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Carbon Capture Storage and Utilisation (CCUS) Development in Thailand

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Abstract: *Thailand is a developing country with a growing economy, which has led to increased energy consumption and carbon emissions. To tackle this issue, the Royal Thai Government has implemented several policies and initiatives to reduce the country's carbon footprint and promote sustainable development. Carbon capture utilisation and storage (CCUS) has just become one of Thailand's policies to help push a low-carbon agenda and to enable net-zero emissions in 2065.*

The Thailand National Committee on Climate Change Policy approved the establishment of the Greenhouse Gas Reduction Steering Committee, which initiated the technology applications for the country's first CCUS. The committee's mission is to accelerate the actions that can mitigate climate impacts by applying CCUS technology in the energy and industry sectors, leveraging the knowledge and experiences in the petroleum exploration and production industry. This first CCUS pilot project, originally initiated by a team in the PTT Group, is the Thailand CCUS HUB Project. This paper summarises the conceptual design and actions required to start implementing the project.

Keywords: carbon capture, CCUS policy, CCUS hub, CCUS development, Thailand

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1. Introduction

The Thailand CCUS Hub Project is a significant effort to promote the development and deployment of CCUS in the country. The project aims to demonstrate the feasibility of large-scale carbon capture and storage and promote the adoption of such a technology. The project comprises two key activities:

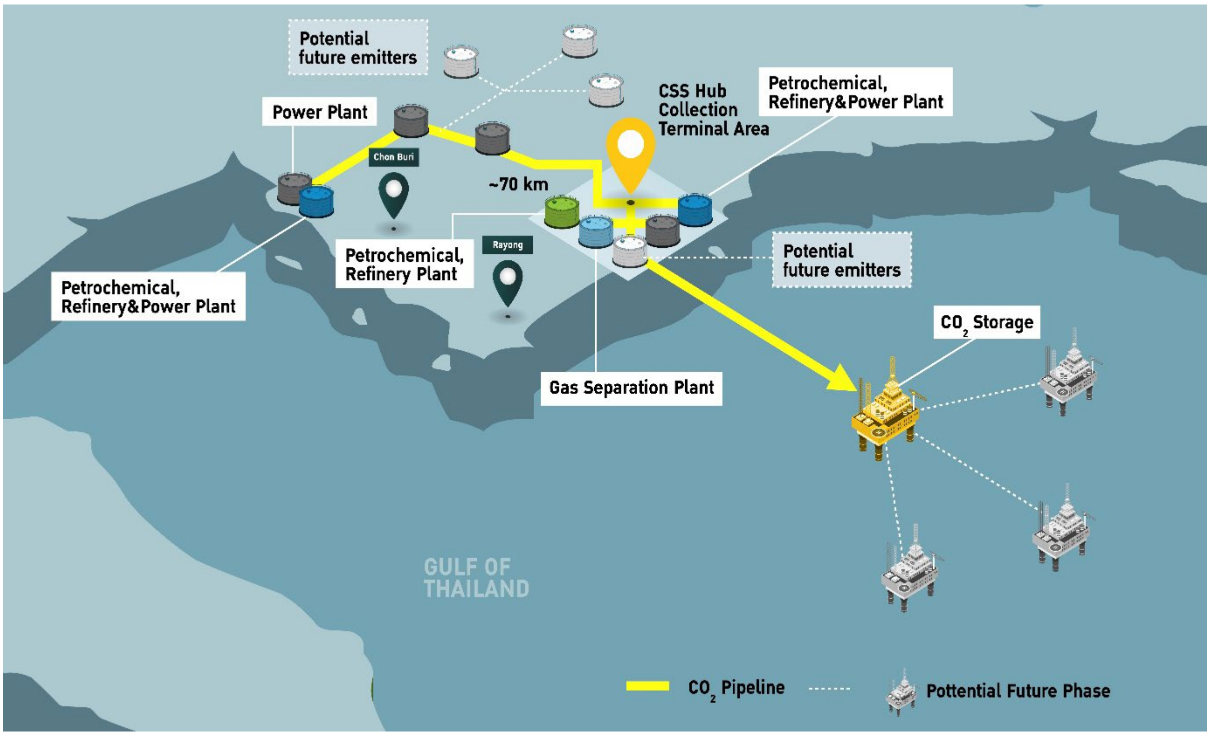
1) a feasibility study encompassing a preliminary assessment of the carbon storage capacity of targeted geological storage formations, and
2) a development plan for supporting infrastructure and storage drilling. The early and preliminary front-end engineering and design have been performed, and the project is expected to start with the execution phase in 2026.

The designated parties to champion this project are PTT, Exploration and Production (PTTEP) (a subsidiary of PTT Group (PTT), Thailand's National Oil & Gas Company, with support from the Department of Mineral Fuels (DMF), Thailand's Ministry of Energy. The contents of section 2 are primarily based on the findings of PTTEP and PTT group members, which can be found in their white paper (PTT Group, 2022).

2. Conceptual Model of the Thailand CCUS Hub Project

The CCUS Hub Project aims to tackle emissions throughout the domestic petroleum value chain and beyond, particularly focusing on the Rayong and Chonburi provinces. Leveraging the storage potential in the northern region of the Gulf of Thailand, situated near the Eastern Seaboard, the project aims to capitalise on economies of scale through a CCUS hub model. This model allows emissions from various sources to benefit from a shared facility for the transportation and storage (T&S) of carbon dioxide (CO_2), strategically located at a carefully selected site. Figure 1 shows the conceptual schematic of this initiative.

Figure 1: Thailand CCUS Hub Project

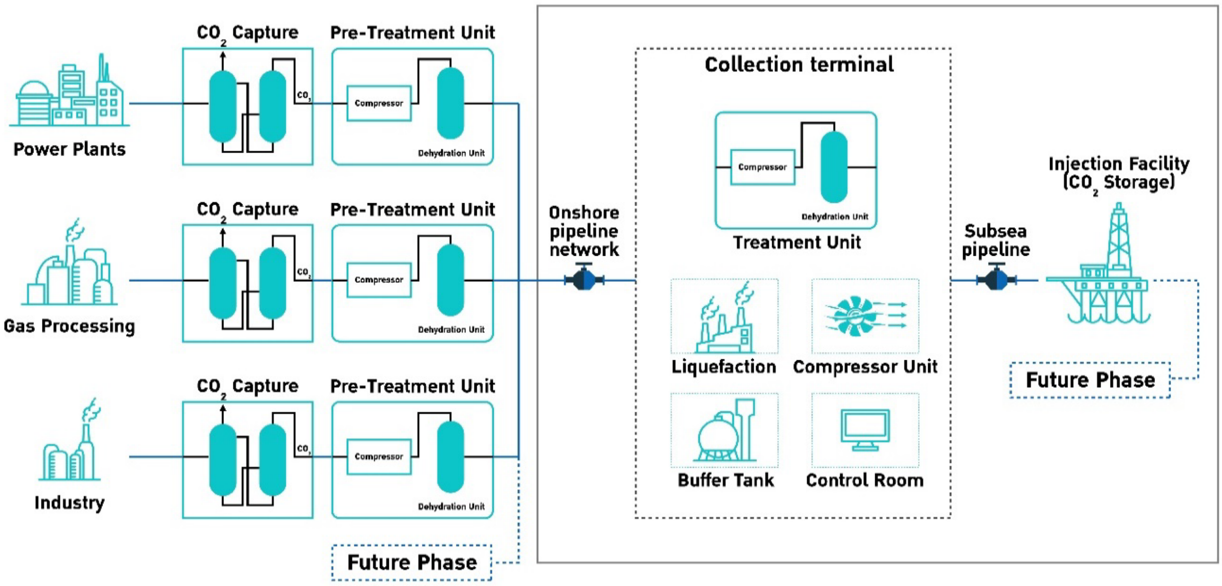


Source: PTT Group (2022).

In the initial phase of this initiative, the attention will be directed towards addressing emissions originating from PTT's diverse facilities, including natural gas–processing plants, refineries, petrochemical plants, and power plants. The preliminary estimates indicate that the emissions targeted for capture and storage by 2030 could reach approximately 6 million metric tons per annum (Mtpa).

Based on the depicted conceptual model in Figure 2, industrial CO_2 from flue gas will be separated using CO_2 capture technologies, including various amine-based capture methods. The captured CO_2 stream is anticipated to undergo a pre-treatment process to eliminate undesirable impurities, aligning with the specifications and technical requirements of the onshore CO_2 pipeline system. Subsequently, the CO_2 will be directed to the CCUS Hub Collection Terminal for additional conditioning.

Figure 2: Illustration of Thailand CCUS Hub Project



Source: PTT Group (2022).

The specifications and requirements for the captured CO_2, which are crucial for the gathering and transportation system, are being investigated. These specifications significantly influence the operational philosophy and overall cost of the proposed hub's value chain. It is essential to highlight that the CCUS Hub Collection Terminal serves as a vital onshore facility specifically designed for receiving, temporarily storing, and preparing the captured CO_2. The terminal plays a pivotal role in ensuring that the CO_2 meets the necessary criteria before being transported via pipeline to the designated offshore injection facilities for permanent underground storage, adhering to the best practices of CCUS.

The terminal is designed to encompass pre-treatment units, a processing system to elevate CO_2 pressure for offshore transportation via subsea pipeline, storage tanks, as well as control and administrative facilities. The planned location for this facility is in Rayong province, strategically situated near the sources of industrial CO_2. This proximity offers enhanced advantages due to the reduced gathering distance, facilitating efficient operations and maximising the benefits of the hub. As a result, this conceptual model allows us to manage CO_2 emissions from diverse sources through a unified T&S network. This approach allows for economies of scale, fostering enhanced collaboration with minimal cross-chain interfaces and mitigating investment risks. It is important to note that developing the proposed Thailand CCUS hub may necessitate an estimated lead time of around 8–10 years. This time frame accounts for the various activities involved before the anticipated commencement of operations by 2030.

Achieving the proposed capacity of 6 Mtpa by 2030 is a significant milestone in developing the Thailand CCUS Hub Project. This milestone serves as a stepping stone towards meeting the national requirements of 40 Mtpa by 2050, demonstrating the feasibility of large-scale CCUS in the region. Accomplishing this target will provide valuable insights and concrete proof of concept for the viability of CCUS at a larger scale. Furthermore, with the establishment of a robust framework encompassing both technical and economic considerations, the cluster holds the potential for subsequent expansion. The Eastern Seaboard region of Thailand, home to the Eastern Economic Corridor industrial sources (emitting 75.3 million metric tons of CO_2) and fossil/biomass power plants (emitting 22.9 million metric tons of CO_2), presents a multitude of emission sources. Leveraging this potential, the cluster can be further expanded, effectively addressing a larger portion of emissions in the region. Through careful planning and implementation, the project can unlock significant opportunities to reduce emissions and contribute to Thailand's decarbonisation goals while simultaneously showcasing the vast potential and benefits of CCUS technology in the Eastern Seaboard region. A series of analyses were conducted to verify its feasibility with respect to three distinct aspects: potential storage capacity, economics of T&S, and financial justifications.

2.1. Storage Capacity Potential

Various researchers have evaluated the CO_2 storage potential specifically in Thailand, utilising different methodologies and making specific assumptions. Their findings, summarised in Table 1, provide valuable insights into the CO_2 storage potential across different regions in Thailand, particularly in the Gulf of Thailand. These research results contribute to our understanding of the potential for CO_2 storage and support the development of the CCUS hub in Thailand.

Table 1: Summary of Estimations for CO_2 Storage Potential in Thailand

Study	Estimated Storage Capacity (Mt)		Note
	Aquifer	Depleted Reservoir	
Asian Development Bank (ADB, 2013)	8,900	1,400	Using 10 geological basins, both onshore and offshore
Li et al. (2021)	5,764	1,404	Conservative estimation
Zhang et al. (2022)	77,582	1,715 (Gas field) 49 (Oil field)	P50 values

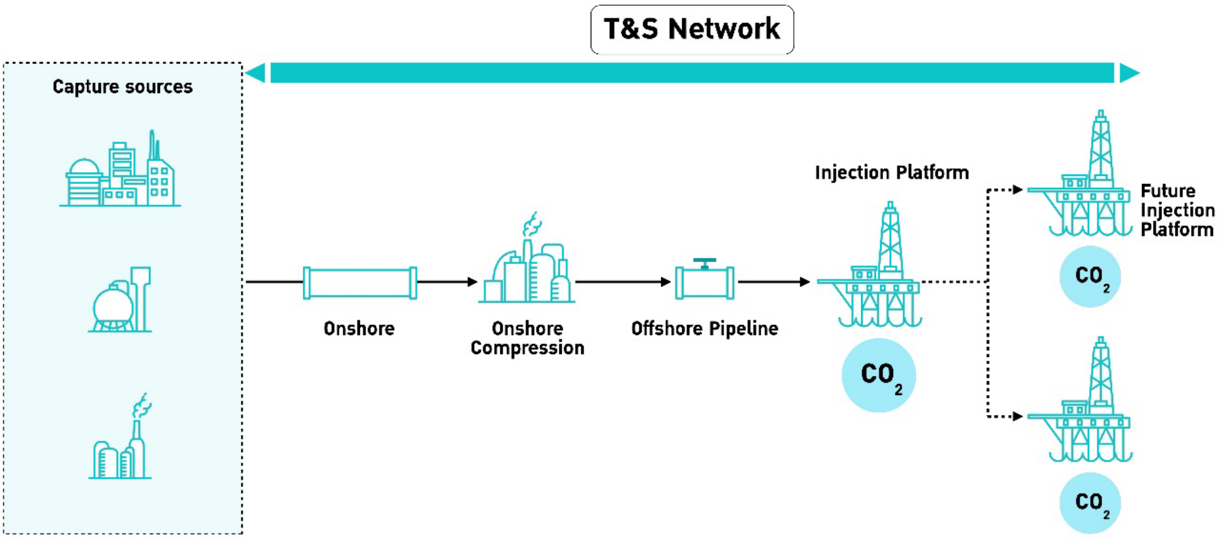
Source: PTT Group (2022).

The analysis of Table 1 reveals notable variations in the estimated storage potential amongst different authors, particularly concerning saline aquifers, while estimates for depleted reservoirs align more closely. However, a promising finding in this literature review is the consensus amongst all studies that Thailand possesses significant CO_2 storage potential, potentially in the gigaton range. Nonetheless, further investigation is required to obtain more reliable and technically consistent estimates.

2.2. Transportation and Storage (T&S) Economics

The CCUS Hub concept promotes individual CO_2 capture at each emission source and emphasises the potential for collaborative utilisation of T&S infrastructure. This approach offers an opportunity for cost savings through the shared use of infrastructure. A preliminary cost evaluation of the T&S system was conducted, considering global benchmarks and internal databases, to assess the feasibility of the Thailand CCUS Hub Project. Figure 3 illustrates the conceptual design of the proposed T&S facility, illustrating the compression of captured CO_2 at the onshore collection terminal by compressor units, followed by transportation through a network of pipelines to offshore injection platforms. Each injection platform will feature multiple injection wells to meet the targeted injection rates and capacity requirements.

Figure 3: Possible Configuration for the T&S Network



Source: PTT Group (2022).

Based on the analysis, comparing a vertically integrated CCUS project with a shared infrastructure model reveals lower unit costs of T&S with shared facilities. However, these facilities should accommodate a higher capacity. Despite increased capital and operational expenditures, the benefits of shared use outweigh the costs. As capacity increases, unit costs decrease, but the reduction becomes less significant relative to facility capacity. Hence, optimising project size is crucial for cost advantage.

For the Thailand CCUS Hub Project, the initial phase of the T&S project is anticipated to require a substantial investment of approximately $2 billion–$3 billion (PTT Group). A portion of this investment is expected to be supported by government subsidies. In these conditions, viable T&S economics can be achieved with a fee of $40 to $60 per tonne of CO_2. While additional subsidies could further decrease this fee, alternative strategies exist to minimise the reliance on subsidies or reduce the T&S cost. These include implementing tax incentives and securing favourable debt financing terms, such as lower interest rates, extended debt tenors, or grace periods.

2.3. Economic Justifications

From an economic standpoint, an emitter would contemplate investing in a CO_2 capture facility and obtaining T&S services if the overall costs are lower than the penalties or incentives associated with CO_2 emissions or reductions. This decision is influenced by the specific carbon price applicable to each emitter. Therefore, it is essential to comprehend the factors impacting the CCUS cost and the carbon price perceived by individual emitters. Such understanding enables an assessment of the emitters' rationale for adopting CCUS. CO_2 capture represents a significant proportion of the total cost of CCUS, particularly when considering post-combustion capture from low-concentration CO_2 streams. The capture cost is expected to decrease as the CO_2 concentration in the stream increases. Examples of high-concentration CO_2 streams include those generated during natural gas processing and chemical processes. According to the International Energy Agency (IEA), excluding direct air capture, the levelised cost of CO_2 capture ranges from $15 to 120/t$CO_2$ (Table 2). Combined with the expected T&S fee from the previous section, **the total CCUS cost could range from $50 to 180/t$CO_2$ for the Thailand CCUS Hub project**.

Table 2: Levelised Cost of Capture, IEA

CO_2 Capture	Levelised Cost ($/ton)
Direct air capture	134–342
Power generation	50–100
Cement	60 – 120
Iron and steel	40–100
Hydrogen	50–80
Ethylene oxide	25–35
Bioethanol	25–35
Ammonia	25–35
Coal to chemicals	15–25
Natural gas processing	15–25

Source: PTT Group (2022).

2.4. Indicative Carbon Pricing

Although Thailand has not yet implemented mandatory measures for CCUS, some emitters may still find it justifiable to incur the additional cost of CCUS due to their voluntary internal policies or regulations in foreign countries. Many companies have implemented or are considering internal carbon pricing as part of their efforts to achieve voluntary net-zero ambitions. For the private sector participating in the Voluntary Carbon Market and having their greenhouse gas emission reduction targets, the Thailand CCUS Hub Project can be attractive if they are willing to invest in it or pay for its use at a reasonable price.

3. Foreseeable Challenges

The regulation and policy aspect is critical to the successful development of CCUS domestically. The current Petroleum Act (B.E. 2514) already addresses certain aspects of CO_2 management. Specifically, the act acknowledges CO_2 as a potential by-product of petroleum activities. It outlines that its management within a petroleum block generally falls under the jurisdiction of the petroleum operator responsible for that particular block. Hence, CCUS could be feasible in scenarios where (i) its implementation is fully integrated within a petroleum upstream project and (ii) it aligns with the objectives of petroleum activities like enhanced oil recovery.

Consequently, developing a CCUS project within the existing framework of the Petroleum Act (B.E.2514) would be a relatively straightforward process. However, considering our ambitious national decarbonisation targets, this approach alone will not be adequate since most of Thailand's domestic emissions originate from sectors beyond the exploration and production (E&P) industry.

Relevant to activities beyond E&P in Thailand, several existing laws and regulations are worth noting, such as (i) the Coastal Resource Act (B.E. 2558), (ii) the Minerals Act (B.E. 2510), and (iii) the Environmental Act (B.E. 2535).

These legislations encompass various non-E&P activities and their associated emissions. However, specific case examples highlight certain regulatory gaps related to CCUS applications:

1) The Land Transport Act (B.E. 2522) does not govern CO_2 pipeline transportation.
2) The ERC licence does not cover the capture system for CO_2 by electricity business licensees.
3) The Petroleum Act (B.E. 2514) does not regulate CO_2 storage outside petroleum concession areas.

As a result, the key challenge for CCUS development lies in obtaining the necessary rights or licences to conduct essential activities for CCUS project implementation, particularly regarding surveys on potential storage areas, despite the absence of dedicated CCUS regulations.

4. Key Takeaways and Ways Forward

The underlying regulations and supportive policies hold significant importance in Thailand, where CCUS development is still in its early stages. Numerous unknown factors should be addressed as the technology and practices surrounding CCUS continue to evolve. Thus, it becomes crucial to establish a robust regulatory framework and supportive policies to guide the implementation of CCUS projects in the country.

To expedite CCUS deployment in Thailand, drawing upon the lessons learned from other countries' experiences is beneficial. By examining successful regulatory and policy frameworks worldwide, valuable insights can be gained. These insights can help identify best practices, potential pitfalls, and effective strategies to overcome challenges in the early stages of CCUS development.

Furthermore, adapting and tailoring international experiences to the specific context of Thailand are essential. While countries may have similarities regarding CCUS challenges and opportunities, each nation has unique regulatory, environmental, and socio-economic considerations. By understanding and incorporating these specific factors, Thailand can develop a regulatory and policy framework aligned with its national goals, priorities, and existing legal structures.

Learning from other countries' experiences also provides an opportunity to avoid reinventing the wheel. By leveraging successful approaches, Thailand can streamline its regulatory processes, identify potential barriers to CCUS deployment, and proactively address them. This approach can help accelerate the adoption of CCUS technologies and position Thailand as a leader in transitioning to a low-carbon future.

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