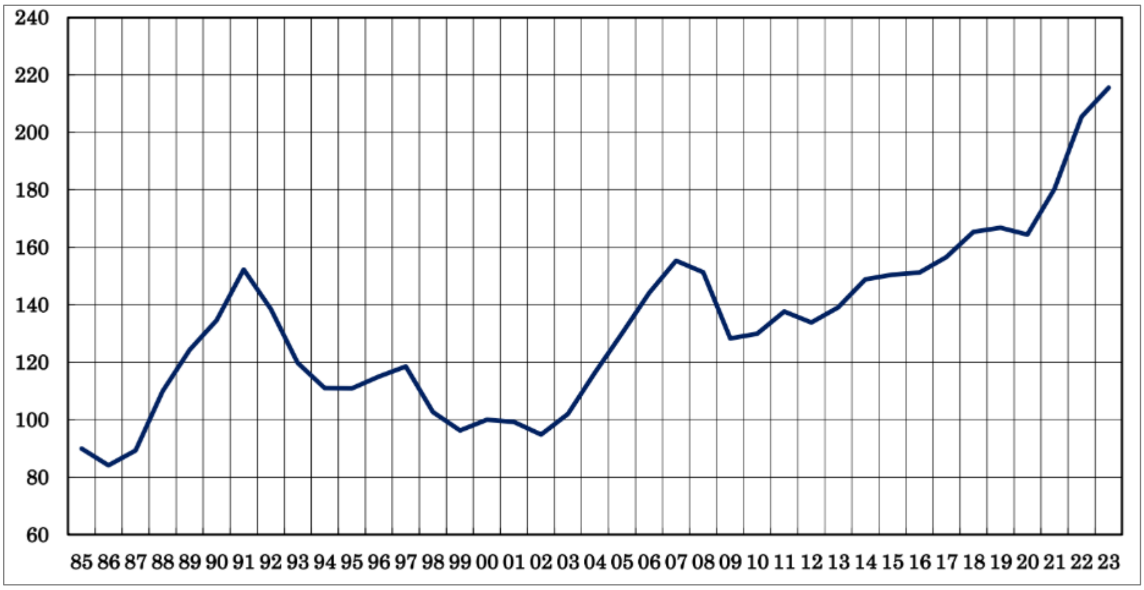
		Capture	Transport	Storage	Total
Sunda Asri	Pipeline	54.75	2.83	13.40	70.98
	Ship	54.75	10.57	13.50	78.82
West Java	Pipeline	54.75	3.81	12.89	71.45
	Ship	54.75	10.61	12.89	78.45

Source: Mitsubishi Research Institute.

Box 2.1. Applying the Plant Cost Index and Location Factor

The target years for the cost calculation differ for the various sources cited in this study. Therefore, the Plant Cost Index (PCI), published by the Machinery Center for Trade and Investment in Japan, was applied to adjust to the cost in 2023, the latest year available. The baseline for this indicator was set at 100 for the year 2000. For each component, the PCI was used to account for the 2023 cross-sectional costs.

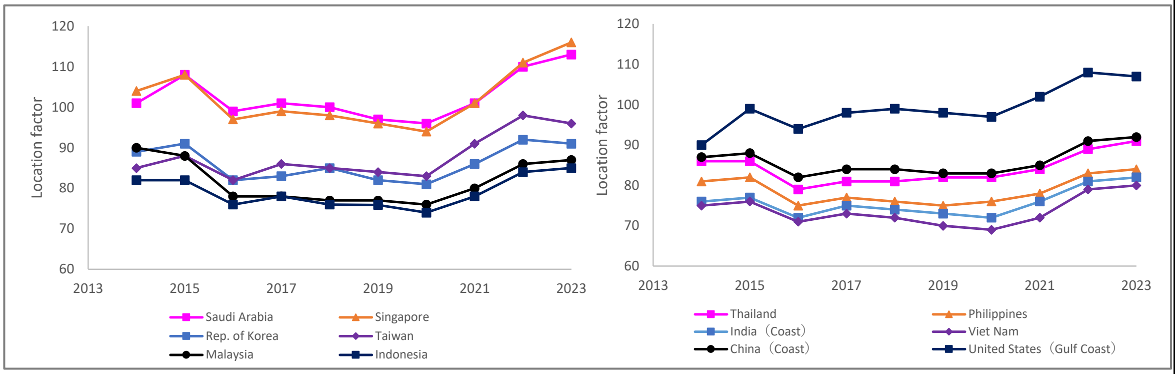
Figure 2.3. Price Cost Index, 1985–2023



Note: Indexed as 100 for 2000.
Source: Japan Machinery Center for Trade and Investment (2023).

The Location Factor quantifies the differences in plant construction costs in different parts of the world, whilst the PCI gives the current domestic plant construction costs based on past actual plant construction costs. The LF varies for each country. However, as shown in Figure 2.4, the PCI remains steady across countries, especially Indonesia (black squares in the left chart), but with the exception of Saudi Arabia (pink squares in the left chart), Singapore (orange triangles in the left chart), and the United States (dark blue squares in the right chart).

Figure 2.4. Location Factors for Selected Countries



Source: Created by Mitsubishi Research Institute based on Japan Machinery Center for Trade and Investment (2023).

3.1. Capture Cost

3.1.1. Estimation method for the capture cost

The capture cost is estimated based on data from the United States National Energy Technology Laboratory (NETL). The NETL data show the plant cost of a coal power plant without CCS and the plant cost of a coal power plant with CCS. The difference between these two costs was assumed to be the cost of installing CCS. From the data, the total plant cost (capital costs), fixed costs, variable costs, and fuel costs were extracted to estimate the cost of installing CCS in the Jawa-7 plant. For cost estimation, a scaling rule of 0.6 power was applied to the capital cost and fixed cost. Other costs were assumed to be proportional to the amount of electricity generated. The data used and the calculation results are described in Table 2.4.

Table 2.4. Cost and Power Plant Data

	Coal Plant without CCS	Coal Plant with CCS
Total plant cost (2018US$/kW)	2,103	3,452
Fixed costs (US$/MWh)	9.5	14.8
Variable costs(US$/MWh)	7.7	13.2
Fuel costs (US$/MWh)	18.9	24.0

Table 2.4. *Continued*

	Model Study (National Energy Technology Laboratory)	Jawa-7
Capacity (MW)	763	991 x 2
Amount of power generation (kWh)	5,603	10,786

Source: Created by the author based on the National Energy Technology Laboratory (2022).

3.1.2. Capture cost calculation for Jawa-7/Sunda Asri basin

When using the NETL (2022) model, the cost of capturing 1 tonne of CO_2 in the capture process was calculated to be US$54.75, as described in Table 2.5. The assumptions for the calculations are as follows:

- The 0.6 power-scaling rule was applied to both capital cost and fixed cost.
- The emission factor obtained in Step 1 was used to calculate the cost per tCO_2.
- A discount rate of 7% was assumed.
- The operational period is 25 years.
- Because the reference data is for 2018 values, we used the PCI for capture cost to correct the data to 2023 values.

Table 2.5. Capture Cost

Category	Cost
Capital costs (US$/$tCO_2$)	22.98
Fixed costs (US$/$tCO_2$)	9.87
Variable costs (US$/$tCO_2$)	11.37
Fuel costs (US$/$tCO_2$)	10.54
Capture cost (2023 US$/$tCO_2$)	**54.75**

Source: Created by Mitsubishi Research Institute.

Box 2.3. Technologies for Carbon Capture

As the capture cost comprises most of the CCS cost, reduction of the capture cost is crucial in bringing down the overall CCS cost, which is much needed in the future to deploy a large number of projects.

Although the capture cost estimation in this Study assumes amine-based chemical absorption, which is the most proven technology, there are several new technologies under development and demonstration. These include advanced solvents and sorbents, such as using new solvents for physical absorption and membranes that enable increasing the effectiveness and efficiency of CO_2 separation and capture, leading to more CO_2 capture at less energy use. The advancement of technological innovation is essential in reducing the cost of carbon capture and enabling large-scale deployment.

3.2. Transport Cost

3.2.1. Estimation method for transport cost

Pipeline costs have proven to be highly variable depending on factors such as terrain and infrastructure. The NETL report includes empirical pipeline costs based on various terrains and scenarios as cited by Kinder Morgan representatives at the 2009 Spring Coal Fleet Meeting, as described in Table 2.6. These costs range from US$50,000 to US$700,000. The NETL model refers to four different calculation models for the pipeline transportation cost, as shown in Table 2.7. Since this study assumes offshore CO_2 storage, which is assumed to incur the highest capital cost, the model with the highest pipeline cost, Parker's model, is selected to calculate the transportation cost in the NETL model.

Table 2.6. Kinder Morgan Pipeline Cost Metrics

Terrain	Capital Cost (US$ / inch / mile)
Flat, Dry	$50,000
Mountainous	$85,000
Marsh, Wetland	$100,000
River	$300,000
High Population	$100,000
Offshore (150-ft to 200-ft depth)	$700,000

Source: Created by MRI based on National Energy Technology Laboratory (2023).

Table 2.7. CO_2 Pipeline Capital Costs Used for the Calculation

Equation	Diameter (in.)	Length (mi)					
		50	100	200	300	500	1,000
Parker	8	100,749	99,826	99,365	99,211	99,088	98,995
	12	85,001	84,386	84,078	83,976	83,894	83,832
	16	89,873	89,356	89,097	89,011	88,942	88,891
	20	94,260	93,824	93,607	93,534	93,476	93,432
	24	102,147	101,762	101,570	101,506	101,454	101,416
	30	108,337	108,029	107,875	107,824	107,783	107,752
	42	125,426	125,206	125,096	125,060	125,030	125,008
McCoy and Rubin	8	55,034	49,572	44,805	42,304	39,426	35,962
	12	53,792	48,396	43,669	41,182	38,312	34,844
	16	59,883	53,866	48,582	45,795	42,573	38,668
	20	63,188	56,851	51,274	48,328	44,916	40,773
	24	67,306	60,580	54,651	51,513	47,877	43,452
	30	68,128	61,366	55,392	52,226	48,549	44,065
	42	70,208	63,342	57,257	54,022	50,256	45,649
Rui et al.	8	45,408	40,768	36,741	34,637	32,224	29,329
	12	44,502	39,831	35,766	33,637	31,190	28,246
	16	49,608	44,334	39,735	37,323	34,545	31,197
	20	52,362	46,758	41,864	39,293	36,330	32,753
	24	55,751	49,764	44,528	41,775	38,599	34,758
	30	56,347	50,283	44,972	42,175	38,945	35,033
	42	57,782	51,571	46,117	43,239	39,908	35,866
Brown et al.	8	55,514	52,956	50,640	49,388	47,912	46,077
	12	53,445	50,879	48,544	47,277	45,777	43,903
	16	59,014	56,124	53,486	52,051	50,349	48,215
	20	61,914	58,848	56,045	54,517	52,703	50,423
	24	65,635	62,365	59,369	57,735	55,791	53,345
	30	66,012	62,707	59,674	58,017	56,043	53,556
	42	67,215	63,841	60,738	59,039	57,012	54,451

Source: National Energy Technology Laboratory (2023).

3.2.2. Transport cost calculation

1) Transport cost (pipeline)

When using the NETL (2022) model, the cost of transporting 1 tonne of CO_2 was calculated to be US$3.93, as demonstrated in Table 2.8. The assumptions for the calculations are as follows:

- The 0.6 power-scaling rule was applied to CAPEX.
- A discount rate of 7% was assumed.
- The operational period is 25 years.
- Because the reference data is for 2011 values, the PCI was applied to the capture cost to correct the data to 2023 values.

Table 2.8. Transport Cost (Pipeline)

	Component	Cost
CAPEX	Materials (2011 US$1,000)	40,883
	Labour (2011 US$1,000)	82,722
	ROW-Damages (2011 US$1,000)	5,322
	Miscellaneous (2011 US$1,000)	27,408
	CO_2 surge tanks (2011 US$1,000)	1,244
	Pipeline control system (2011 US$1,000)	112
	Pumps (2011 US$1,000)	9,870
	Contingency (2011 US$1,000)	25,135
OPEX	Pipeline fixed O&M (2011 US$1,000/yr)	3,942
	Pipeline-related equipment and pump fixed O&M (2011 US$1,000/yr)	449
	Electricity costs for pumps (variable O&M) (2011 US$1,000/yr)	3,718
Transport cost (2023 US$/t-$CO_2$)		**2.83**

O&M = operation and maintenance, ROW = right of way.
Source: Mitsubishi Research Institute.

2) Estimation method for transport cost (ship)

The UK government's CO_2 transport cost model, which is also cited in the IEAGHG Technical Report (IEAGHG, 2020b), was used as the basis for the calculation of the transport cost by ship. The model provides values at a flow rate of 0.5 Mtpa, 1 Mtpa, 2 Mtpa, 5 Mtpa, and 10 Mtpa. Since the transport volume from the Jawa-7 plant is 9.87 Mtpa, the calculation is conducted by interpolation from the costs for the 5 Mtpa and 10 Mtpa cases. In this model, the optimal size and number of vessels are determined based on the relationship between distance and transport volume, as described in Table 2.10.

Table 2.9. Optimal Ship Size and Number of Vessels Calculated from the Relationship between Distance and Transport Volume

	Flow rate (Mtpa)						
Transportation distance (km)	0.1	0.2	0.5	1	2	5	10
200	1x1,000	1x2,000	1x4,000	1x8,000	1x20,000	1x30,000	2x30,000
400	1x2,000	1x2,000	1x4,000	1x8,000	1x20,000	1x40,000	2x40,000
600	1x2,000	1x2,000	1x8,000	1x10,000	1x20,000	1x50,000	2x50,000
800	1x2,000	1x4,000	1x8,000	1x20,000	1x30,000	2x30,000	3x40,000
1,000	1x2,000	1x4,000	1x8,000	1x20,000	1x30,000	2x40,000	3x50,000

Source: Element Energy (2018).

The IEA model was then applied to estimate the cost of transporting the CO_2 by ship. The estimated costs are shown in Table 2.10. The assumptions for the calculations are as follows:

- The 0.6 power-scaling rule was applied to CAPEX.
- A discount rate of 7% was assumed.
- The operational period is 25 years.
- Because the reference data is for 2019 values, the PCI was applied to the capture cost to correct the data to 2023 values.

Table 2.10. Transport Cost (Ship)

Component	Cost
Liquefaction (2023 US$/t-$CO_2$)	5.08
Temporary CO_2 storage (loading) (2023 US$/t-$CO_2$)	0.60
Loading (2023 US$/t-$CO_2$)	0.22
Ship (2023 US$/t-$CO_2$)	2.50
Ship fuel cost (2023 US$/t-$CO_2$)	0.15
Harbour fee (2023 US$/t-$CO_2$)	0.38
Unloading (2023 US$/t-$CO_2$)	0.32
Gasification (2023 US$/t-$CO_2$)	1.31
Total (2023 US$/t-$CO_2$)	**10.57**

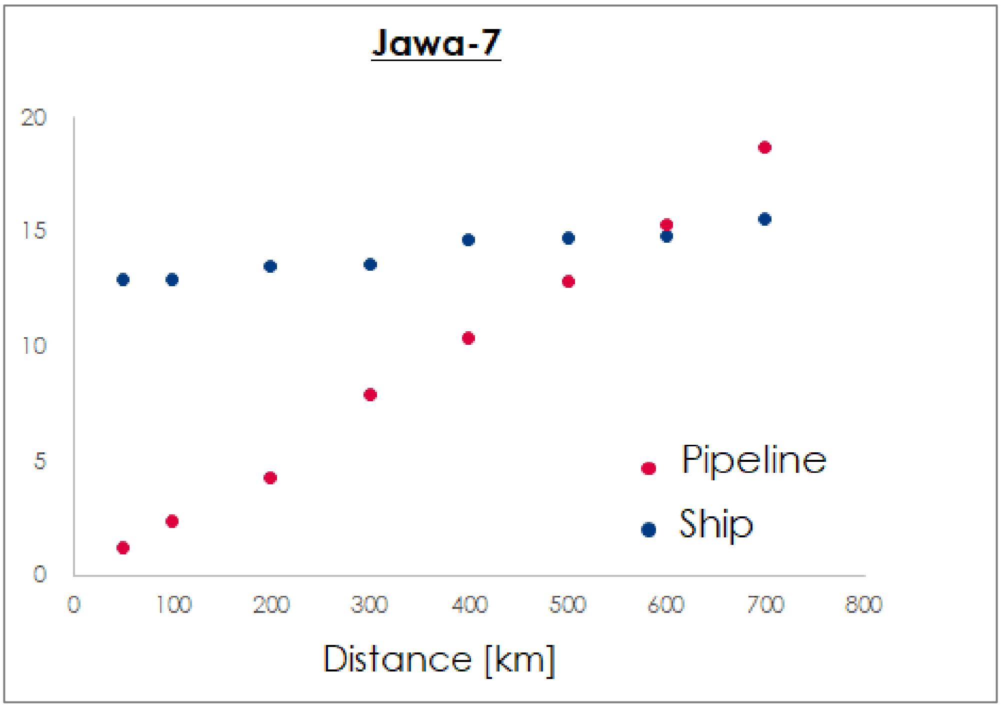
Source: IEAGHG (2020b).

Box 2.4. Transport Cost Sensitivity Analysis

A sensitivity analysis was conducted for transportation costs by pipeline and ship, with the distance from Jawa-7 Power Plant as a variable.

The results of the calculation of the transportation costs for pipelines and ships over distances of 50–700 km showed that in both cases, pipelines have a cost advantage within approximately 500 km, whilst ships have a cost advantage over pipelines for distances of 500 km or more.

Figure 2.5. Transport Cost Sensitivity Analysis



Source: Mitsubishi Research Institute.

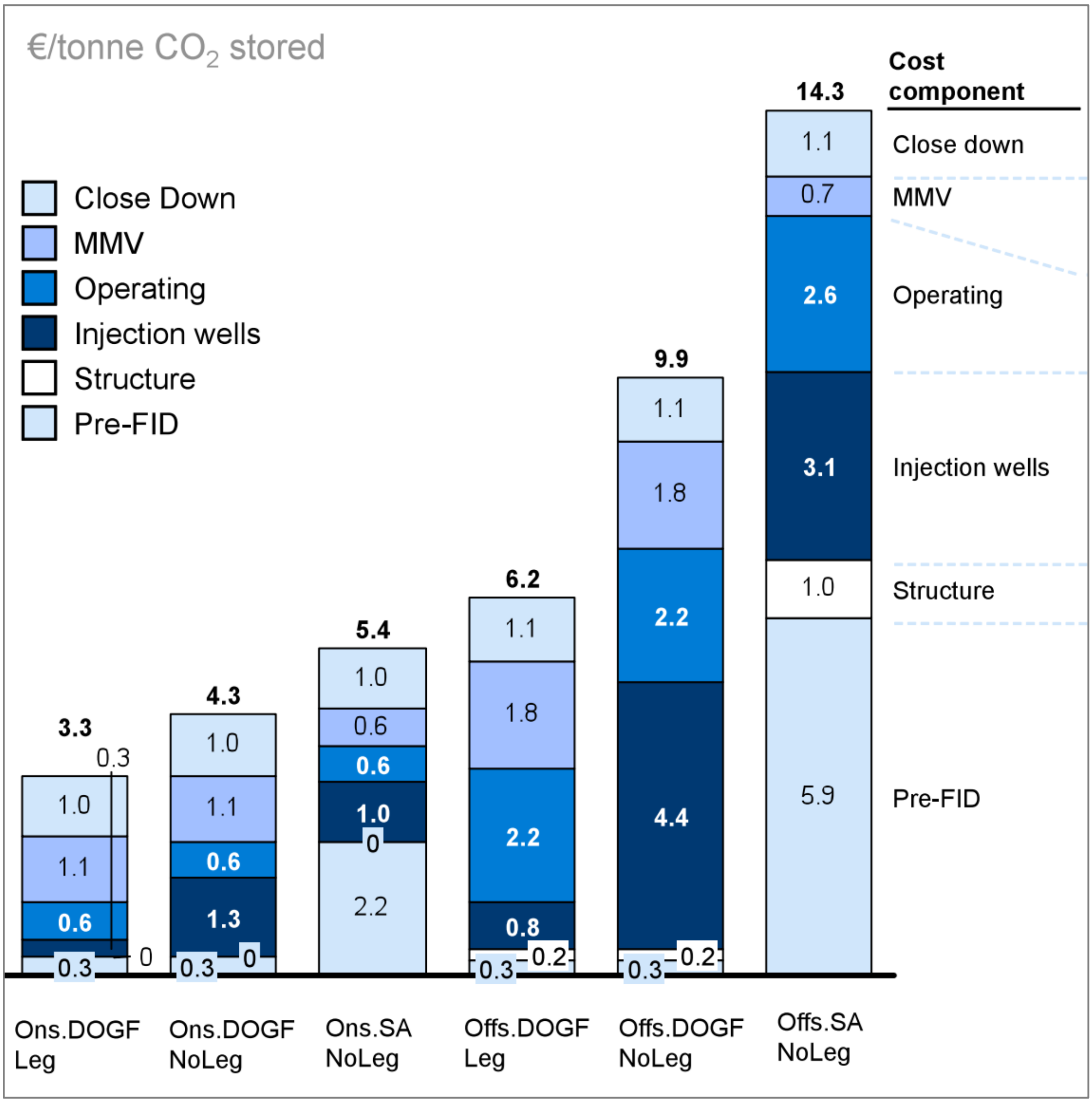
3.3. Storage Cost

3.3.1. Estimation method for storage cost

The storage cost is estimated based on the Zero Emissions Platform (ZEP, n.d.), an initiative established with the support of the European Union, primarily to promote CCS technologies for offshore/onshore and reservoir storage. As shown in Figure 2.6 and Figure 2.7, storage costs are expected to vary depending on the CO_2 storage volume and depth of storage; since there is no detailed breakdown for CAPEX and OPEX, the following assumptions are made for the storage volume and depth.

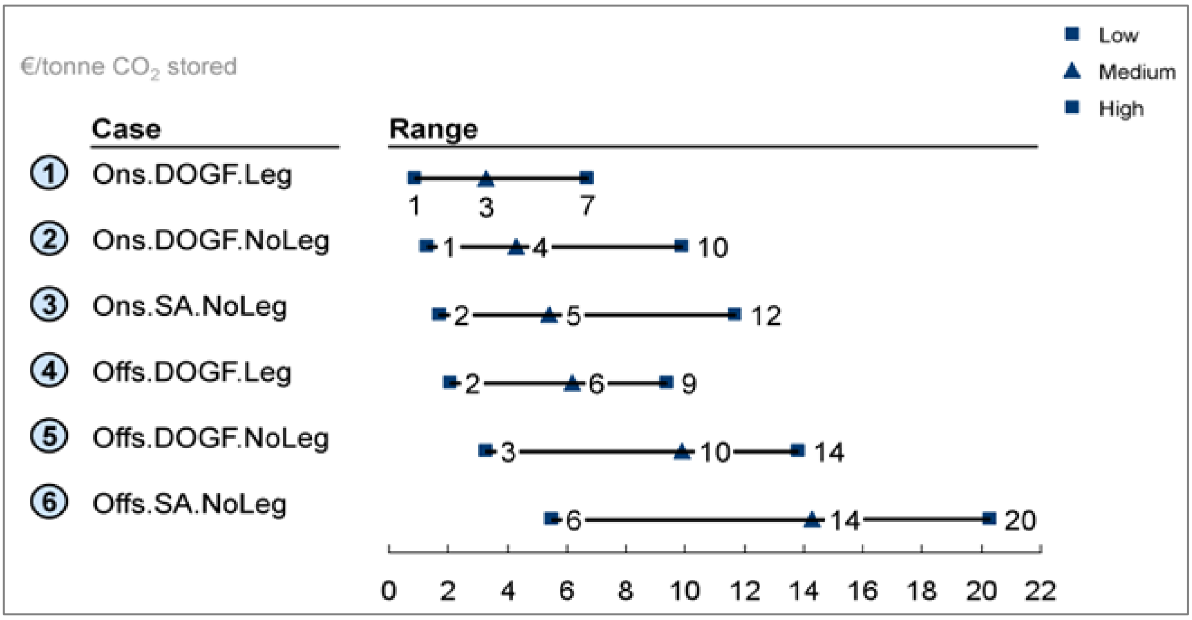
- Storage volume: In the ZEP document, costs are set for each storage volume. In this case, the value for 200 Mt was applied. (The storage volume from the power plant is 10 Mt x 25 years = approximately 250 Mt.)
- Storage depth: The injection well/structure cost was assumed to be proportional to the storage distance. (It is assumed economies of scale would not work because of the linear construction.)

Figure 2.6. Breakdown of the Storage Cost



DOGF = depleted oil and gas fields, FID = final investment decision, Leg = reuse of existing (legacy) wells, MMV = monitoring, measurement, and verification, NoLeg = no use of existing (legacy) wells, Offs = offshore, Ons = onshore, SA = saline aquifers.
Source: IEAGHG and Zero Emissions Platform (n.d.).

Figure 2.7. Storage Cost per Case



DOGF = depleted oil and gas fields, Leg = reuse of existing (legacy) wells, NoLeg = no use of existing (legacy) wells, Offs = offshore, Ons = onshore, SA = saline aquifers.
Source: IEAGHG and Zero Emissions Platform (n.d.).

3.3.2. Storage cost calculation

When using the ZEP (n.d.) model, the cost of storing 1 tonne of CO_2 in the storage process was calculated to be US$13.4. The assumptions for the calculations are as follows:

- The operational period is 25 years.
- Because the reference data is for 2008 values, the PCI was applied for the capture cost to correct the data to 2023 values.
- It is assumed storage is in an aquifer from offshore.
- Since the storage cost cannot be divided into CAPEX and OPEX based on the information in the reference, the calculation does not take into account the discount rate.
- Pre-Final Investment Decision (Pre-FID) costs are not considered in this study with the assumption that a storage site with adequate pre-existing geological information that does not require extensive exploration will be selected. If pre-FID costs are accounted for, storage costs would increase by US$12.66/t$CO_2$.

Table 2.11. Storage Cost

Component	Cost
Close down (US$/t-$CO_2$)	2.36
Monitoring, measurement, and verification (US$/t-$CO_2$)	1.5
Operating (US$/t-$CO_2$)	5.58
Injection wells (US$/t-$CO_2$)	2.99
Structure (US$/t-$CO_2$)	0.97
Storage cost (2023 US$/t-$CO_2$)	**13.40**

Source: Mitsubishi Research Institute.

3.4. Validity of Feasibility Study Results

The validity of the results of the FS is confirmed based on summarisations of the cost estimations made by the Intergovernmental Panel on Climate Change (IPCC), United States Department of Energy (DOE), and others as reference values as demonstrated in Table 2.12. Regarding the transportation cost, the cost determined in this study is considerably lower than the reference value. However, this is because the pipeline transportation cost in the study by Budinis et al. (2018) is the cost per 250 km, whilst the transportation cost in this study is the cost per 160 km. Therefore, the cost per km was recalculated by the Mitsubishi Research Institute for the same distance, giving a value for this FS close to the reference price, which is considered reasonable.

Table 2.12. Comparison between the Reference Value Costs and Those Used in This Study

	Capture (US$/t-$CO_2$)	Transport		Storage (US$/t-$CO_2$)
		US$/t-$CO_2$	US$/t-$CO_2$/km	
Values in this study	54.75	2.83	0.017	13.40
Reference values*	58.9–89.1	5.0–7.0	0.020–0.028	13.5–45.1

Source: Created by Mitsubishi Research Institute cost information from Budinis et al. (2018).

3.5. Total Estimated Cost

With the assumption that all CO_2 emitted from Jawa-7 Power Plant is captured and that the Sunda Asri basin is used as the storage site, the cost incurred for the entire CCS project period is estimated to be US$21.12 billion for the pipeline case, as shown in Table 2.13.

Table 2.13. Costs Incurred Over the Lifetime of the CCS Project under the FS

(US$ billion)

	Capture	Transport	Storage	Total
Pipeline case	14.96	0.77	3.66	19.39
Ship case	14.96	2.89	3.66	21.50

Source: Mitsubishi Research Institute.

Chapter 3

Recommendations on the Required Regulatory Framework

1. Review of Existing Regulations in Indonesia on CO_2 Capture, Transport, and Storage

Indonesia has established three regulatory frameworks for CCS project development (Table 3.1). The first regulatory framework is the Regulation of the Ministry of Energy and Mineral Resources No. 2 of 2023. The second regulatory framework is Presidential Regulation No. 14 of 2024. The third regulatory framework is SKK Migas PTK-070/SKKIA0000/2024/59.

Table 3.1. Key Regulatory Frameworks for CCS Project Development

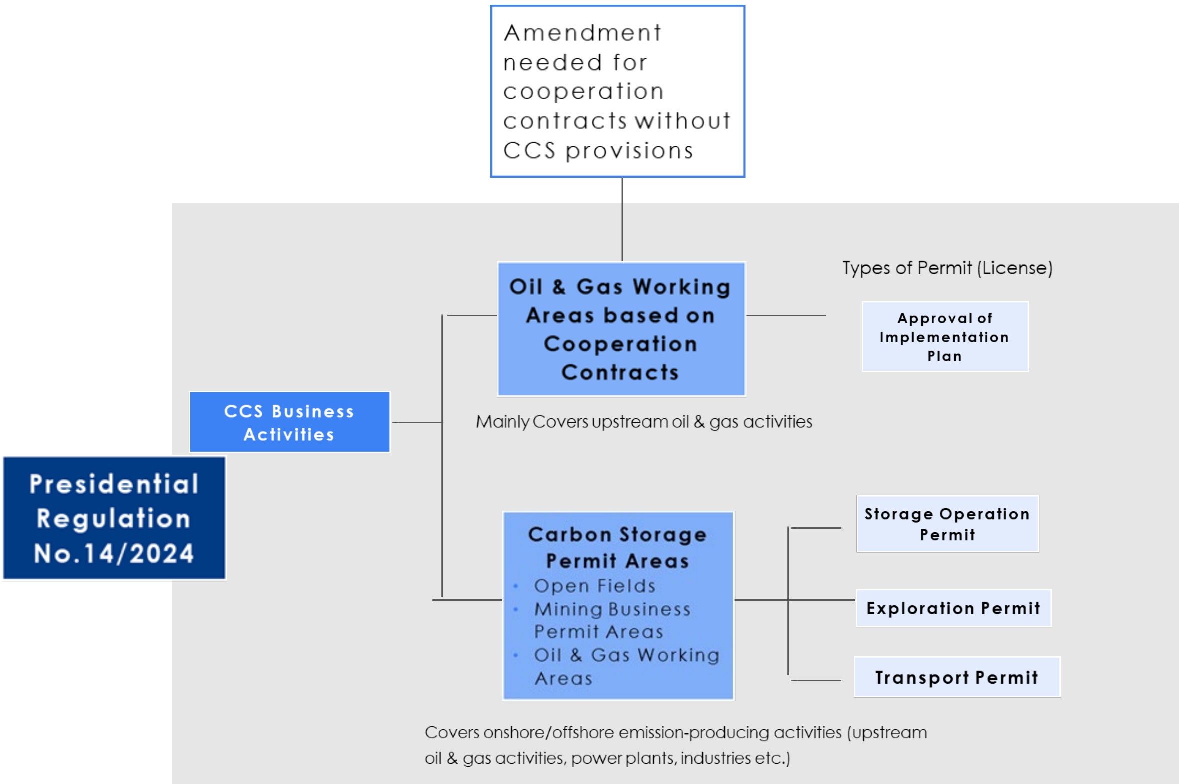
Regulatory Framework	Overview
Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023 concerning the Implementation of Carbon Capture and Storage, as well as Carbon Capture, Utilisation, and Storage in Upstream Oil and Gas Business Activities	• Regulates CCS and CCUS implementation **in upstream oil and gas activities**, including the enforcement, implementation, MRV, and economic provisions.
Presidential Regulation No. 14 of 2024 on the Implementation of Carbon Capture and Storage	• Provides **a broad national framework of CCS** in Indonesia, establishing general legal, environmental, and operational guidelines. • Also sets out the overarching policy and incentives for CCS, including cross-border cooperation.

Regulatory Framework	Overview
SKK Migas, PTK - 070/SKKIA0000/2024/S9 （Work procedure guidelines regarding the implementation of carbon capture and storage, as well as carbon capture, utilisation, and storage in the work area of cooperation contract contractors）	• **Guidelines on CCS/CCUS for oil and gas upstream activities** in alignment with other regulations, such as the MEMR regulation, Carbon Economic Value, MRV, etc. • Working procedural guidelines on CCS/CCUS on Working Areas of Cooperation Contract Contractors in oil and gas upstream activities in alignment with the MEMR regulation

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

The presidential regulation provides a broad national framework for CCS in Indonesia, establishing general legal, environmental, and operational guidelines. MEMR No. 2 2023 and the SKK Migas Guidelines cover details on CCS/CCUS implementation by contractors in the upstream oil and gas sectors. The key regulatory framework for CCS project development is shown in Figure 3.1.

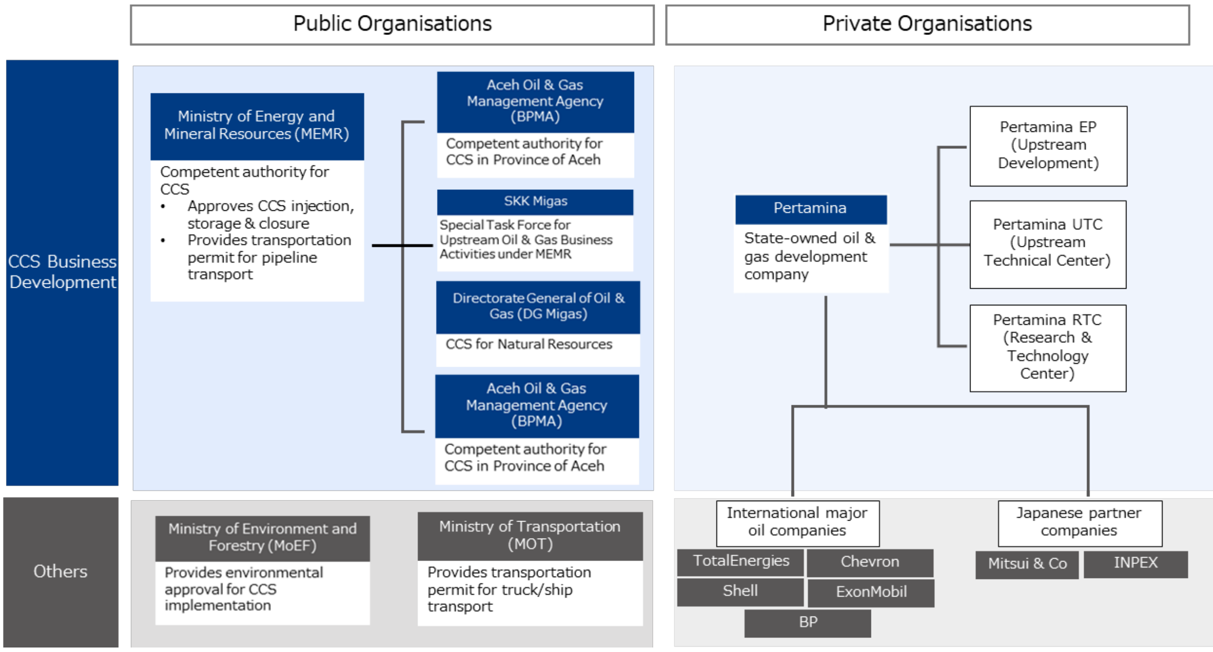
Figure 3.1. Key Regulatory Framework for CCS Project Development



Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

CCS projects are implemented and managed by public organisations and private organisations. The former include the Ministry of Energy and Mineral Resources, SKK Migas, Ministry of Environment and Forestry, and Ministry of Transportation. The latter is comprised of Pertamina, the state-owned oil and gas development company, and international private companies. These relevant organisations are summarised in Figure 3.2.

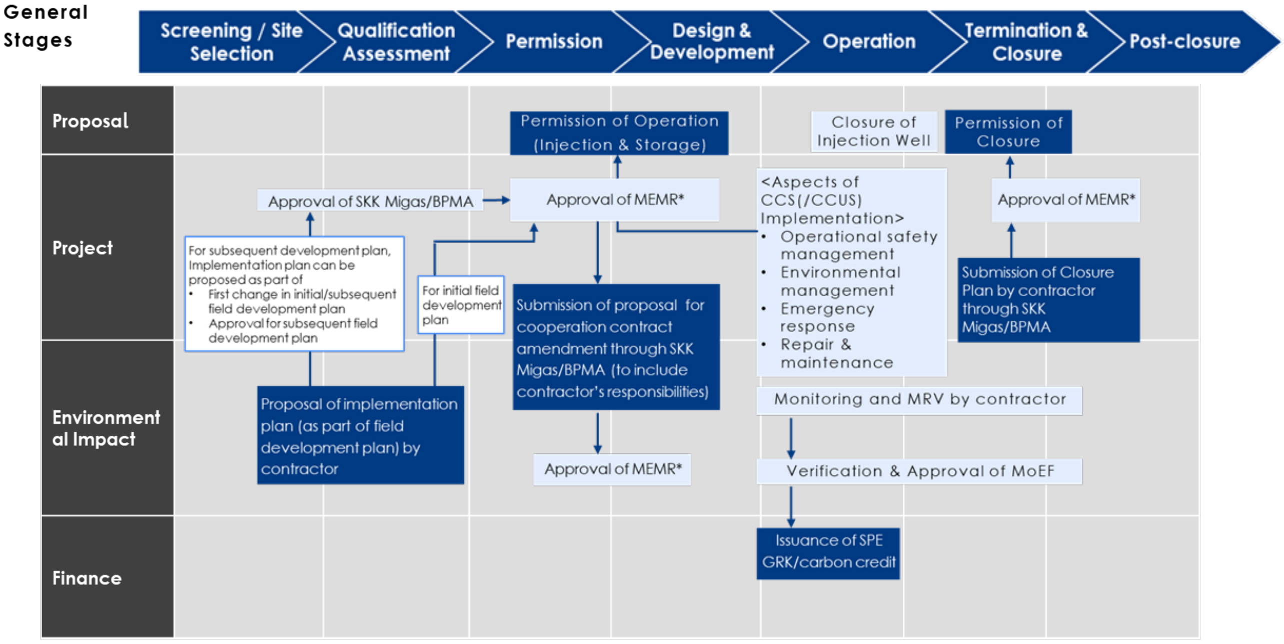
Figure 3.2. Relevant Organisations



Source: Mitsubishi Research Institute.

CCS/CCUS activity consists of screening and site selection, quality assessment, permission, design and development, operation, termination and closure, and post-closure. Each activity has four stages: proposal, project, environmental impact, and finance. Each activity for CCS/CCUS needs cooperation contracts and final approval from public organisations such as the Ministry of Energy and Mineral Resources, SKK Migas, or the Ministry of Environment and Forestry, as shown in Figure 3.3.

Figure 3.3. CCS/CCUS in Working Areas Based on Cooperation Contracts



* Ministry responsible for governmental affairs in the field of oil and gas.

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023.

Box 3.1. Details of the Implementation Plan

The implementation plan study must include results on at least the following items:

a. Carbon storage capacity estimation conducted through static and dynamic modelling at the injection target zone;

b. Depth and thickness of the injection target zone;

c. Hydraulic conductivity of the injection target zone;

d. Composition of carbon emissions and their impact on the injection target zone;

e. Integrity of the buffer zone layers, impermeable zone layers, and geological traps that contain at least:

1. the highest limit of injection pressure in the wellbore that does not exceed the fracture gradient/minimum in situ stress; and
2. a geomechanics and geochemistry study of the rocks.

f. Well integrity at injection wells, production wells, monitoring wells, and/or abandoned wells in the vicinity that have the potential to become a source of carbon emission leakage;

g. Flow rate and injection pressure;

h. Injection timeframe;

i. Design and implementation plan for injection well drilling;

j. Increase in injection target zone pressure due to injection activities;

k. Surface facility requirements and specifications for injection operations;

l. Integrity of required surface facilities;

m. Dynamic modelling of the distribution of carbon emissions during and after a certain period of injection;

n. Estimation of increased production of oil and gas for the results of CCUS activities;

o. Estimated reduction in carbon emissions;

p. Economic analysis;

q. Risk assessment and mitigation for long-term storage, including the environmental, social and public engagement impacts;

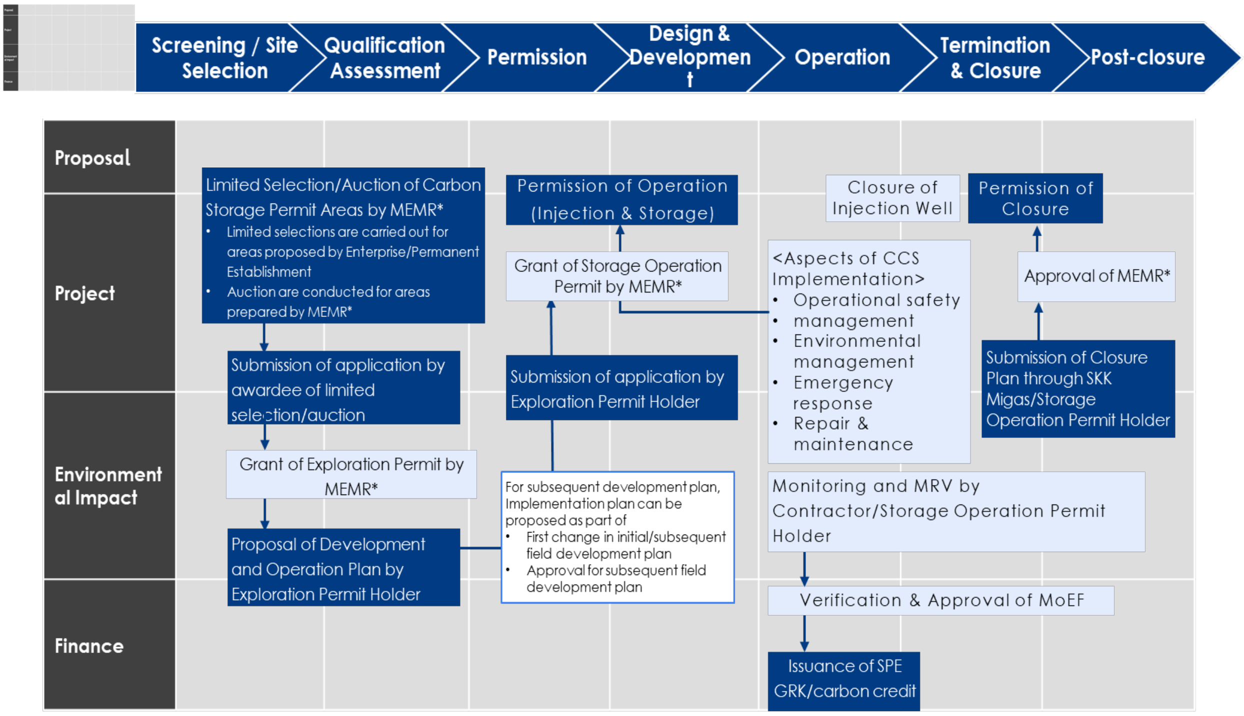
r. Carbon storage capacity utilisation plan; and

s. Monitoring and MRV plans that include the preparation stage for activities until after the closure of CCS/CCUS activities, which are prepared in accordance with referenced standards and good engineering principles.

Source: Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023.

The process of preparing for and implementing CCS in Carbon Storage Permit Areas is described in Figure 3.4. The entity needs permission for exploration, injection and storage operations, and closure.

Figure 3.4. CCS in Carbon Storage Permit Areas



* Ministry responsible for governmental affairs in the field of oil and gas.
Source: Created by Mitsubishi Research Institute; information based on Presidential Regulation No. 14 of 2024.

When submitting the application for an exploration permit, the awardee of the limited selection/auction must fulfil administrative, technical, environmental, and financial requirements. Details of the applications and permissions are described in Box 3.2.

Box 3.2. Detailed Requirements for Exploration Permit Applications

- The administrative requirements shall at least include:
  a. A single business number;
  b. The name and deed of the company to apply for the permit, provided that the entity is owned or directly controlled by the awardee of the limited selection or tender or its parent company;
  c. An application letter; and
  d. The composition of the management, list of shareholders, and list of beneficial owners of the enterprise or permanent establishment in the event of data updating.
- The technical requirements include:
  a. Injection Target Zone (Zona Target Injeksi; ZTI) Exploration definitive

commitment;

b. Work plan for the implementation of ZTI Exploration definitive commitment;

c. Performance bond of ZTI Exploration definitive commitment;

d. Leakage track mitigation, well drilling, and formation injectivity tests studies;

e. Conceptual studies of carbon storage development and the selection of the development concept; and

f. Other technical requirements in accordance with other requirements.

- The environmental requirements include the environmental approval in accordance with the provisions of laws and regulations concerning environmental protection and management.
- The financial requirements shall at least include:

a. Evidence of the placement of ZTI Exploration definitive commitment performance bond; and

b. A fiscal certificate in accordance with the provisions of laws and regulations in the field of taxation.

Source: Presidential Regulation No. 14 of 2024.

When submitting the application for the storage permit, exploration permit holders must fulfil the administrative, technical, environmental, and financial requirements as described in Box 3.3.

Box 3.3. Detailed Requirements for Storage Permit Applications

- The administrative requirements include:

a. A single business number;
b. The name and deed of the company to apply for the permit, provided that the entity is owned or directly controlled by the holder of the Exploration Permit;
c. An application letter
d. The composition of the management, list of shareholders, and list of beneficial owners of the enterprise in the event of data updating; and
e. Basic requirements in accordance with the provisions of laws and regulations.

- The technical requirements shall at least include:
    a. A map of the proposed Storage Operational Permit completed with coordinates in the form of latitude and longitude in accordance with the geographic information system that applies nationally;
    b. A full report of the ZTI Exploration phase of activities; and
    c. Approval for the ZTI's Plan for Development and Operation by the Ministry.
- The environmental requirements include at least:
    a. Environmental approval; and
    b. Operations plan documents.
- The financial requirements shall at least include:
    a. Evidence of placement of the performance bond for carbon storage operations;
    b. Financial statements for the last 3 years audited by a public accountant; and
    c. A fiscal certificate in accordance with the provisions of laws and regulations in the field of taxation.

Source: Presidential Regulation No. 14 of 2024.

The study for the development and operation plan that accompanies the storage operational permit application must include at least the results described in Box 3.4.

Box 3.4. Details of the Development and Operation Plan

a. Technical documents for the plan to organise capture, transport, and operate carbon storage;

b. A carbon storage capacity estimation conducted through static and dynamic modelling at ZTI;

c. Depth and thickness of the ZTI;

d. Hydraulic conductivity of the ZTI;

e. Composition of carbon emissions and their impact on the ZTI;

f. Integrity of the ZTI that contain at least:

    1. the highest limit of injection pressure in the wellbore that does not exceed the fracture gradient/minimum in situ stress based on the fault regime; and

    2. a geomechanics and geochemistry study of the rocks.

g. Well integrity at injection wells, monitoring wells, and/or abandoned wells in the vicinity that have the potential to become a source of leakage;

h. Flow rate and injection pressure;

i. Injection timeframe;

j. Design and implementation plan for injection well drilling;

k. Increase in ZTI pressure due to injection activities;

l. Surface facility requirements and specifications for injection operations;

m. Integrity of required surface facilities;

n. Dynamic modelling of the distribution of carbon emissions during and after a certain period of injection;

o. Estimation of increased production of oil and gas for the results of CCUS activities;

p. Estimated reduction in carbon emissions;

q. Economic analysis;

r. Risk assessment and mitigation for long-term storage, including environmental, social, and public engagement impacts subject to environmental approvals;

s. Carbon storage capacity utilisation plan; and

t. Monitoring and MRV plans that include the preparation stage for activities until after the closure of the CCS activity, which are prepared in accordance with referenced standards and good engineering principles.

Source: Presidential Regulation No. 14 of 2024.

1.1. Content of Each Regulation

The following sections scrutinise the current regulations in order to propose more complete regulations in line with the IEA's key legal and regulatory issues for CCUS.

Firstly, Table 3.2 shows each chapter of the Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023 concerning the Implementation of Carbon Capture and Storage, as well as Carbon Capture, Utilisation, and Storage in Upstream Oil and Gas Business Activities.

Table 3.2. Content of Regulation of the MEMR No.2 of 2023

Chapter	Contents
Chapter 1: General Provisions (2 articles in total)	Definition of terms (32 articles in total), scope
Chapter 2: Implementation of CCS/CCUS (7 articles in total)	Definitions of value chains
Chapter 3: Stages in CCS/CCUS implementation (16 articles in total)	Content to be included in the business plan, CO_2 injection acquired from third parties, precautions for the implementation and closure of CCS/CCUS
Chapter 4: Monitoring, measurement, reporting, and verification (12 articles in total) 27	Monitoring period, monitoring items, reporting frequency, verification
Chapter 5: Economy (5 articles in total)	Funding and profitability of CCS/CCUS implementation, incentives, use of insurance companies for risk compensation
Chapter 6: Assets (1 article in total)	Attribution of assets acquired in CCS/CCUS operations
Chapter 7: Emergency response (7 articles in total)	Requirements for emergency management
Chapter 8: Coaching and supervision (3 articles in total)	Role of SKK Migas
Chapter 9: Administrative sanctions (2 articles in total)	Administrative sanctions and related articles
Chapter 10: Other terms (3 articles in total)	Administrative requirements
Chapter 11: Closing terms (1 article in total)	Effective date

Source: Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023.

Secondly, Table 3.3 shows each chapter of Presidential Regulation No. 14 of 2024 on the Implementation of Carbon Capture and Storage.

Table 3.3. Content of Presidential Regulation No. 14 of 2024

Chapter	Contents
Chapter 1: General provisions (1 article [34 paragraphs] in total)	Definitions of terms
Chapter 2: Carbon capture and storage implementation scheme (2 articles in total)	Definition of CCS implementation
Chapter 3: Carbon capture and storage implementation under cooperation contract (4 articles in total)	Definitions and precautions of cooperation contract for CCS implementation; plan of CCS implementation and the ministry's role
Chapter 4: Carbon capture and storage implementation based on exploration permit and storage operational permit (19 articles in total)	Requirements and information for exploration permit and storage and operational permit needed for CCS implementation
Chapter 5: Performance of carbon capture and storage implementation through the storage operational permit and cooperation contract (8 articles in total)	Detailed activities for CCS implementation, carbon capture, carbon transportation, carbon injection and storage, and carbon storage capacity for domestic needs
Chapter 6: Closure of carbon capture and storage implementation (6 articles in total)	Conditions for closure or temporary suspension of CCS implementation; the ministry's role.
Chapter 7: Economics or business scheme (3 articles in total)	Storage fees, incentives for CCS implementation, and assets of CCS implementation
Chapter 8: Mechanism for cross-border transportation of carbon (3 articles in total)	Bilateral cooperation agreement for cross-border transportation, laws and regulations, and international regulations related to climate change
Chapter 9: Measurement, reporting, and verification (6 articles in total)	Content of MRV activities: measurement, reporting, validation and verification.

Chapter	Contents
Chapter 10: Economic value of carbon (3 articles in total)	Implementation of NEK, carbon economic value, to generate a greenhouse emission unit
Chapter 11: Safety, environment, and emergency response (11 articles in total)	Operational safety monitoring, emergency response management plan
Chapter 12: Coaching and supervision (6 articles in total)	Role of the Ministry
Chapter 13: Administrative sanctions (2 articles in total)	Administrative sanctions and related articles for the holders of Exploration Permit, Storage Operational Permit, and Carbon Transportation Permit
Chapter 14: Closing provisions (2 articles in total)	Effective date of all laws and regulations

Source: Presidential Regulation No. 14 of 2024.

Thirdly, Table 3.4 shows each chapter of SKK Migas, 'PTK - 070/SKKIA0000/2024/S9 (work procedure guidelines regarding the implementation of carbon capture and storage, as well as carbon capture, utilisation, and storage in the work area of cooperation contract contractors).

Table 3.4. Content of the SKK Migas Work Procedure Guidelines

Chapter	Content
Chapter 1: General (5 articles in total)	Intent and goal, scope, legal basics, legal reference, term definition
Chapter 2: General policies, responsibilities, and principal tasks (3 articles in total)	General policy for CCS and CCUS, principal responsibility and assignment of oil and gas, contractor's principal responsibility and tasks
Chapter 3: CCS and/or CCUS planning and equipment (5 articles in total)	CCS and/or CCUS activity planning, substitute for CCS and CCUS development plan, implementation of the development and administration of

Chapter	Content
	CCS and/or CCUS, economics of development and implementation of CCS and/or CCUS
Chapter 4: Monitoring and measurement, reporting, and verification (MRV) (4 articles in total)	Details of operational activity implementation monitoring plan and/or CCUS; steps for plan measurement, reporting, and verification; steps for monitoring and MRV implementation
Chapter 5: Health, work safety and environmental protection, and CCS and/or CCUS closure (3 articles in total)	Administering health, safety, and environmental protection; proposals for closure and administering CCS and CCUS; provisions for the rights, obligations, and responsibilities of the contractor
Chapter 6: CCS and/or CCUS equipment monetisation (3 articles in total)	Monetisation of CCS and/or CCUS, setting of monetisation system for CCS and/or CCUS
Chapter 7: Accounting and asset management policies (8 articles in total)	Accounting policies including CCS and/or CCUS, operations cost accounting, asset management, revenue accounting, insurance change accounting, funding mechanism, formulation of cost and realisation planning and reporting, revenue from CCS and/or CUS activities, and taxation
Chapter 8: Surveillance, reporting, and guidance (1 article in total)	Contractor's role for surveillance, contractor's responsibility for reporting

Source: SKK Migas PTK - 070/SKKIA0000/2024/S9.

Here, as a reference, the key legal and regulatory issues for CCUS provided by the IEA are shown in Figure 3.5. The IEA points out that regulations should prescribe the following eight steps: (1) the definition of regulatory scope, (2) environmental reviews and permitting, (3) enabling first-mover projects, (4) ensuring safe and secure storage, (5) addressing long-term liabilities, (6) international and transboundary issues, (7) facilitating the CCUS hub, and (8) other key and emerging issues.

Figure 3.5. Key Legal Regulatory Issues for CCUS

Step1: Defining the regulatory scope	Step2: Environmental reviews and permitting	Step3: Enabling first-mover projects	Step4: Ensuring safe and secure storage	Step5: Addressing long-term storage liabilities:	Step6: International and transboundary issues	Step7: Facilitating CCUS hubs	Step8: Other key and emerging issues
• Issues that set the legal parameters for the classification and ownership of CO2.	• Requirements for operators to minimise environmental and public health impact through detailed assessments and data collection and reporting	• Approaches to reduce regulatory barriers and provide certainty to first- and early-mover projects	• Issues that cover the full range of the storage development process, from resource assessment to the site closure process.	• Issues surrounding requirements and responsibilities of operators and the relevant authority following the closure of a storage site	• Regulatory issues that may arise from the cross-border transport and storage of CO2.	• Considerations for enabling shared CO2 transport and storage infrastructure.	• Points that reflect recent developments and experience, but which may not be addressed in detail in current frameworks

Source: IEA (2022).

This study proceeds to compare three Indonesian regulations by step based on the IEA key regulatory issues.

As Table 3.5 demonstrates, regarding the definition of the regulatory scope, the Presidential Regulation has enough stipulations. On the contrary, the other two regulations lack definitions of the classification and purity of CO_2.

Table 3.5. Step 1: Defining the Regulatory Scope

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Classification and purity of CO_2	N/A	• Captured carbon must undergo processing and purification based on good engineering principles to meet the national and/or international standards recognised by the Ministry for safe transportation and injection (Art. 29)	N/A

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Ownership and title of CO_2	• All goods and equipment used for CCS/CCUS implementation procured by the contractor become state property (Art. 45) # No mention of whether CCS assets include CO_2	[For CCS in working areas based on cooperation contracts] • All goods and equipment procured by the contractor become state property [For CCS in carbon storage permit areas] • All goods and equipment shall be the property of the holder of the storage operational permit (Art. 44) # No mention of whether CCS assets include CO_2	• All goods and equipment used for CCS/CCUS implementation procured by the contractor become state property (Chpt. VII Art. 3.1) # No mention of whether CCS assets include CO_2

Note: CO_2 does not explicitly fall under the definition of 'waste' in any of the relevant regulations. CO_2 is not included in either B3 or non-B3 waste under environmental management law.

The performance of mitigation actions from CCS can be implemented through a NEK and may require a Sertifikat Pengurangan Emisi - Gas Rumah Kaca (SPE-GRK) (carbon credit in Indonesia) as evidence of the emission reduction performance of mitigation actions (PR No.14/2024).

If CO_2 were to be included in the definition of CCS assets, it must be handled as a carbon unit. A carbon unit means proof of carbon ownership in the form of a certificate or allowance expressed in 1 tonne of CO_2 as registered in the National Registration System for Climate Change Control (Sistem Registrasi Nasional Pengendalian Perubahan Iklim; SRN PPI) (PR No.98/2021).

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.6 demonstrates, regarding the environmental reviews and permitting, the MEMR and Presidential Regulation have enough stipulations. The SKK Migas Guidelines, however, lack environmental impact assessment and public engagement and consultation.

Table 3.6. Step 2: Environmental Review and Permitting

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Environmental impact assessment (EIA)	• Results of implementation plan study are to include assessment and mitigation of risks for long-term storage (including environmental engagement impacts) (Art. 12)	• Exploration/ transportation/storage operational activities shall obtain environmental approval (Art. 16, 31, 34) • If a change in the ZTI (Injection Target Zone) exploration activities results in a change in the scope of the existing environmental approval, the Exploration Permit holder must obtain environmental approval from the Ministry (Art. 17) [For CCS in carbon storage permit areas] • Results of the Development and Operation Plan study are to include assessment and mitigation of the risks for long-term storage (including environmental engagement impacts) (Art. 20)	N/A
Permitting and authorisation	• Requires approval of implementation plan as part of the field development	[For CCS in working areas based on cooperation contracts] • Requires approval of the implementation plan as part of the field	• SKK Migas gives approval of implementation plans (Chpt. 2 Art. 2.2.2)

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
	plan (Art. 10–18)	development plan (Art. 4-8, 28) [For CCS in carbon storage permit areas] • Requires Exploration Permits and Storage Operational Permits (Art. 3, 9, 28) and stipulates procedures for granting permits (Art. 23) • Requires transportation permits for CO_2 transport activities (Art. 30-31)	
Public engagement and consultation	• CCS/CCUS implementation is to be carried out through the preparation of mitigation and handling of environmental, social, and public engagement (Art. 19)	• CCS implementation is to be carried out through environmental, social, and public engagement management in accordance with environmental approval (Art. 28)	N/A

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.7 shows, regarding the enabling first-mover projects, the three regulations have no stipulations.

Table 3.7. Step 3: Enabling First-mover Projects

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
One-off or project-specific legislation	N/A	N/A	N/A
Preferential approaches and projects	N/A	N/A	N/A

Note: In Indonesia, the state-owned company Pertamina has been the lead or collaborator in facilitating the development of specific projects.
Indonesia promoted early-stage development by limiting the MEMR Ministerial Regulation to the upstream sector because of the availability of existing geological knowledge and data, and because the contractor has the necessary subsurface expertise and project management experience to develop CO_2 storage.
Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.8 shows, regarding ensuring safe and secure storage, the three regulations all have stipulations except for the ownership of pore space. SKK Migas has no stipulation on storage site inspection, either.

Table 3.8. Step 4: Ensuring Safe and Secure Storage

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Storage resource assessment	• Results of the implementation plan study are to include assessments related to injection and storage capacity (Art. 12)	[For CCS in carbon storage permit areas] • The designation of a carbon storage permit area may be prepared by the Minister of MEMR, or it may be based on a proposal from an enterprise or permanent	• Contractors must collect data on potential CO_2 injection target zones (Chapter III Art. 2)

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
		establishment (Art. 10) • Results of the Development and Operation Plan study are to include assessments related to injection and storage capacity (Art. 20)	
Ownership of pore space	N/A	N/A	N/A
Monitoring, measurement, and verification (MMV) plans	• Stipulates procedures for monitoring (Art. 27–31) and MRV (Art. 32–39) • Requires monitoring and MRV during CCS/CCUS implementation (Art. 19)	• Stipulates procedures for monitoring (Art. 57–61) and MRV (Art. 48–53) (Art. 57–61) • Requires monitoring and MRV during initial data collection, operation, and post-closure of CCS/CCUS activities (Art. 28)	• Stipulates procedures for monitoring and MRV (Chpt. IV) • Requires monitoring and MRV during CO_2 capture, transport, and storage to ensure emission reduction and permanent storage of CO_2 (Chpt. IV Art. 1.1)

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Storage site inspections	• The MIGAS Inspectorate carries out safety checks and monitoring of CCS/CCUS equipment, installations, and facilities periodically every 1 year or at any time when required (Art. 55)	• The contractor or the holder of a Storage Operational Permit shall report the monitoring results to the Ministry periodically: every 6 months during operation and every 1 year during post-closure monitoring (Art,60) • Supervision of installation and equipment safety in CCS implementation to be carried out by the MEMR (Art. 72)	N/A
Operational liabilities and financial security	• Contractors can choose insurance companies for underwriting liability to pay for part or all of risks occurring in CCS/CCUS activities (Art. 44)	• Consideration for site closure in accordance with the force majeure provisions of the cooperation contract or storage operational permit (Art. 36) (No mention of insurance)	• Insurance for CCS/CCUS assets in oil and gas business activities is subject to the provisions of Insurance Management PTK (PTK-044/SKKMA000/2017/SO) (Chpt.VII Art. 5)
Site closure process	• Stipulates conditions and procedures for	• Stipulates conditions and procedures for	• Stipulates conditions and procedures for the

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
	the closure of CCS/CCUS activities (Art. 22–26)	the closure of CCS activities (Art. 36-40)	closure of CCS/CCUS activities (Chpt. V Art. 2)
Storage site inspections	• The MIGAS Inspectorate carries out safety checks and monitoring of CCS/CCUS equipment, installations, and facilities periodically every 1 year or at any time when required (Art. 55)	• The contractor or the holder of a Storage Operational Permit shall report the monitoring results to the Ministry periodically: every 6 months during operation and every 1 year during post-closure monitoring (Art. 60) • Supervision of installation and equipment safety in CCS implementation to be carried out by the MEMR (Art. 72)	N/A
Operational liabilities and financial security			• Insurance for CCS/CCUS assets in oil and gas business activities is subject to the provisions of Insurance Management PTK (PTK-044/SKKMA000/2017/SO) (Chpt. VII Art. 5)

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Site closure process	• Contractors can choose insurance companies for underwriting liability to pay for part or all of risks occurring in CCS/CCUS activities (Art. 44)	• Consideration for site closure in accordance with the force majeure provisions of the cooperation contract or storage operational permit (Art. 36) • # No mention of insurance	• Stipulates conditions and procedures for the closure of CCS/CCUS activities (Chpt. V Art. 2)
	• Stipulates conditions and procedures for the closure of CCS activities (Art. 36–40)		

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.9 shows, regarding addressing the long-term liabilities, the three regulations have enough stipulations.

Table 3.9. Step 5: Addressing the Long-term Storage Liabilities

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas guidelines
Long-term liability post site closure	• Requires 10 years of monitoring after closure of CCS/CCUS activities (Art. 27) • Stipulates conditions for the rights, obligations, and responsibilities of	• Requires 10 years of monitoring after the closure of CCS activities (Art. 57) • Stipulates conditions for the rights, obligations, and responsibilities of contractors or	• Requires 10 years of monitoring after the closure of CCS/CCUS activities (Chpt. IV Art. 2.2)

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas guidelines
	contractors to expire and be transferred to the state (Art. 31)	storage operational permit holders to expire and be transferred to the state (Art. 61)	
Financial assurances of long-term site stewardship	• Post-closure monitoring costs are to be reserved by contractors (Art. 27)	• Post-closure monitoring costs are to be reserved by contractors or storage operational permit holders (Art. 57)	• Stipulates procedures for reserving post-closure monitoring costs, referring to the Abandonment and Site Restoration (ASR) Scheme (Chpt. VII Art. 2.5)

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.10 shows, regarding international and transboundary issues, the MEMR has no stipulations. None of the regulations have any stipulations on the interaction of pressure fronts across international borders. The SKK Migas Guidelines have only a stipulation on regulating cross-border CO_2 transport.

Table 3.10. Step 6: International and Transboundary Issues

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Regulating cross-border CO_2 transport	N/A	• Rights and obligations related to CO_2 cross-border transfer are to be governed by applicable laws and legislations and in accordance	• In case of the sale and/or purchase of emission certification abroad, an authorised request for foreign

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
		with commercial agreement (Art. 47)	carbon trading must be issued to SKK Migas, as the transfer of SPE-GRK abroad is required (Chpt. VI Art. 3.4)
Compliance with the London Protocol	N/A	• Bilateral agreements are required prior to conducting cross-border CO_2 transport (Art. 47) • Carbon transportation into the Indonesian customs territory must be carried out with engineering standards and practices ensuring aspects of safety, occupational health, and environmental protection (Art. 47)	N/A
Interaction of pressure fronts across international borders	N/A	N/A	N/A
Overlap between multiple frameworks	N/A	N/A （Enacted to avoid duplication with existing regulatory framework）	N/A

Note: Indonesia restricts the import of 'waste' from overseas and activities that discharge waste into Indonesian territory (Law No. 32/2009 on Environmental Protection and Management], but unlike the London Protocol, it does not explicitly mention CO_2 as waste.
CCUS in the upstream sector is regulated by MEMR No. 2/2023 and Pure-CCS by PR No. 14/2024.
The Carbon Economic Value conforms to PR No. 98/2021.
Details of some articles to be stipulated in the Ministerial Regulation.
Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.11 shows, regarding facilitating CCUS hubs, the Presidential Regulation has enough stipulations. The MEMR lacks stipulation on access to shared transport infrastructure. The SKK MIGAS Guidelines have no stipulations.

Table 3.11. Step 7: Facilitating CCUS Hubs

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Access to shared transport infrastructure	N/A	• The government granted carbon transport permits to enterprises as well as to holders of storage service permits (Art. 30)	N/A
Facilitating shared storage infrastructure	• Contractors can inject/store CO_2 emissions generated by third parties in their working area based on agreement (Art. 20) • Third parties can utilise facilities operated by contractors (Art. 21)	• Emission producers may utilise CCS operation facilities operated by the contractor (Art. 8) • Prioritises storage capacity for domestic CO_2 producers (Art. 35)	N/A

Source: Created by Mitsubishi Research Institute; information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

As Table 3.12 shows, regarding other key and emerging issues, the Presidential Regulation has enough stipulations. The MEMR lacks stipulations on interaction with other surface and subsurface resources. The SKK Migas Guidelines have no stipulations for this step.

Table 3.12. Step 8: Other Key and Emerging Issues

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Treatment of CO_2 removal technologies	• Refers to direct air capture technology as a method to capture carbon emissions (Art. 6)	• Refers to direct air capture technology as a method to capture carbon emissions (Art. 29)	N/A

	MEMR No. 2/2023	PR No. 14/2024	SKK Migas Guidelines
Interaction with other surface and subsurface resources	N/A	• The designation of the Carbon Storage Permit Area shall be carried out by considering the potential impact of CCS activities on the sustainability of petroleum operations and mining business (Art. 14)	N/A
Transitioning from CO_2-enhanced oil recovery (EOR) to dedicated storage	Intends to conduct CCUS to reduce emissions whilst increasing oil and gas production (Art. 4, 9)	**[For CCS in working areas based on cooperation contracts]** • If the ZTI in the work area extends outside the work area and can be utilised as a carbon storage site, the contractor, through SKK Migas, may propose the expansion of the work area to the Ministry (Art. 8)	Intends to conduct CCUS to reduce emissions whilst increasing oil and gas production (Chpt. I Art. 2.2.2)
CCUS-ready requirements	N/A	N/A	N/A

Note: Interaction with geothermal resources is unknown. Injection into formations other than depleted oil/gas fields, aquifers, and coal bed methane formations is unknown (e.g. basalt for mineralisation).

Indonesia has launched a mandatory, intensity-based ETS for the power generation sector.

The introduction of a carbon levy has been postponed until after 2025, and the reduction incentives are currently small and not at the level of CCS-introduction.

Source: Created by Mitsubishi Research Institute, information based on Regulation of the Ministry of Energy and Mineral Resources (MEMR) No. 2 of 2023, Presidential Regulation No. 14 of 2024, and SKK Migas PTK - 070/SKKIA0000/2024/S9.

2. Identification of Any Additional Environmental and/or Safety Regulations That May be Needed, Including Responses Required to Address CO_2 Leakage and the Assurance Of CO_2 Storage

This section proposes additional regulations necessary for the future based on the preceding analysis. Firstly, regulatory framework required in the MEMR ministerial regulation is demonstrated. Secondly, regulatory framework that is not mentioned in the Presidential Regulation but should be developed as an MEMR Ministerial Regulation is described. Finally, regulatory framework to be developed across ministries in the future is shown.

3. Recommendations on Required Regulatory Framework

I: Regulatory framework to be stipulated in the MEMR Ministerial Regulation as described in Presidential Regulation No. 14/2024

As Table 3.13 shows, the MEMR Ministerial Regulation needs additional stipulations, such as on CCS in working areas under cooperation contracts and CCS carbon storage permit areas. These are described in Presidential Regulation No.14/2024.

Table 3.13. Regulatory Framework to Be Stipulated in the MEMR Ministerial Regulation

	Topic	Chapter/ Article	Overview
CCS in Working Areas under Cooperation Contracts	Carbon Storage Capacity	Chapter III, Article 5	• Certification of carbon storage capacity to be achieved in the CCS implementation plan
CCS in Carbon Storage Permit Areas	Selection and Grant of Carbon Storage Permit Areas	Chapter IV, Article 11	• Procedures for preparing and determining the Carbon Storage Permit Area
		Chapter IV, Article 15	• Procedures for the implementation of limited selection and tender, evaluation, and determination of the awardee of the limited selection and tender of the Carbon Storage Permit Area

	Topic	Chapter/ Article	Overview
	Exploration Permit	Chapter IV, Article 18	• Procedures for granting and implementing the Exploration Permit
		Chapter IV, Article 19	• Transfer of share ownership of an enterprise or permanent establishment which holds an Exploration Permit
	Plan for Development and Operation	Chapter IV, Article 21	• Procedures for submitting the ZTI's Plan for Development and Operation
	Carbon Storage Capacity	Chapter IV, Article 22	• Procedures to appoint an independent body, agency, or institution to carry out certification of the carbon storage capacity
	Storage Operational Permit	Chapter IV, Article 25	• Procedures for application, requirements, and evaluation of renewal of term for the Storage Operational Permit
		Chapter IV, Article 26	• Procedures for granting and implementing a Storage Operational Permit
		Chapter IV, Article 27	• Transfer of ownership of enterprise shares by the holder of a Storage Operational Permit
CCS in Working Areas under Cooperation Contracts/CCS in Carbon	CCS Performance	Chapter V, Article 29	• Certain specifications for safe transportation and injection of captured carbon
		Chapter V,	• Standards for carbon

	Topic	Chapter/ Article	Overview
Storage Permit Areas		Article 34	injection and storage
	Storage Fees (Business Scheme)	Chapter VII, Article 42	• The amount of storage fees for CCS implementation performed under a Storage Operational Permit
	Closure of CCS Activities	Chapter V, Article 39	• Procedures for verification of the completion of the closure of CCS activities, and the criteria for the appointment of an independent verifier
		Chapter XI, Article 61	• Closure of CCS activities
	Administrative Sanctions	Chapter XIII, Article 74	• Procedures for imposing administrative sanctions on permit holders
		Chapter XIII, Article 75	• Procedures for imposing administrative sanctions on contractors of cooperation contracts

Source: Created by Mitsubishi Research Institute, information based on Presidential Regulation No. 14 of 2024.

II: Regulatory framework that is not mentioned in the Presidential Regulation but should be developed as an MEMR Ministerial Regulation in the future

There is regulatory framework that the Presidential Regulation does not mention but that should be developed by the MEMR, of which categories include CO_2 characteristic standards, obligations to allow third party access, damages arising from storage operations, post-transfer liability, and public interest privileges, as shown in Table 3.14.

Table 3.14. Regulatory Framework That Should Be Developed as an MEMR Ministerial Regulation

Category	Overview of Proposed Additional Provision
CO_2 characteristic standards	Establishment of CO_2 standards for security and environmental purposes according to CO_2 purities, etc. • Setting standards for captured CO_2: CO_2 concentration (e.g. 99%), waste material contamination, etc.
Obligation to allow third-party access	Establishment of business environment in which emitters can properly use storage transportation services • Prohibition of refusal of transportation/storage requests from emitters without justifiable reasons and discriminatory treatment of specific emitters • Obligation to report storage/transportation fees to the MEMR/SKK Migas, etc.
Damages arising from storage operations	Establishment of appropriate remedies for third parties who have suffered damages • Provisions regarding liability for damages not caused by the operator's intention or negligence (non-fault liability)
Post-transfer liability	Clarification of management responsibility and cost burden after the storage project • Responsible governmental entity after the transfer of liability from the operator (e.g. monitoring obligation after transfer) • Method of sharing the cost of monitoring after the transfer of liability
Public interest privileges	Special measures for land access and use for transportation and storage projects of public interest • Access to land for surveying, fieldwork, construction, etc. for storage projects, and handling of the development of a long-distance pipeline in the transportation business

Source: Mitsubishi Research Institute.

III: Regulatory framework to be developed across ministries in the future

As Table 3.15 shows, the responsible entities, MEMR, MOEF, and SKK Migas, should develop a regulatory framework for addressing categories including the treatment of CO_2 leakages in GHG inventory, environmental approval for CO_2 storage, incentives for CCS, and capacity building.

Table 3.15. Regulatory Framework to Be Developed Across Ministries in the Future

Category	Responsible Entity*	Overview of Proposed Additional Provision
Treatment of CO_2 leakages in GHG inventory	MoEF	Resolving inconsistencies with IPCC guidelines regarding the handling of leaked CO_2 during cross-border CO_2 transportation • In the event of a leakage during cross-border carbon transportation in Indonesia, the leakage shall not be added to Indonesia's GHG inventory (Article 47 (4) in the Presidential Decree)
Environmental approval for CO_2 storage	MoEF	Development of guidance/guidelines for the EIA, specifically for CCS • The Presidential Decree has only a provision for obtaining environmental approval • It is necessary to develop guidance/guidelines in the form of information sharing on good practice approaches to the EIA process in preparation for an increase in the number of CCS projects in the future
Incentives for CCS	MEMR/MoEF/OJK	Creating tangible incentives for CCS • Creating the value of CO_2 reductions achieved through Carbon Economic Value such as ETS and carbon credits
Capacity building	SKK Migas/CoE for CCS/CCUS	Development of guidelines for project developers

Category	Responsible Entity*	Overview of Proposed Additional Provision
		• Briefing on licensing applications for businesses developers <u>Development of guidance for project verification based on ISO 14064-3</u> • There are limited verification bodies with experience in verifying CCS projects based on ISO 14064-3 • Need to prepare a national verification scheme and associated expert training to verify the appropriateness of CCS quantification

* Proposed by MRI.
Source: Mitsubishi Research Institute.

Chapter 4

Recommendations on Required Finance

1. Financing Approaches to CCS

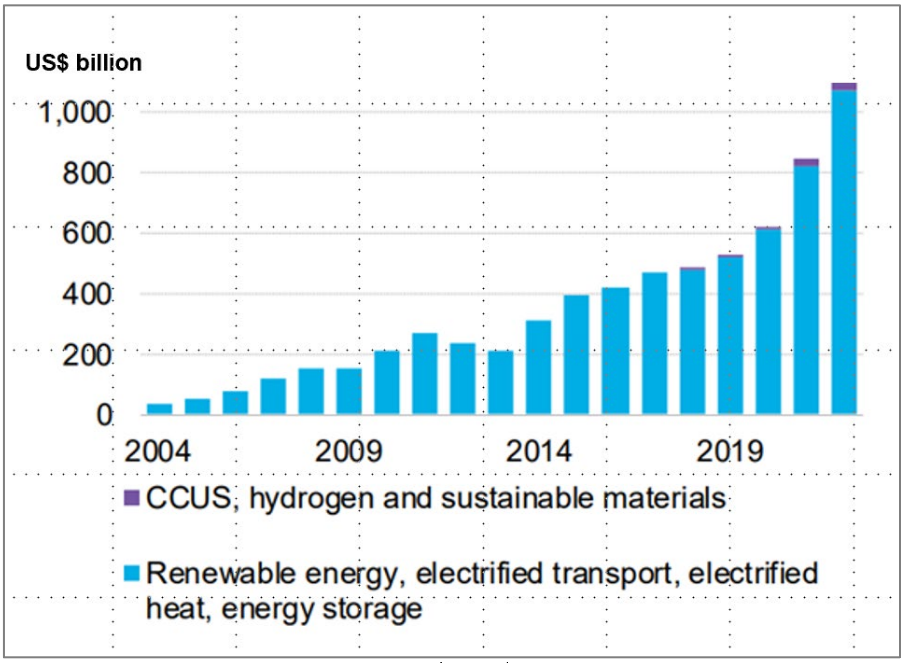
1.1. CCS Financing: Overview of the Market

Globally, 50 CCUS projects are in operation as of July 2024, securely storing around 51 Mt of CO_2 per year. A further 44 facilities are under construction (GCCSI, 2024).

Investment in CCUS is well below other CO_2 mitigation technologies. According to the IEA's World Energy Outlook and World Energy Investment reports, between 2017 and 2022, total global clean energy investment averaged US$1.2 trillion per year. During the same period, annual investment in CCUS averaged around US$1.5 billion, i.e. 0.13%. In 2022, CCUS investment amounted to around US$3 billion (Clean Energy Ministerial, 2023), and could rise to US$26 billion by 2025 if all projects are developed in time according to IEA's World Energy Investment 2024. According to Bloomberg NEF (2023), investments in carbon capture, transport, and storage infrastructure hit $6.4 billion in 2022. Investment in 2023 reached a record US$11.3 billion (BloombergNEF, 2024).

The market, which was once dominated by projects deployed at natural gas processing facilities, is diversifying rapidly into hard-to-abate sectors such as cement, iron and steel, and power (Bloomberg NEF, 2023). However, as shown in Figure 26, investments in CCUS, hydrogen, and sustainable materials accounted for less than 3% of annual investments in the energy transition in 2022 (Bloomberg Philanthropies, 2023).

Figure 4.1. Global Investment in Clean Energy

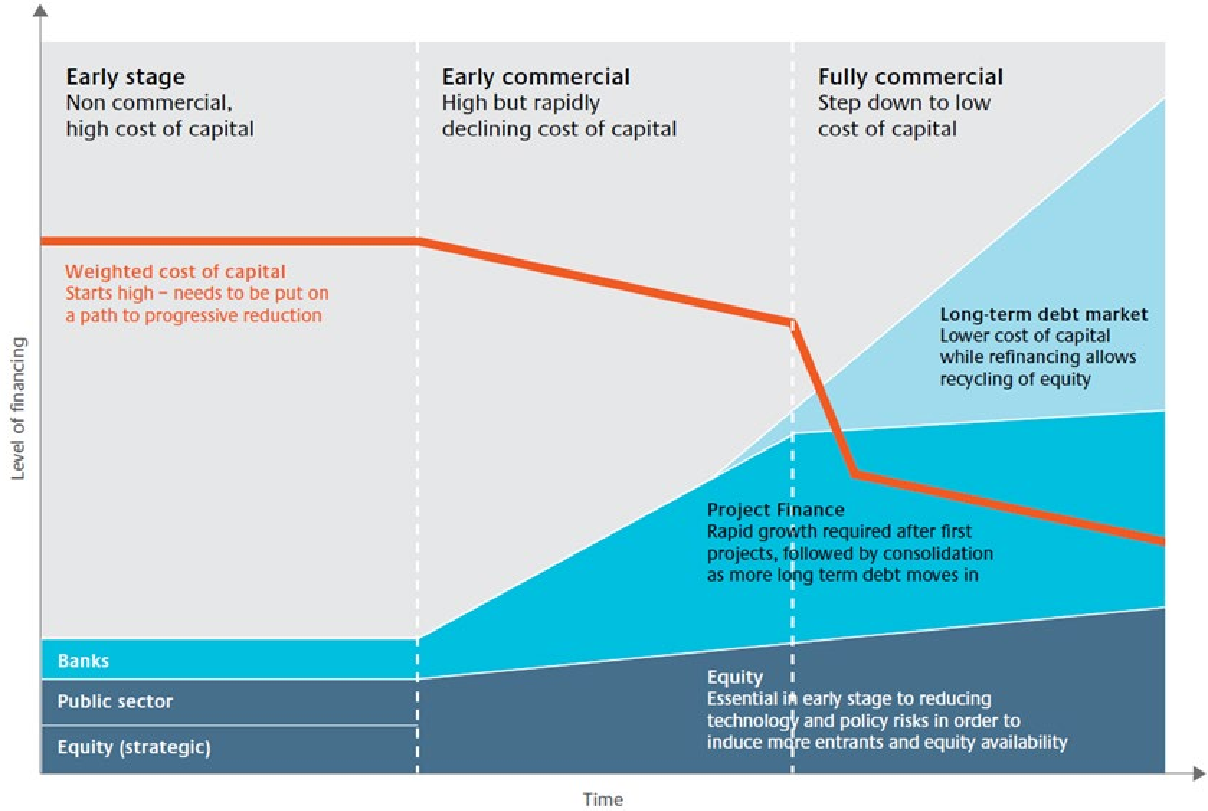


Source: Bloomberg Philanthropies (2023).

1.2. CCS finance: Risk acceptance and financial instruments

Financing for CCS is likely to be very high during the early phase but is expected to decrease over time as technology, systems, and industry integration are demonstrated. As Figure 4.2 and Figure 4.3 demonstrate, the risks associated with CCS decline over time, providers of finance may evolve, and early stage projects may require significant government support, concessional financing, and committed equity.

Figure 4.2. How the Cost of Capital and Sources of Finance Might Evolve as Risks are Addressed



Source: Energy Technologies Institute and Ecofin Research Foundation (2012).

Figure 4.3. Financing Instruments and Structures Offered by Special Financiers

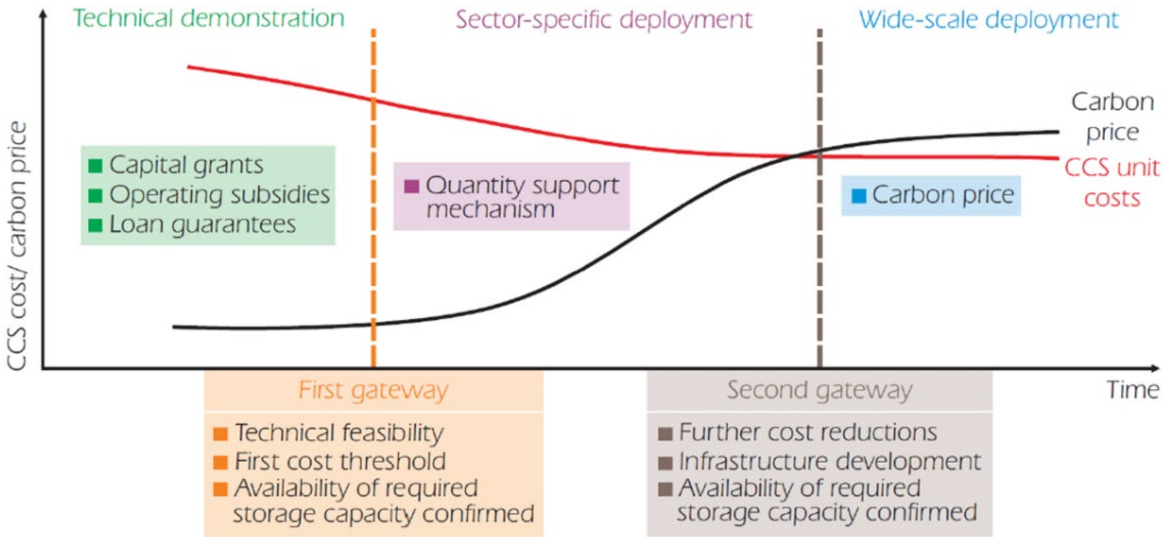
* Mezzanine debt is a form of subordinate debt that bridges the gap between conventional debt and equity finance. It is more expensive than senior debt, which tends to be secured and is more likely to be paid back in the event of bankruptcy.
Source: GCCSI (2021)

1.3. CCS Finance: Position of Carbon Credits

Regarding carbon credits in CCS projects, CCS requires a long-term carbon price incentive. Policy commitment by the government to strategic funding is necessary to advance CCS from the pilot project stage to demonstration and then to deployment phases.

As shown in Figure 4.4, IEA predicts that carbon prices will increase, and CCS costs will decrease. Carbon credits for CCS may be of greater interest because of their more stable long-term potential for CO_2 removal compared to nature-based solutions. However, CCS can be categorised into several types, and pricing is expected to vary depending on whether it involves emission reduction or carbon removal.

Figure 4.4. Position of Carbon Credits



Source: IEA (2013).

1.4. CCS Finance: CCS Hub and Clusters

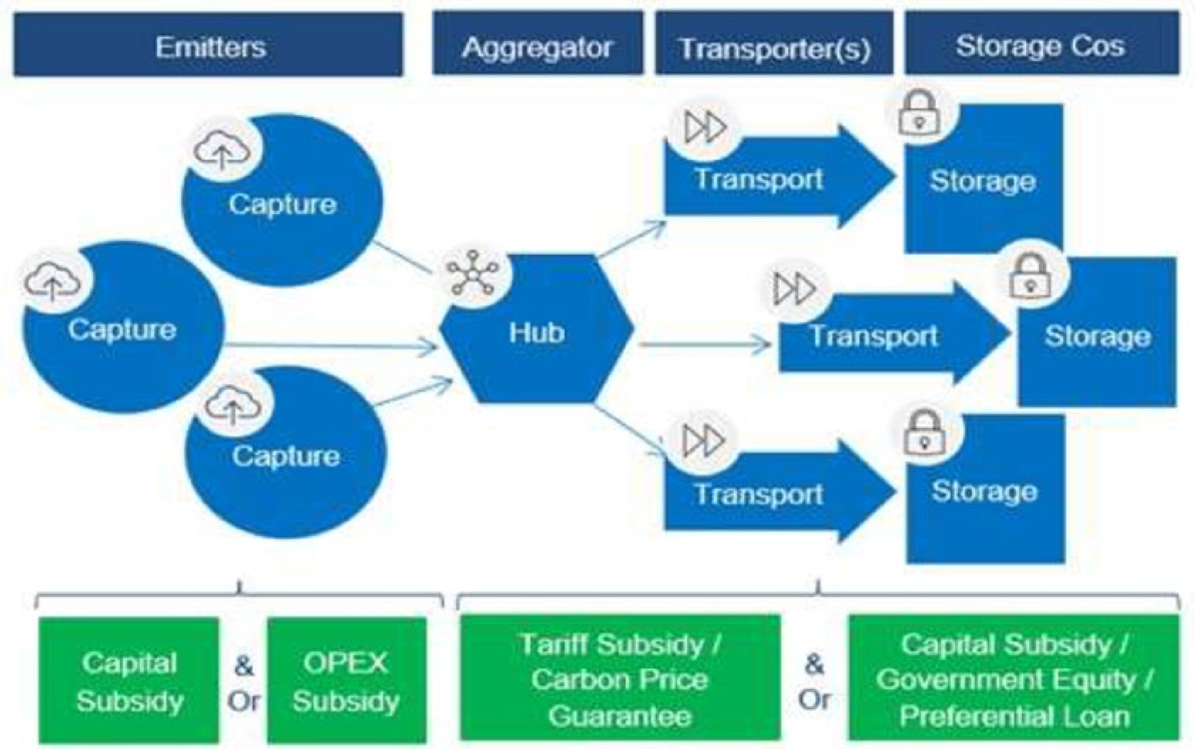
For Indonesia, considering both cross-border CO_2 imports and collecting domestic emissions for sequestration, a model with a separate collection hub from the transportation elements is appropriate. A separate entity would be needed to own and operate the CO_2 transportation.

As Figure 4.5 shows, the value chain is split into four separate components: (1) emitters, (2) aggregators, (3) transportation, and (4) storage. The aggregators would design, build, and operate the aggregation infrastructure and integrate the CCS value chain, as well as negotiate off-take agreements with emitters, transporters, and storage operators.

- To build CO_2 capture facilities, both the emitter's CAPEX and OPEX will be required to be directly subsidised.

- For CO_2 aggregation and transport and storage charges, OPEX also needs to be subsidised.
- Government subsidies or equity investment in aggregation infrastructure will assist aggregators in sharing the project's financial risk and reduce the aggregator's weighted average cost of capital, resulting in a reduction in the aggregation tariff.
- Governments can also acquire equity in projects in exchange for capital contributions to aggregation infrastructure, allowing for horizontal expansion.

Figure 4.5. CCS Hub and Clusters



Source: Oxford Institute for Energy Studies (2024).

2. Case Study of CCS Finance

This section studies cases of CCS finance. As Table 4.1 shows, CCS finance applicable to this study has four categories: international climate funds, private and blended source financing, carbon credits, and the Indonesia finance scheme. The following sections describe these in detail.

Table 4.1. CCS Finance: Category and Content

Category	Content
International Climate Funds	World Bank: CCS Trust Fund
	Green Climate Fund: Readiness and Preparatory Support Programme
Private and Blended Source Financing	PT Sarana Multi Infrastructure Bond
	Mitsubishi UFJ Financial Group (MUFG)
Carbon Credits	CCS in Crediting Mechanisms and the Indonesian Carbon Market
Indonesia Finance Scheme	Cooperation Contracts in the Oil and Gas Sector: Production Sharing Contract/Gross Split

Source: Mitsubishi Research Institute.

2.1. International Finance: World Bank's 'CCS Trust Fund'

As international finance, the World Bank has been administering the CCS Trust Fund for 14 years since 2009 and has provided technical assistance to 12 countries, which is scheduled to end in 2024. Table 4.2 summarises this fund. A new World Bank fund to support the deployment of carbon management technologies globally is under discussion. The SCALE Trust Fund with its results-based climate finance could be used as an example in the following manner:

1) Legal, regulatory, and policy frameworks that support and encourage carbon management activities;
2) Resource identification and assessment to produce national CO_2 storage atlases;
3) Infrastructure planning for CCUS hubs and transport networks; and
4) Technical knowledge and capacity-related carbon management.

Table 4.2. Overview of the CCS Trust Fund

Item	Content
Donors	• United Kingdom, Norway
Purpose	• Assist client government in assessing their potential for CCUS to aid in meeting climate change mitigation goals. • To build CCUS capacity within client countries
Structure	• Phase 1 (2009–2014): activities focused on developing a CCUS enabling environment in nine countries and regions. • Phase 2 (2014–2024): activities dive deeper into deployment.

Item	Content
	• Two phase 1 countries (South Africa and Mexico) advanced to phase 2 for piloting. Nigeria, Timor-Leste, India, and Egypt were later added in response to demand.
Type of support	• Global knowledge management • Capacity building • Technical assistance for pilot preparations • Funding for pilots • Market development

Source: Convergence (n.d.); ESMAP and the World Bank (2023).

Box 4.1. World Bank's 'SCALE Trust Fund'

Scaling Climate Action by Lowering Emissions (SCALE) is an umbrella trust fund partnership designed to support countries to accelerate their low-carbon development by mobilising affordable finance.

SCALE provides high-impact concessional finance to support countries to generate and transact high-integrity, socially inclusive carbon credits. This support further facilitates their access to international carbon markets and the affordable finance available for achieving domestic climate targets. Detailed approaches and mechanism of SCALE are shown in Table 4.3 and Figure 4.6.

Becoming operational in late 2023 with initial funding from the United States, SCALE is gearing up to provide support for up to 20 countries across Africa, Asia, and Latin America and the Caribbean.

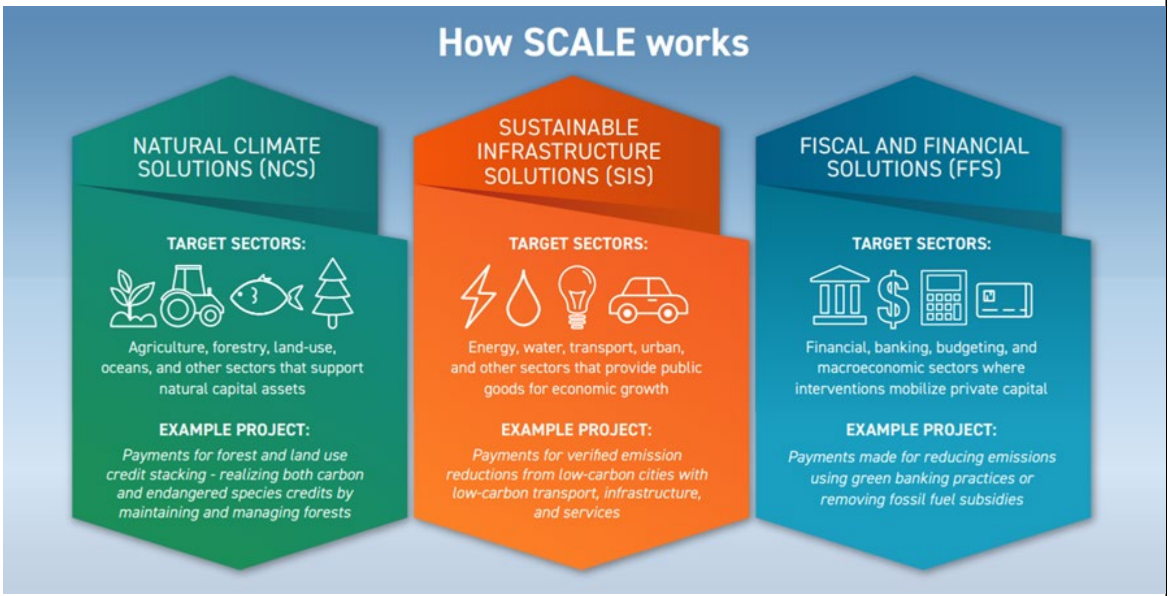
Table 4.3. World Bank Scale Trust Fund

Approach	Content
Financing the generation of high-integrity carbon credits	• Sets standards and provides countries with capacity building and **technical assistance (TA)** to apply them to programmes. • Together with price-floors embedded in the **results-based climate finance agreements**, this incentivises action and guarantees payment upon achieving results, empowering countries with the option to sell on carbon markets or exercise the price-floor guarantee for the best possible returns.

Supporting countries in building operational infrastructure and experience	• Supports building the operational infrastructure and experience required to generate and transact in carbon markets. • Sets effective incentives for mitigating and reducing risks within emerging carbon markets, enabling further replication.
Crowding-in private sector finance by simplifying access to carbon markets	• Bridges gaps between supply and demand, and collaborating with carbon buyer aggregators, such as the Energy Transition Accelerator, to boost impactful climate financing.

Source: World Bank (n.d.).

Figure 4.6. World Bank Scale Trust Fund



Source: World Bank (2024a).

2.2. CCS trust fund: (1) Timor-Leste

The International Finance Corporation (IFC), with cross support from the World Bank, supports the development of CCUS legal and regulatory frameworks as follows:

- Assesses the existing legal and regulatory framework: reviews current legislation/regulation in Timor-Leste and presents framework options;

- Identifies fiscal benefit-sharing and local participation: reviews existing licence/production-sharing frameworks and fiscal frameworks that could be applied to CO_2 storage projects to maximise revenues to the country; and
- Supports capacity building on CCUS and carbon markets: conducts market assessments for future international CO_2 trade in the Asia-Pacific region to understand the potential and competitive position of the Bayu-Undan CCS project to become a regional CO_2 storage hub.

Details of IFC's funding for Timor-Leste are described in Table 4.4.

Table 4.4. Overview of the International Finance Corporation's CCS Trust Fund

Item	Content
Implementing Entity	International Finance Corporation (IFC)
Investor	Government of Timor-Leste
Schedule	IFC approval: 31 May 2023; disclosure: 3 April 2024; project estimated end: 1 September 2025
Project Budget	US$1,606,148 (project budget includes all project-funded activities)
Technical Support	• To develop the Bayu-Undan Carbon Capture and Storage Project (Bayu-Undan CCS) • The IFC, with cross support from the World Bank, will provide assistance by conducting assessments on legal and regulatory issues and best practices, knowledge sharing, and potential fiscal benefit sharing and local participation opportunities through four key components: CCS knowledge sharing, CCS legal and regulatory mapping, CO_2 storage hub assessment and carbon markets, and CCS fiscal and benefit sharing planning.
Target Project	• Type: CCS at the depleting Bayu-Undan reservoir • Sector: Oil and gas production from Bayu-Undan in the Timor Sea expected to cease in 2023 • Eligibility: To store 10 million tonnes per annum of CO_2
Characteristics	• The Government of Timor-Leste is currently evaluating the development of a CCS hub facility at the depleting Bayu-Undan reservoir. • The CCS hub is to play a key role in: (i) generating revenue for the Government of Timor-Leste, (ii) developing a new industry for Timor-Leste, and (iii) supporting climate change mitigation ambitions and commitments locally and regionally.

Source: IFC Project Information & Data Portal (n.d.).

2.3. CCS trust fund: (2) Other countries in Phase 2

Some of the Phase 2 target country activities are still ongoing, and the expected key achievements at the end of Phase 2 are as follows:

- Legal and regulatory framework scoping and development in four countries: Mexico, Nigeria, Timor-Leste, and South Africa;
- Supported detailed CO_2 storage atlas development in South Africa and Nigeria;
- Supported CCUS hub scoping in Egypt and Timor-Leste;
- Supported CO_2 storage piloting in South Africa; and
- Supported CCUS policy development in India.

The scope, budget, and project content for the Phase 2 activities of each country are summarised in Table 4.5.

Table 4.5. Country Activities in Phase 2 of the CCS Trust Fund of the IFC

Item	Scope	Budget	Project Component	Status
Egypt	Phase 1: To assess CCS potential and capacity building for Egypt Phase 2: Improve understanding of the four potential CCUS hubs in Egypt	Phase 1: US$300,000 Phase2: US$750,000	• Phase 1: Technical and economic assessment of CCS potential, analysis of barriers and how to overcome them, capacity building • Phase 2: Creation of a CCS strategy and action plan, assessment of technical and financial feasibility of industrial CCS hubs	Phase1: Completed in 2013 Phase 2: Completed in 2023
Nigeria	Complete a diagnostic and scoping study of industrial CCUS activities in Nigeria	US$2.2 million	• Assessment and mapping of CO_2 sources and CO_2 storage potential • Screening of industrial CCUS pilot options • Capacity building workshops • Legal and regulatory study	Completed in 2023

Item	Scope	Budget	Project Component	Status
South Africa	Phase 1: Support the establishment of a CCUS enabling environment Phase 2: Prepare and implement a CCS pilot	Phase 1: US$1.35 million Phase 2: US$42.4 million	• Phase 1: Studies on CCS legal and regulatory frameworks, techno-economics of CCS, stakeholder engagement, capacity building • Phase 2:Pilot CO_2 storage project – proof of concept for CO_2 storage in South Africa technical and governance capacity building, CO_2 capture pilot project – technology assessment and front-end engineering and design	Ongoing for completion in 2024
India	Support the government in creating a policy framework for CCUS in India	US$700,000	• Identification of global CCUS policies and business models that can be adapted to an Indian context • Creating an approach to stimulate the development of CCUS hubs and clusters • Quantification of the role of CCU in India's energy transition	Completed in 2023

Source: ESMAP and the World Bank (2023).

2.4. International Finance: Green Climate Fund's 'Readiness Programme'

The Green Climate Fund (GCF) is a fund for climate finance that was established within the framework of the United Nations Framework Convention on Climate Change (UNFCCC). Its objective is to assist developing countries with climate change adaptation and mitigation activities. The GCF's Readiness and Preparatory Support Programme supports developing countries in strengthening their capacity building, strategic frameworks (NDCs), national adaptation plans (NAPs), pipeline development, and knowledge sharing and learning for climate change mitigation or adaptation. As of 30 April 2024, the Readiness Programme has approved US$627.3 million to 142 countries in the 10 years since the programme started operations.

In 2024, the GCF has provided a Readiness Grant to Surinam and Trinidad and Tobago for CCS activities, including assessment of the storage potential in deep saline formations and the development of a national storage atlas that outlines the potential for CCS. Trinidad and Tobago is the first country to be provided funding from the GCF for CCS activities. This should set a precedent for other developing countries to be financed by the GCF for CCS-related activities. Detailed information is shown in Table 4.6.

Table 4.6. International finance: Green Climate Fund's 'Readiness Programme' for CCS Activities in Trinidad and Tobago

Item	Content
Implementing Entity	• Green Climate Fund (GCF)
Background	• Trinidad and Tobago launched its first Technology Needs Assessment (TNA) in 2021 as part of the global TNA project funded by the Global Environment Facility and implemented by the UNEP Copenhagen Climate Centre. • Trinidad and Tobago placed a top priority on mitigation for the industrial and power sectors whilst also approaching adaptation in a comprehensive manner. The TNA analysed specific sectors and technologies to help the country move towards implementation. • During the TNA, the analysis of technical possibilities, barriers, and enablers for deploying CCS technology provided pathways to address financial, regulatory, and technical challenges, facilitating the subsequent phases that led to GCF funding.
Schedule	• IFC approval: 31 May 2023; disclosure: 3 April 2024; project estimated end: 1 September 2025
Project Budget	• Surinam and Trinidad and Tobago requested US$2 million in their proposal to the GCF
Characteristics	• Partnerships: UNEP Copenhagen Climate Centre, IEAGHG R&D programme, University of West Indies, University of Trinidad and Tobago, and University of Texas

Item	Content
	• Recently unveiled plans for the University of West Indies and the University of Trinidad and Tobago to establish a research hub focusing on CCUS

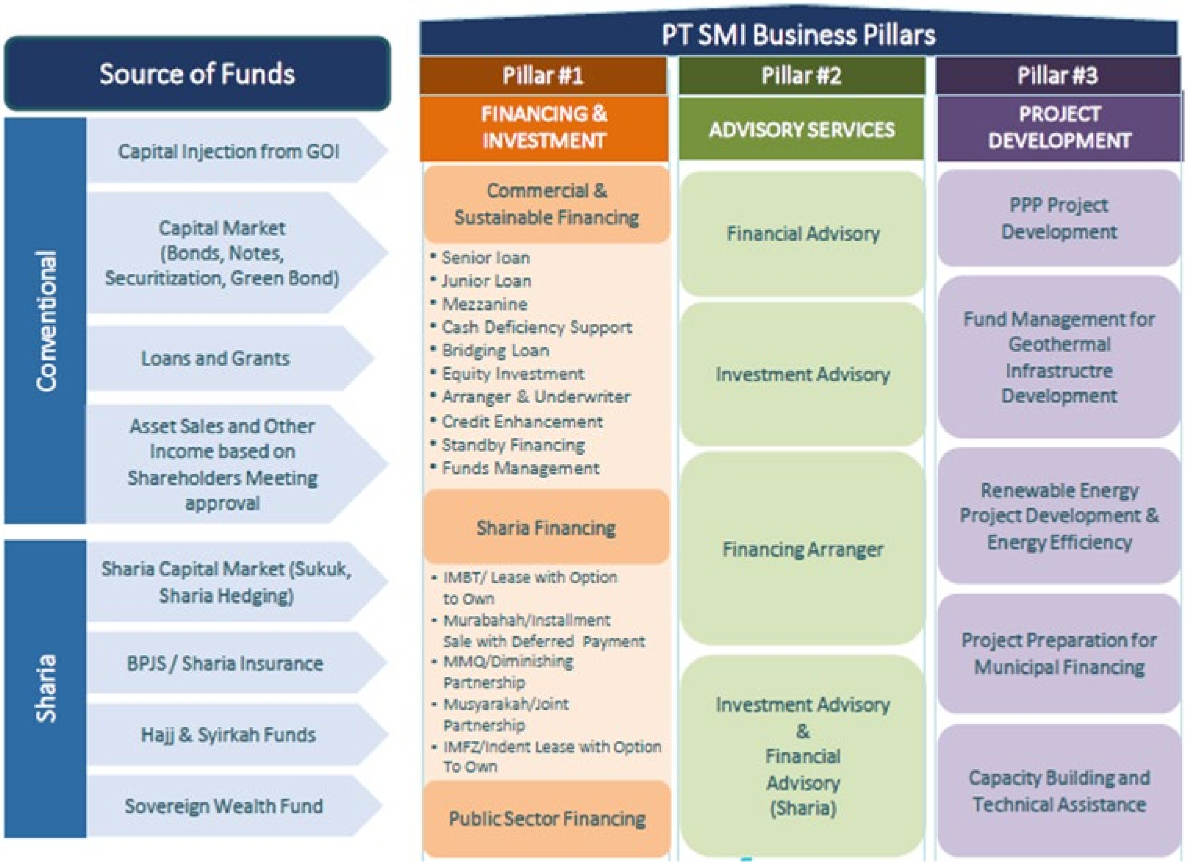
Source: Green Climate Fund (2024); IEAGHG (2024); UNEP (2024).

2.5. Public Finance: PT SMI's 'Blended Finance for Clean Energy'

PT SMI was established in 2009 as a State-Owned Enterprise and carries the duty of supporting the Indonesian government's infrastructure development agenda through partnerships with private and/or multilateral financial institutions, including in public-private partnership projects. As Figure 4.7 shows, PT SMI is composed of three business pillars: financing and investment, advisory services, and project development.

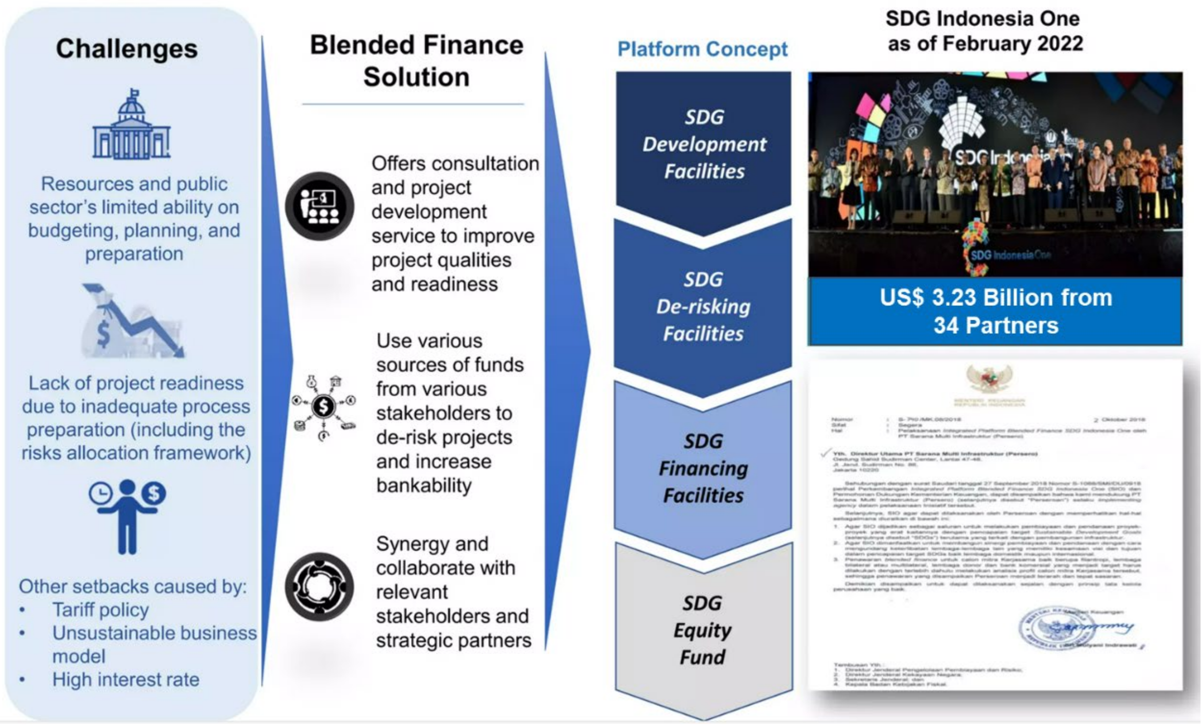
The aim of blended finance is to overcome challenges such as insufficient resources and limited ability in the public sector and private sector. Blended finance, including consultation and mixed funds, improves the quality of projects and decreases the risks that stakeholders and strategic partners take. Details are shown in Figure 4.7.

Figure 4.7. Three Core Business Pillars of PT SMI



Source: PT SMI (2024).

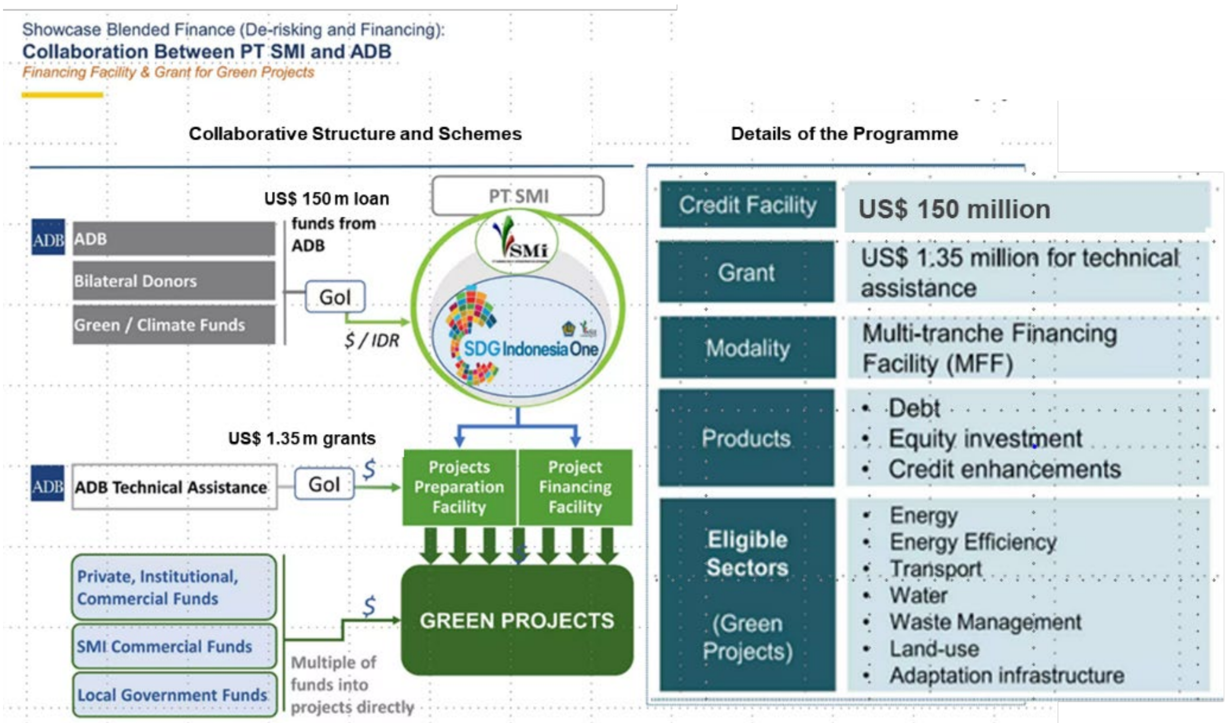
Figure 4.8. Aims and Solutions of Blended Finance



Source: PT SMI (2024).

PT SMI cooperates with several governments, development banks, and other commercial banks to finance green projects. These may not exclude CCS or CCUS, though cases of CCS or CCUS have not been found so far. To date, PT SMI have had partnerships with the Asian Development Bank (ADB) (see Figure 4.9), the Japanese government's Joint Crediting Mechanism (JCM) (see Figure 4.10), Agence Française de Développement-European Union, and other private banks.

Figure 4.9. PT SMI Blended Finance: Collaboration with the Asian Development Bank



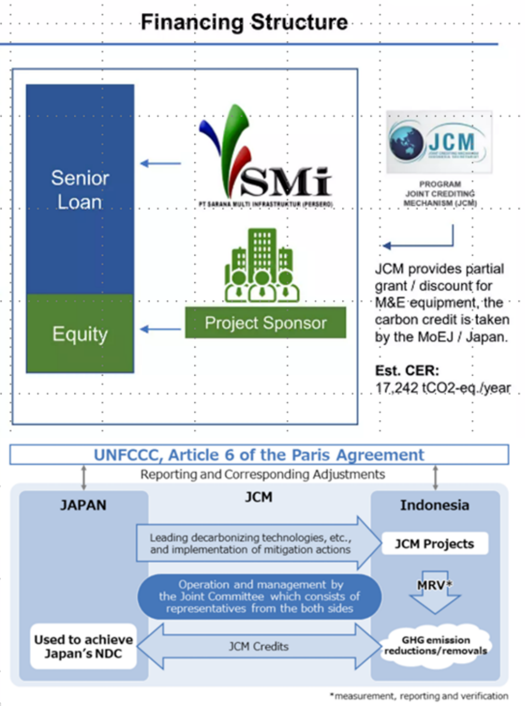
Source: PT SMI (2022).

Figure 4.10. PT SMI Blended Finance: Collaboration with the JCM

Showcase Blended Finance (De-risking and Financing):
Collaboration Between PT SMI and JCM
Joint Crediting Mechanism (JCM) Support for Clean Energy Project

Facility Details

Sector	Electricity – Renewable Energy
Project Name	Bayang Nyalo Minihydro Project
Location	Pesisir Selatan, West Sumatera
Installed Capacity	3x 2MW
Project Cost	Rp 207 billion(US$ 14.4 million)
JCM Support	The Ministry of Environment Japan (MoEJ) applies the carbon credit for RE project through JCM Crediting Mechanism. The project owner benefits JCM Grant in the form of discounted price of M&E equipment manufactured by the Voith Hydro/ Voith Fuji Hydro KK, Japan.



Source: PT SMI (2022).

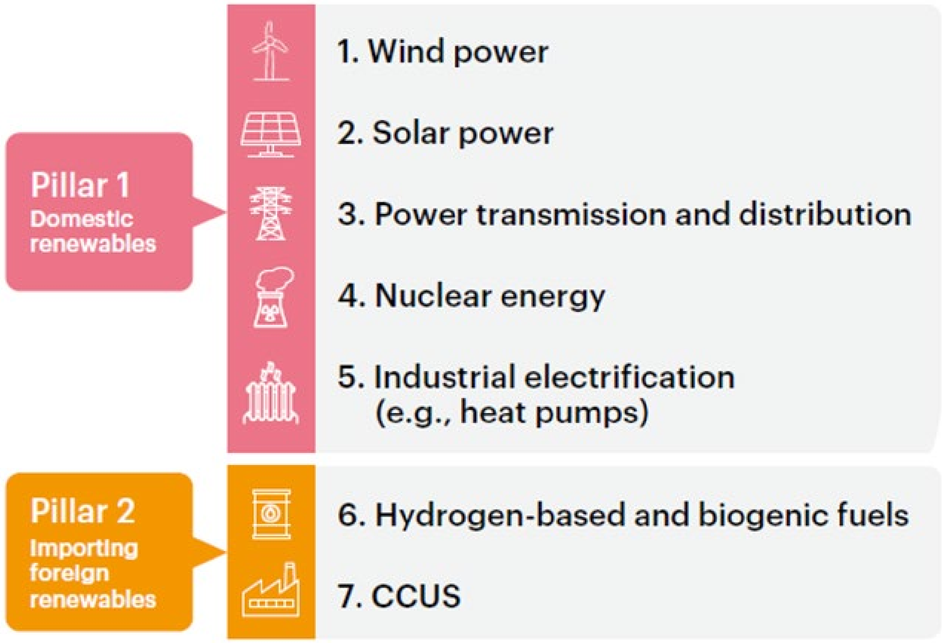
2.6. Private Finance: Mitsubishi UFJ Financial Group: Blended Finance is Appropriate for CCUS

Mitsubishi UFJ Financial Group (MUFG) is committed to supporting the energy transition for as wide a range of clients as possible through engagement, rather than divestment, based on the idea of realising carbon neutrality.

MUFG applies the 'Environmental and Social Policy Framework' for individual projects. Regarding the fossil fuel-related sector, MUFG's policy is that 'MUFG does not provide financing to new coal-fired power generation projects or expansion of existing facilities.' However, it provides 'finance for coalfired power generation equipped with CCUS, mixed combustion, and other technologies necessary to achieve the Paris Agreement target may be considered on an individual basis.' (MUFG, 2022).

Based on this direction, MUFG (2023a) published Transition Whitepaper 2023, focusing on carbon neutrality in electricity and heat. As Figure 4.11 shows, MUFG states that seven key technologies should be supported to achieve carbon neutrality.

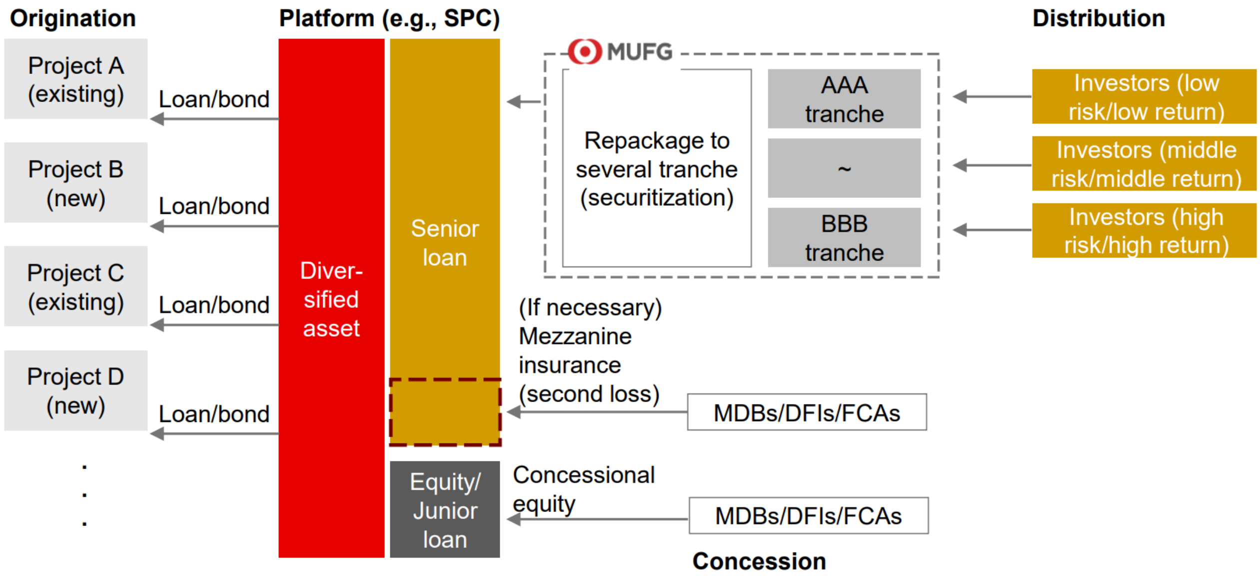
Figure 4.11. MUFG's Seven Key Technologies to Be Supported



Source: MUFG (2023a).

Blended finance could help accelerate deployment of CCUS technology by unlocking private capital. Blended finance not only supports project financing but also lowers risk assessment for corporate banks.

Figure 4.12. MUFG's Blended Finance Platform Mechanism



Source: MUFG (2023b).

As Figure 4.12 shows, MUFG proposes developing an innovative blended finance platform, taking a portfolio approach combined with securitisation solution.

According to the global institution Convergence (n.d.) blended finance has a structuring approach that allows organisations with different objectives to invest alongside each other whilst achieving their own objectives, for instance financial return, social impact, or both.

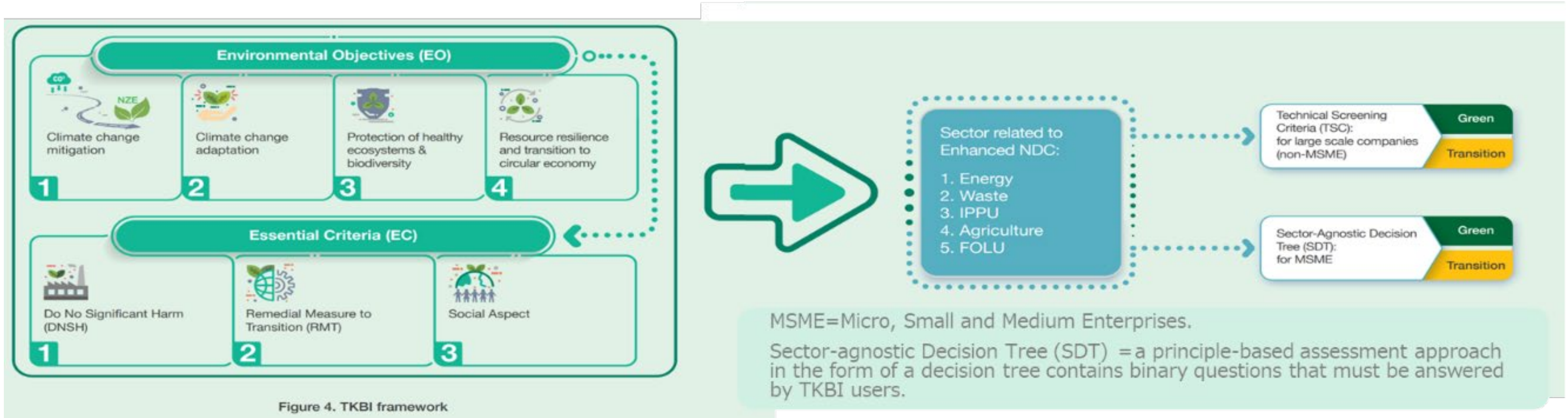
3. Taxonomy in Indonesia

3.1. OJK Indonesia's Taxonomy

The Indonesia Taxonomy for Sustainable Finance (TKBI) classifies economic activities that support Indonesia's Sustainable Development Goals, encompassing the economy, environment, and social aspects. This taxonomy promotes capital allocation and sustainable financing to achieve Indonesia's net zero emissions (NZE) targets.

The scope of the TKBI comprises NDC-related sectors. The 2022 Indonesia Enhanced NDC provides five key focus sectors: energy, waste, industrial processes and product use, agriculture, and forestry and other land use (FOLU). In order to align with national and regional policy developments, the TKBI will be carried out in stages, commencing in 2024 with the energy sector as the first focus sector, and subsequently progressing to other NDC-related sectors in the years to come.

Figure 4.13. OJK Indonesia's Taxonomy



Source: Indonesian Financial Services Authority (2024).

The Indonesian Financial Services Authority (Otoritas Jasa Keuangan; OJK) established the TKBI, which classifies activities into three categories: green, transition, and unqualified. As shown in Table 4.7, green activities are those to keep the global temperature rise below 1.5°C, in line with the Paris Agreement.

Thee TKBI provides Technical Screening Criteria (TSC), a set of criteria for assessing economic activities based on their contribution to environmental objectives. In order to classify some activities of the energy sector into green or transition activities, the TSC stipulate the enabling activities, such as CCS or CCUS, as shown in Table 4.8 and Table 4.9.

Table 4.7. OJK Indonesia's Taxonomy: General Principles

Classification	General Principle
Green	Activities in line with the commitment to keep the global temperature rise to below 1.5°C, in line with the Paris Agreement including considering Indonesia's NZE in 2060 (or earlier) and fulfilling social aspects.
Transition	Activities that are not currently in line with commitments to keep the global temperature rise on the NZE pathway, however: • Are moving towards a 'green' classification within a specified timeframe; • Facilitate significant emissions reductions in the short or medium term by a specific deadline; or • Encourage other activities to be sustainable and fulfilling social aspects.
Unqualified	Other activities not classified above.

Source: Indonesia Financial Service Authority (2024).

Table 4.8. OJK Indonesia's Taxonomy: TSC Stipulations for CCS and CCUS

TSC stipulate activities where CCS could be used in energy sector
Coal-fired power plants
Production of heating/cooling from renewable non-fossil gaseous and liquid fuels
Production of heating/cooling from fossil gas
Production of heating/cooling from bioenergy
Mining of petroleum
Natural gas mining
TSC stipulate activity where CCUS could be used in the energy sector
Electricity generation from gas power

Source: Indonesia Financial Service Authority (2024).

The TKBI has classified some CCS-related activities a green, as described in Table 4.9.

Table 4.9. TKBI-classified Green CCS Activities

Green Activities	Technical Screening Criteria of Green Activities for Environmental Objectives, Climate Change Mitigation
Carbon capture and storage attached to mining of petroleum or natural gas mining Transport of CO_2	1. CO_2 transported from capture point to injection point does not lead to leakages above 0.5% of CO_2 by mass on an annual basis. 2. CO_2 is delivered directly or indirectly to a permanent storage site that meets the criteria for underground geological CO_2 storage; and 3. Appropriate leakage detection systems are applied and an MRV plan is in place that includes steps developed according to the relevant standards and good engineering practices.
Carbon capture and storage attached to mining of petroleum or natural gas mining Underground permanent geological storage of CO_2	1. Assessment of the potential of the storage complex and its surroundings, or exploration is conducted to determine whether the geological formation is suitable for use as a CO_2 storage site. 2. For the operation of underground geological CO_2 storage sites, including closure and post-closure obligations: appropriate leakage detection systems are implemented to prevent release during operation; 3. A monitoring plan of the injection facilities, where appropriate, the surrounding environment is in place, with the regular reports checked by the competent national authority; and 4. Exploration and operation of storage sites comply with the applicable standards.
Research, development, and innovation for CCS-related technologies	Activities meet 1 and 3 or 2 and 3. 1. Engage in research and development, or innovation activities for technologies, products, or other solutions dedicated specifically to CCS; 2. Implement technologies, products, or other solutions being researched for CCS, with the potential to reduce overall GHG emissions upon commercialisation; 3. If the technology, product or other solution is being researched developed of innovated:

Green Activities	Technical Screening Criteria of Green Activities for Environmental Objectives, Climate Change Mitigation
	a. At a Technology Readiness Level (TRL) 1 to 7, the GHG emissions are calculated by the party conducting research; or b. At TRL 8 or higher, the GHG emissions are calculated using ISO 14067:2018 or ISO 14064-1:2018 and verified by an independent third party.

Source: Indonesia Financial Service Authority (2024).

3.2. ASEAN Taxonomy: CCUS Useful for the Energy Sector

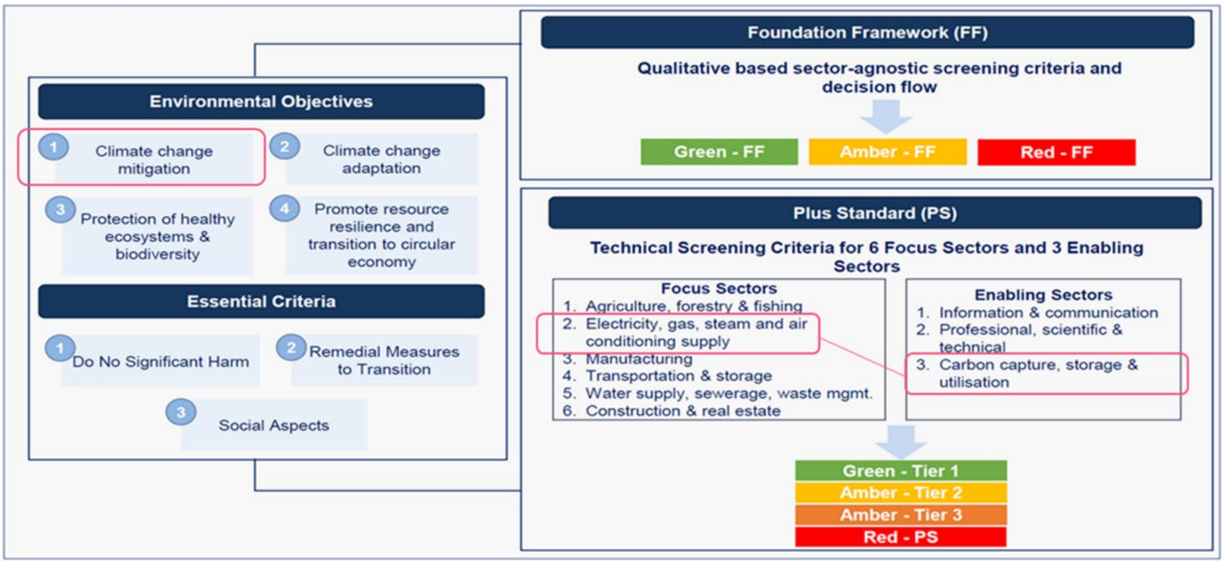
In November 2021, the ASEAN Taxonomy Board, supported by the ASEAN Finance Ministers' and Central Bank Governors' Meeting, made public the ASEAN Taxonomy for Sustainable Finance to promote financing for sustainable economic activities.

The first version provides the overall framework. The subsequent versions define the details.

The ASEAN Taxonomy stipulates environmental objectives: climate change mitigation, climate change adaptation, the protection of a healthy ecosystem and biodiversity, and the promotion of resource resilience and the transition to a circular economy. To be classified, any activity must demonstrate that it contributes to at least one of these objectives and does not have any adverse effects on the other objectives.

The ASEAN Taxonomy has a Foundation Framework (FF), Technical Screening Criteria (TSC), and Plus Standard (PS) for screening activities. Activities in the energy sector (electricity, gas, steam, and air conditioning supply) that cannot meet the criteria could use CCUS for environmental objective as enabling sectors. The structure of the ASEAN Taxonomy is shown in Figure 4.14.

Figure 4.14. Structure of the ASEAN Taxonomy for Sustainable Finance



Source: ASEAN Taxonomy Board (2024).

The TSC of the ASEAN Taxonomy have green, amber, and red tiers for all the ASEAN Member States. The green TSC were set for interoperability with international taxonomies and alignment with national taxonomies. The amber TCS were set against future emissions projections for activities of energy in Southeast Asia, as derived from the IEA Sustainable Development Scenario. Amber Tier 2 reflects the projected emissions intensity for Southeast Asia in 2030. Amber Tier 3 reflects the projected emissions intensity for Southeast Asia in 2027. Other activities are classified as red in the ASEAN Taxonomy. These include coal or oil power generation without CCUS and heat recovery from coal- or oil-fuelled power generation.

Table 4.10. ASEAN Taxonomy

Activities in energy sectors that could use CCUS to meet the TSC for environmental objectives
351[011] Electricity generation from fossil gas
351[012] Electricity generation from renewable non-fossil gaseous and liquid fuels, including co-firing with fossil fuels
351[013] Hybrid fossil, renewable power generation, transmission and distribution, and/or energy storage for island systems
351[014] Electricity generation from bioenergy, including co-firing with fossil fuels
351[022] Electricity generation using concentrated solar power technology

Activities in energy sectors that could use CCUS to meet the TSC for environmental objectives
352[010] Transmission and distribution networks for renewable and low-carbon gases
353[013] Production of heating/cooling from renewable non-fossil gaseous and liquid fuels
353[014] Production of heating/cooling from fossil gas

Source: ASEAN Taxonomy Board (2024).

It is noted that the taxonomy excludes power generation using gas derived from coal except where it can be shown that, by abatement through CCUS, the respective TSC as shown in Table 4.11 are fulfilled.

Table 4.11. Technical Screening Criteria for Climate Change Mitigation

Tier	EO1: Climate Change Mitigation Technical Screening Criteria (TSC)
Tier 1 (Green)	Lifecycle GHG emissions from the generation of electricity by the entire facility <100 gCO_2e/kWh.
Tier 2 (Amber T2)	Lifecycle GHG emissions from the generation of electricity by the entire facility: ≥100 and <425 gCO_2e/kWh.
Tier 3 (Amber T3)	Lifecycle GHG emissions from the generation of electricity by the entire facility: ≥425 and <510 gCO_2e/kWh.
TSC applicable to all tiers	1. For facilities that are equipped with CCUS, CO_2 from power generation that is captured for underground storage, must be transported and stored in accordance with the TSC for activities 000[010], transport of CO_2, and 000[020] underground permanent geological storage of CO_2. 2. The activity meets either of the following criteria: a. At construction, measurement equipment for monitoring of physical emissions, such as methane leakage is installed, or a leak detection and repair programme, is introduced; or b. At operation, physical measurement of methane emissions is reported, and leaks are eliminated.

Source: ASEAN Taxonomy Board (2024).

As shown in Table 4.12, version 2 also includes activities related to the CCUS-enabling sector that are not included in the International Standard Industry Classification (ISIC), namely:

- Activity 000[010] transport of CO_2; and
- Activity 000[020] underground permanent geological storage of CO_2.

Table 4.12. ASEAN Taxonomy CCUS Activities Not in ISIC

Activity	Tier 1 (Green)
Transport of CO_2, including equipment for the transport of CO_2 for the purposes of sequestration	• CO_2 transported from the capture point to the injection point does not lead to leakages above 0.5% of CO_2 by mass on an annual basis; and • CO_2 is delivered directly or indirectly to a permanent storage site that meets the criteria for underground geological CO_2 storage as described in Activity 000[020]; and • Appropriate leak detection systems are applied, and a monitoring plan is in place, with the report verified by an independent third party in accordance with international standards.
Underground permanent geological storage of CO_2	• Characterisation and assessment of the potential storage complex and surrounding area, or exploration is carried out in order to establish whether the geological formation is suitable for use as a CO_2 storage site; and • For operation of underground geological CO_2 storage sites, including closure and post-closure obligations: appropriate leakage detection systems are implemented to prevent release during operation; and • A monitoring plan of the injection facilities, the storage complex, and, where appropriate, the surrounding environment is in place, with the regular reports checked by the competent national authority; and • Exploration and operation of the storage sites comply with the applicable standards.

Source: ASEAN Taxonomy Board (2024).

3.3. ERIA selects CCUS to boost financing and decarbonisation

In 2024 ERIA made public its selected transition technology list with an aim to unlock funding as a guide for financial institutions and to help private sectors to identify business opportunities, and policy makers to understand the technology landscape.

ERIA's selection focuses on transition technologies that will have the most impact on reducing emissions. For that reason, it focuses primarily on the power sector and related upstream activities that together account for more than 50% of the region's CO_2 emissions.

Selected technologies include CCUS in coal/gas power plants and CCUS in gas processing after the assessment of six elements: emissions impact, reliability, cost, lock-in prevention considerations, Do No Significant Harm (DNSH) considerations, and social considerations.

Figure 4.15. The Ten Technologies Considered

The first version of the document prioritises technologies based on

- Direct and sizable impact on emissions reduction
- Neither zero emissions/green, nor brown
- Involving sizable deployment scale or investments

Technology tier	Sector Power (Electricity generation)	Upstream (Fuel production)
Early decarbonisation Lower emission	①CCGT (coal avoidance, higher efficiency conversion) ②Waste to energy power plant	⑥Leak detection and repair (LDAR) for fugitive emissions reduction
Partial emissions reduction much lower emission	③Biomass co-firing ④Low-carbon ammonia co-firing ⑤Low-carbon hydrogen co-firing	⑦Process electrification in gas production and processing
Deep decarbonisation Near-zero emission	⑧CCUS in coal/gas power plant	⑨Blue hydrogen & blue ammonia production ⑩CCUS in gas processing

CCGT = combined-cycle gas turbine; CCUS = carbon capture, utilisation, and storage.
Source: Economic Research Institute for ASEAN and East Asia (2022).

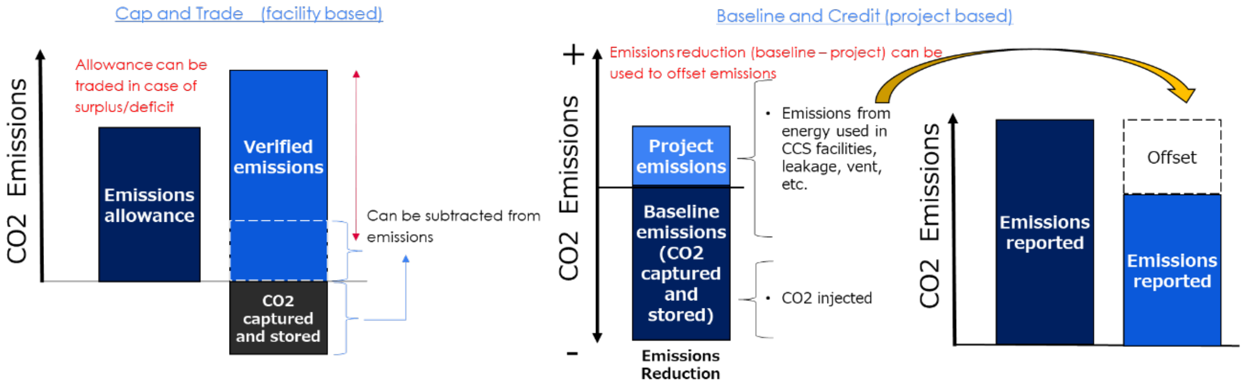
ERIA's list does not include hydrogen or ammonia zero carbon technologies of which guidance has already been published for financial institutions.

Source: ERIA (2022).

4. CCS in the carbon market

Carbon credits may be used as a form of CCS financing. As a background, the carbon market has two types: (1) Cap and Trade (emissions trading) and (2) Baseline and Credit Schemes, as shown in Figure 4.16. Carbon credits generated through baseline and credit schemes can be used as a tool for financing CCS/CCUS.

Figure 4.16. Types of Carbon Market



Source: Mitsubishi Research Institute.

4.1. Positioning of carbon credit market segments

The carbon market is characterised by several segments, as shown in able 4.13.

The landscape of the carbon market is quite complex, with public schemes such as the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) using voluntary credits whilst corporates use all sorts of credits for voluntary use.

Table 4.13. Carbon Credit Market Segments

Market Segment		Overview	Example		Eligibility of CCS
Compliance Carbon Market	International	Credit purchases aimed at helping countries meet their NDCs and airlines to comply with CORSIA	• United Nations: CDM, Article 6.4 Mechanism • Bilateral: JCM, KliK Foundation, etc.		N/A
	Domestic	Credit purchases aimed at complying with obligations	American Carbon Registry (United States)	Compliance (California Compliance Offset Program) and voluntary	CCS and CO_2-EOR

Market Segment		Overview	Example		Eligibility of CCS
		under carbon taxes, ETS	Alberta Emission Offset System (Canada)	Compliance offset for Technology Innovation and Emissions Reduction (TIER) Regulation	CCS and CO_2-EOR
			T-VER (Thailand)	Voluntary	CCS
			Emission Reduction Fund (Australia)	Compliance offset for safeguard mechanism, voluntary	CCS
Voluntary Carbon Market		Credit purchases aimed at meeting voluntary targets or commitments	Puro.earth (Interna-tional)	Voluntary	DACCS and BECCS
			GCC	Voluntary	CCS
			T-VER (Thailand)	Voluntary	CCS
			Verified Carbon Standard (Interna-tional)	Voluntary (eligible for compliance offset in some areas)	CCS

Source: Created by Mitsubishi Research Institute based on World Bank (2024b).

4.2. Carbon Credit Market in Indonesia

Indonesia has also established a domestic carbon market, allowing the trading of offset credits (SPE-GRK). Offset credits must stem from mitigation activities from the following:

- New and renewable energy power plants;
- Transportation, construction, and industry, including energy efficiency activities; or
- Other activities in the energy sector.

MEMR No. 2/2023 stipulates that if the source of carbon emissions is upstream oil and gas businesses, the monetisation of CCS/CCUS consists of carbon trading. PR No.

14/2021 also refers to carbon trading, but additional provisions regarding SPE-GRK for CCS projects shall be stipulated in the future (ICAP, n.d.).

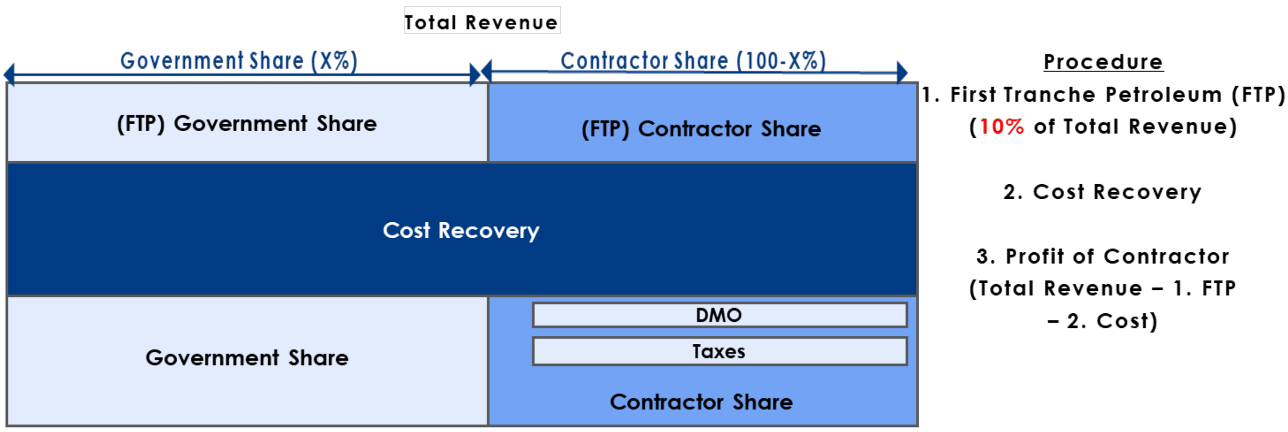
4.3. CCS Financing Scheme in Indonesia

4.3.1. Production sharing contract (PSC)

1) Cost recovery PSC

According to PR No. 14/2024, cooperation contracts for CCS implementation may take the form of cost recovery PSC or gross split PSC, allowing the contractor to finance CCS projects. Overview of cost recovery PSC scheme is shown in Figure 4.17. The allocation between the government and contractor depends on each PSC, typically 65:35 between the government and contractor for oil, and 60:40 between the government and contractor for gas.

Figure 4.17. Cost Recovery PSC Scheme

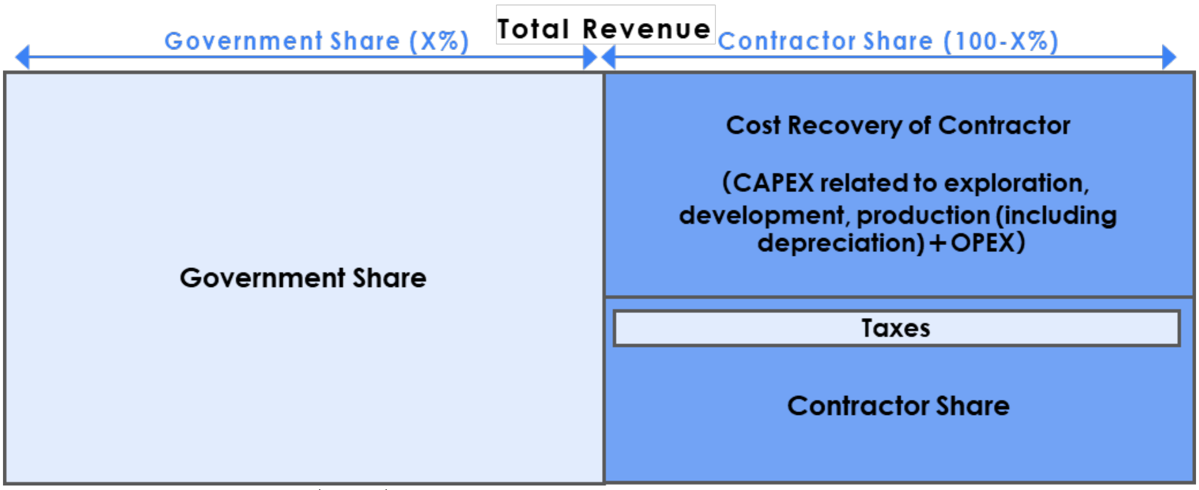


Source: SSEK Law Firm (2021).

2) Gross split PSC

Overview of Gross Split PSC scheme is shown in Figure 4.18. The share of the contractor depends on the base split, as shown in Table 4.14, and several other components, as shown in Table 4.15. According to the SKK Migas Guidelines (PTK 070), contractors may monetise CCS/CCUS implementation relating to carbon emissions from upstream oil and gas using carbon trading, and the profits resulting from CCS/CCUS implementation may be treated as a reduction in operating costs or other form of monetisation.

Figure 4.18. Gross Split PSC Scheme



Source: SSEK Law Firm (2021).

Table 4.14. Base Split

	Government Share (%)	Contractor Share (%)
Oil	57	43
Gas	52	48

Source: SSEK Law Firm (2021).

Table 4.15. Components Other Than the Base Split

Variable Components	Working area status, field location, reservoir depth, infrastructure availability, reservoir type, CO_2 content, H2S content, specific gravity, local content achievement, production phase, etc.
Progressive Components	Oil and gas price, cumulative oil or gas production

Source: SSEK Law Firm (2021).

Chapter 5

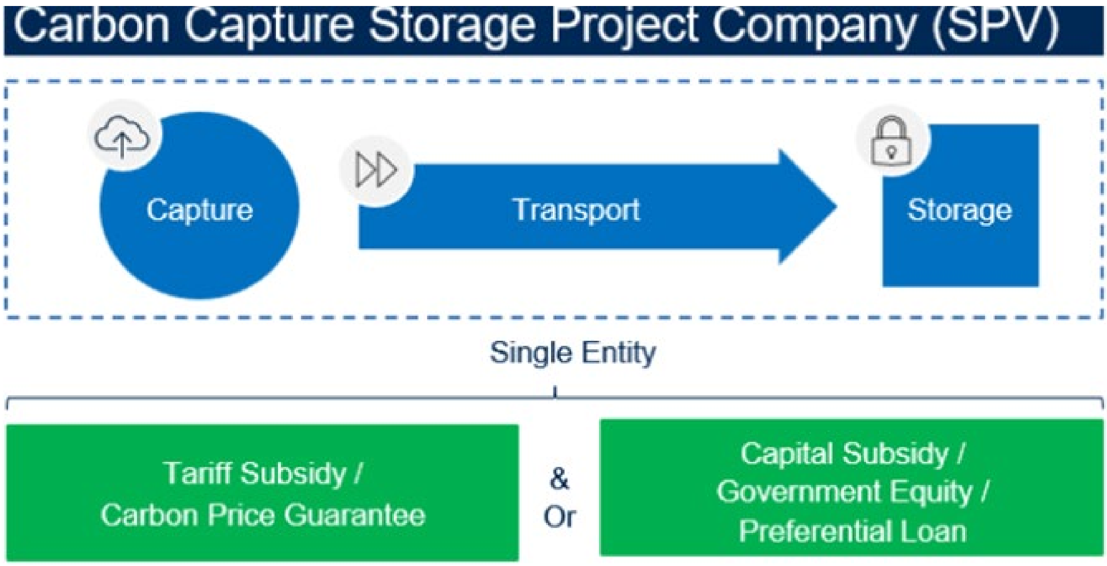
Recommendations on the Implementation Structure of the Pilot Project

1. Business Models for CCS/CCUS Projects

CCS business models can be classified into two types: the full chain model and the partial chain model. In the full chain model, the captured CO_2 is transported from one capture facility to one injection site. The project is usually developed, owned, and operated by a single entity, as demonstrated in Figure 5.1. In the partial chain model, the CCS value chain is split, with partial chain projects focused on capture, transport, and/or dedicated storage developing in connection with emerging shared infrastructure within CCS hubs, as demonstrated in Figure 5.2.

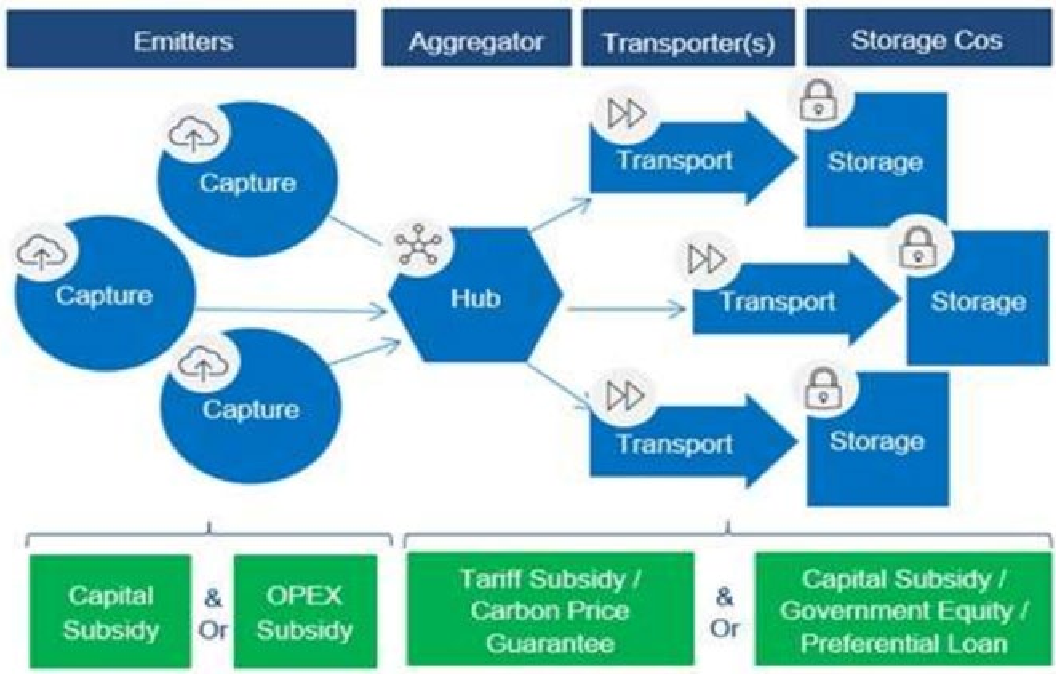
For pilot projects, the full chain model is suitable, where the operator can control the development, execution, and operation of the full value chain from emissions to the storage site.

Figure 5.1. Full Chain Model



Source: Oxford Institute for Energy Studies (2024).

Figure 5.2. Partial Chain Model (with Offshore CO_2 Transport)



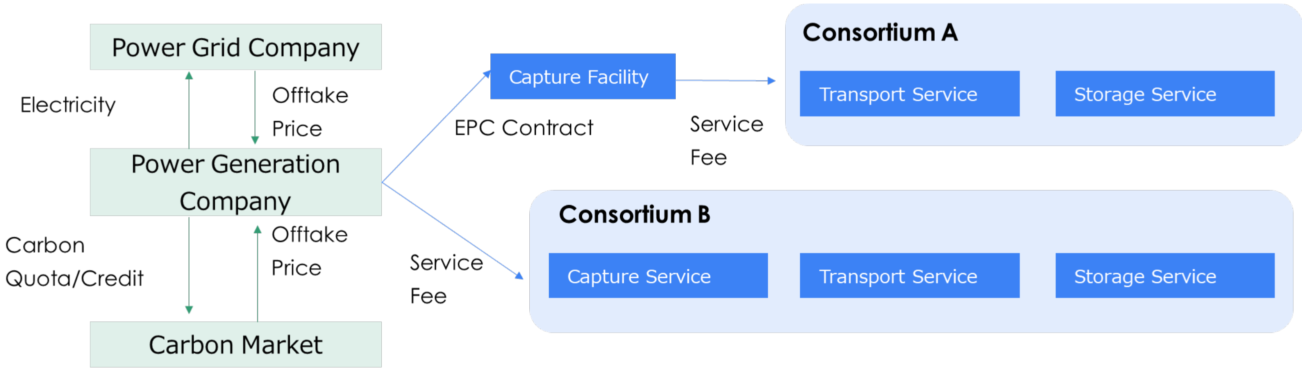
Source: Oxford Institute for Energy Studies (2024).

2. Assessment of the Possibility of Consortium formation by key industrial players

The pilot CCS project is assumed to be a retrofit (additional capture facility installation) for an existing power plant. Based on this, two types of consortium formation are considered as demonstrated in Figure 5.3.

- Consortium A: The power generation company orders the engineering, procurement, and construction (EPC) contract for the CO_2 capture facility. The transport and storage company provides CO_2 treatment services and receives a service fee.
- Consortium B: CO_2 capture, transportation, and storage services are provided to the power generation company, and the company receives a service fee.

Figure 5.3. Types of CCS Implementing Consortium



Source: Mitsubishi Research Institute.

3. Assessment of Key Industrial Players in Indonesia and the Possibility of Participation by Overseas Corporations

The industrial players currently demonstrating (or planning) CCS projects in Indonesia in each CCS value chain are summarised in Table 5.1.

Whilst various players, including entities from countries such as Japan, are considering entering the Indonesian market, the overseas players are mainly oil majors.

Table 5.1. CCS Projects and the CCS Value Chain in Indonesia

	Capture	Transport			Storage
Coordinator/Project Management	• Indonesian key players: Pertamina, PLN • Oil majors: Exxon Mobile, BP, Eni • Project developers: Mitsubishi Corporation, Mitsui Co., Sumitomo Co., Marubeni • IPP companies: J-Power, Chubu Electric				
Consortium A	EPC contractor: JGC, Chiyoda	Land: Pertamina	Ship: NSY, Mitsui, NYK	Pipeline: Pertamina	Indonesian players: Ache Storage Service Offshore Experts: JAPEX, INPEX, JOGMEC
Consortium B	Capture technology provider: MHI				

Source: Mitsubishi Research Institute.

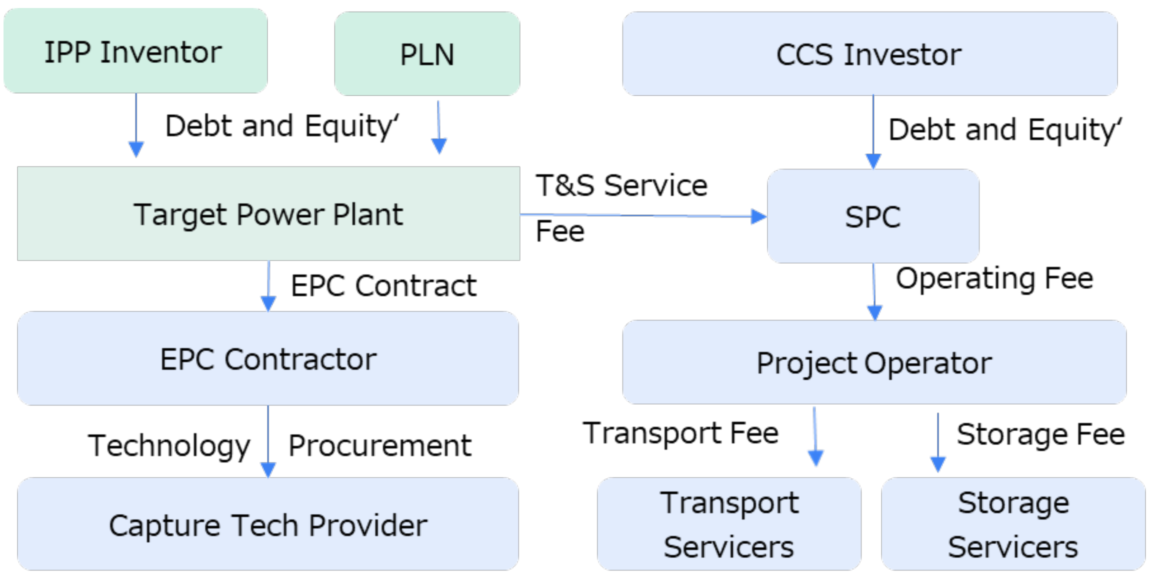
4. Assessment of Possibilities for Investment in the Consortium

Due to the large-scale infrastructure and projects involving a variety of businesses, project operators should allocate risks with the related entities of the consortium, and one approach could be to establish a Special Purpose Company. To address risks specific to CCS project such as cross-chain risks and leakage risks, it is essential to consider structured finance that includes public institutions and multilateral development banks.

Since most CCS equipment costs are for the capture facility, Consortium A, as shown in Figure 5.4, in which the power generation company directly makes orders for the capture facility, increases the possibility of commercialisation as it reduces risks for investors. On the other hand, the power generation company must take the lead, and large incentives (subsidies and/or carbon pricing) are necessary as a prerequisite.

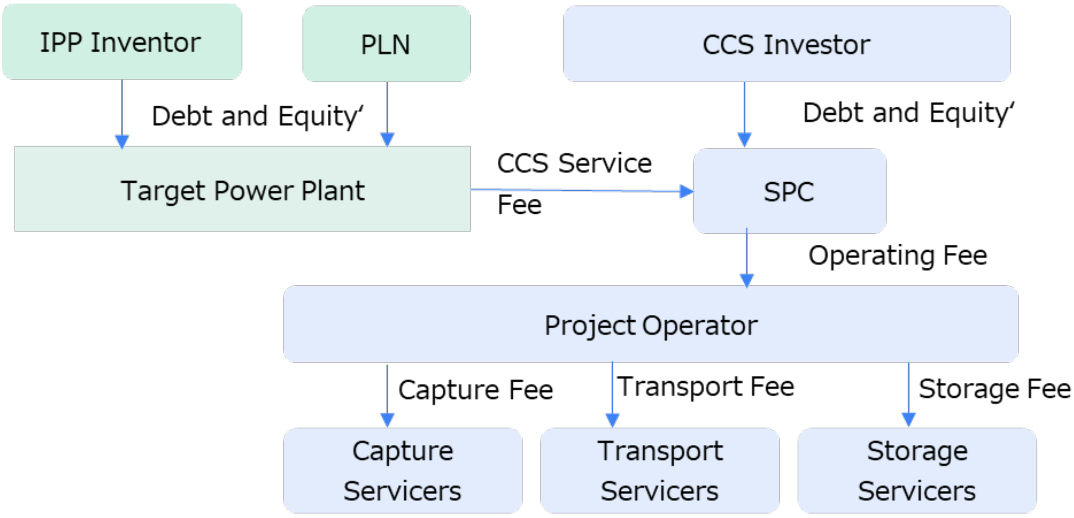
Given the current situation in Indonesia where incentives are limited for the time being, a business operator that leads the 'CCS As a Service' model, such as Consortium B, as shown in Figure 5.5, is needed. To make this a commercialisation model, the operator's track record will be one of the evaluation criteria for investors, so it is effective to first build up a track record by working on it as a demonstration project using public and development funds.

Figure 5.4. Consortium A



Source: Mitsubishi Research Institute.

Figure 5.5. Consortium B



Source: Mitsubishi Research Institute.

5. Suggestion for a Potential Transition Plan from the Pilot Phase to the Commercial Phase

Cost reductions and the wide-scale deployment of CCS are important to realise the transition from the pilot phase to the commercial phase. Pilot projects tend to rely on direct subsidies from the government. However, as the scale of CCS projects increases, an effective carbon price must be introduced to serve as an incentive for deploying CCS. Most CCUS projects to date have operated on the same business model: they are 'full-chain' projects where CO_2 is transported from one capture facility to one injection site, typically involving a single operator. Whilst this was a natural model for first-of-a-kind projects, full-chain projects suffer from high investment, cross-chain risks, and liabilities born by a single developer. Breaking up the CCUS value chain can help mitigate these hurdles as CCUS scales up. We are now seeing this happen, with part-chain projects focused on capture, transport, or dedicated storage developing in connection with emerging shared infrastructure within CCUS hubs.

The CCUS hub model spreads the infrastructure costs amongst emitters and generates economies of scale to reach emitters that are smaller in scale or further away from the identified CO_2 storage sites. The development of CCUS hubs can also send a positive signal to the operators of emitting facilities seeking to reduce their emissions: should they invest in CO_2 capture, the required CO_2 management infrastructure will be available (IEA, 2023). The transition from full-chain to hub model and from pilot to commercial phase is described in Figure 5.6.

Figure 5.6. Image of the Transition from the Pilot to Commercial Phase for CCS

Technical Demonstration (Pilot Projects)	Sector-specific deployment (within the power sector)	Wide-scale deployment (within multiple sectors)
• Direct subsidies are utilised to finance pilot projects • Regulatory framework for supporting consortiums needs to be developed	• Coal-fired power with CCS could be supplied as decarbonised power source • CCS can also contribute to blue hydrogen production	• Need of effective carbon price to generate and sell carbon credits • Carbon pricing can encourage hard to abate sectors, such as material and chemical industries, to introduce CCS

Source: Mitsubishi Research Institute.

Chapter 6

Recommendations on Incentives Required for CCS/CCUS Activities in Indonesia

1. Review of Existing Incentives Scheme for Decarbonisation in Indonesia

1.1. Implementation of Carbon Economic Value (NEK)

Presidential Regulation No. 98 of 2021 on the Implementation of Carbon Economic Value to Achieve Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development (PR 98/2021) stipulates the implementation of Carbon Economic Value (NEK).

The four mechanisms to implement NEK are carbon trading (emissions trading and emissions offset), result-based payment, carbon levy, and other mechanisms in accordance with the development of science and technology.

Details are elaborated in Regulation of the Ministry of Environment and Forestry (MoEF) No. 21 of 2022 on the Procedure for the Implementation of Carbon Economic Value Citing the Presidential Regulation as the legal basis for its enactment. The implementation of NEK is divided into the sectors and sub-sectors as described in Table 6.1.

Table 6.1. Implementation of NEK

Sector	Energy	Waste	Industrial Process and Use of Products	Agriculture	Forestry	Other Sectors
Sub-sector	Generation Transporta-tions Buildings	Solid waste Liquid waste litter	Industry	Rice fields Ranches Plantations	Forestry Manage-ment of peat and mangroves	Other sub-sectors in accordance with the develop-ment of science and technology

Source: Lexology (2022).

1.2. ETS and Carbon Taxes in Indonesia

Indonesia introduced a mandatory, intensity-based ETS for the power sector in 2023. In its first phase from 2023 to 2024, it exclusively covers coal-fired power plants connected to the Perusahaan Listrik Negara (PLN) grid with a capacity of 25 MW or more.

Eventually, the ETS is expected to function as a hybrid 'cap-tax-and-trade' system, operating concurrently with a carbon tax projected to be introduced in 2025. Facilities failing to meet their obligations under the ETS will be subject to this tax, and the rate will be aligned with the domestic carbon market's price. The minimum price for the carbon tax is set at Rp30,000 (US$1.83)/t$CO_2$e.

Taxpayers who participate in emissions trading (under the cap-and-trade mechanism) and emission offset, as well as other mechanisms (in accordance with laws and regulations in the environmental sector), can be granted a carbon tax reduction and/or other benefits for the fulfilment of the carbon tax obligation (ICAP, n.d.; Climate Home News, 2023; PwC, 2024).

1.3. Regulatory Gaps Identified through This Study

This study has identified certain regulatory gaps that need to be filled for Indonesia to promote the commercialisation of CCS/CCUS and establish a CCUS hub. The identified gaps and the directions for solving them are summarised in Table 6.2.

Table 6.2. Regulatory Gaps in the Commercialisation of CCS/CCUS in Indonesia

	Identified Gap	Direction of Enhancing Activities
Regulatory Framework	• Lack of specific provisions to support CCS business environment, such as obligation to allow third party access or liability issues involving third parties • Need to align with international standards for cross-border transport and storage, such as adjusting the inconsistency with IPCC guidelines regarding CO_2 leakages in Indonesian territory	• Remaining issues should be clarified in future MEMR regulations. The MEMR should also play an active role in providing sufficient guidance for CCS project developers and verifiers. • Compliance with the London Protocol is expected to be met through relevant CCS regulations. • However, suggestions to enable bilateral negotiations are needed to resolve liability issues

	Identified Gap	Direction of Enhancing Activities
		between exporting and importing countries.
Finance	• Lack of multilateral financial schemes to support the establishment of regional CCUS hubs (e.g. ADB/World Bank)	• Government subsidies are not enough to finance CCUS hubs. The involvement of multilateral development banks (MDBs) is vital. • Need to include CCUS in the scope of multilateral financial schemes. PT SMI could also promote blended finance schemes for CCS.
Incentive	• Need for tangible incentives for CCS, such as the development of ETS and carbon credit market, to enable the issuance of carbon credits from CCS projects	• Consideration of the enhancement of carbon pricing schemes, including in countries with potential for exporting CO_2 to Indonesia. • Future regulations are expected to clarify the provisions regarding the monetisation of CCS/CCUS through carbon trading.

Source: Mitsubishi Research Institute.

1.4. Expected Approach and Policy Proposal: De-risking Mechanism to Facilitate Financing for First Movers of CCS/CCUS

Private investment is a key driver of CCS/CCUS acceleration, and a regionally comprehensive de-risking mechanism could be one of the solutions. Such a solution can be developed through the following steps. After identifying the barriers and possible solutions as described in Table 6.3, it is recommended that a mechanism to remove risks and enable solutions is introduced.

Table 6.3. Step 1: Identification of the Barriers and Possible Solutions

Barrier	Examples of Solutions
Financial barrier (e.g. limited access to finance)	• Identify the most appropriate business model for scale-up • Establish mechanism to promote private sector investment participation
Regulatory barrier (e.g. limited policy incentives)	• Public-private stakeholder engagement, such as a CCS/CCUS working group • Identify a common approach and methodology for the carbon credit/decarbonisation value of decarbonised fuel, such as hydrogen and ammonia and the application of the corresponding adjustment based on Article 6 of the Paris Agreement
Cross-chain barrier (e.g. different chains require different support measures)	• Regional hub for CO_2 transportation and storage • Sharing of good practices for the CCS/CCUS value chain for related decarbonised activities

Source: Mitsubishi Research Institute.

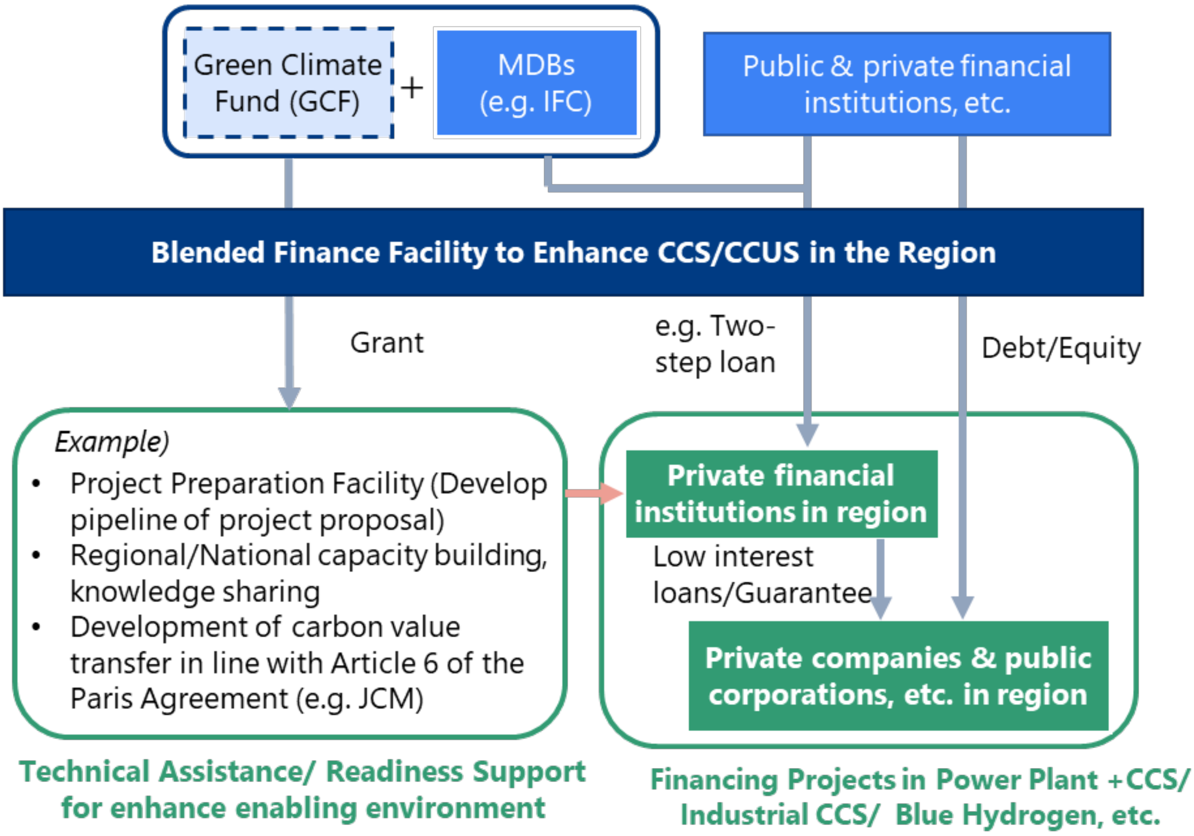
As described in Figure 6.1, a de-risking mechanism entails multiple stakeholders to enable financing of CCS/CCUS through blended finance. Involvement of international financing institution is a key in reducing and sharing risks so other financial institutions both from other countries and domestically can also be motivated to provide fiancé. Blended finance will not only provide much needed finance to local projects but also provide required technical assistance and capacity development. The role of key players is as follows.

- International financial institutions: Multilateral development banks (MDBs), such as the IFC, World Bank Group, and Asian Development Bank, may provide anchor finance to a project. An MDB can also act as an accredited entity to source climate finance, such as the Green Climate Fund. These international financial institutions may provide concessional loans and/or provide grants for technical assistance for project preparation, capacity development for both projects and developing infrastructure, and know-how required for carbon finance/credits.
- Other public and private institutions: These may include national development banks, such as PT SMI, a partner country government entity with interest in developing CCS/CCUS project in Indonesia, such as Japanese government and Japanese

government-related entities like the Japan Bank for International Cooperation, possibly as a source of carbon credits or CO_2 storage. These institutions can either provide direct loans or equity investment into project companies, or they can provide loans to local banks facing shortages of funds as a two-step-loan, who in turn, will provide loans or guarantees to project companies. Partner country institutions may also provide technical assistance and capacity development.

- Local private financial institutions: These institutions can work with MDBs or the public and private financial institutions of partner countries to provide loans to project companies. These institutions can also work with international and multilateral institutions to deliver effective technical assistance and capacity development programmes. Initial support from MDBs and other international institutions to create enabling environment for bankable business is essential in enabling participation from local institutions.

Figure 6.1. Step 2: Creating De-risking Mechanism for CCS/CCUS First Movers



Source: Mitsubishi Research Institute.

Apart from removing barriers for regulatory and financial issues and creating a de-risking mechanism, it is also crucial to work with international entities that support the research and development of new emerging technologies that can bring cost reductions to CCS to enable a greater number of projects for achieving carbon neutrality.

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