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Transboundary CCS Developments in Southeast Asia: Key Challenges Ahead

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SYNOPSIS

Transboundary carbon capture and storage (CCS) has been promoted as a promising approach to help achieve the common goal of decarbonisation in multiple high-emission industries across different countries. Regional cooperation for deploying cross-border CCS has progressed in Europe, whereas Southeast Asia has just begun with bilateral cooperation. There are various challenges in building a single CCS facility in addition to the transboundary scheme, which forces the complexity of infrastructure development associated with multiple jurisdictions. This policy brief emphasises the need for cooperation across state governments and industrial stakeholders to address the challenges of transboundary CCS.

KEY POINTS

- The strategic implementation of CCS in industrial facilities is likely to be important for achieving the targeted decarbonisation.
- Regional cooperation for cross-border CCS in European countries has been strengthened with a multilateral declaration and collaboration, whereas Southeast Asia has just started with a bilateral agreement.
- Several factors, including economic viability, financial incentives with tight emission regulations, policy support, assessment of overall emissions, availability of vessels, and regulatory framework, should be addressed to implement transboundary CCS.
- Regional transboundary CCS requires commitment and strong partnerships not only between industrial stakeholders but also between national governments.

INTRODUCTION

In the "2-degree scenario" by the International Energy Agency (IEA), carbon capture and storage (CCS) is required to contribute approximately 12% to the required emission reduction by 2050. CCS is an interconnected technology consisting of three main components: i) capturing carbon dioxide (CO_2) by separating it from flue gas in a fuel combustion system and compressing it; ii) transporting it by pipelines or vessels; and iii) injecting and storing it into the geological subsurface. CCS application in hard-to-abate sectors, such as cement, steel, and chemical production plants, can potentially lower emissions. In recent years, transboundary CCS through regional cooperation is considered an exciting scheme. In this scheme, the point sources of CO_2 are connected to a CO_2 sink in another country via a cross-border transport network. It is perceived to be beneficial for addressing the challenges of high cost and limited suitable geological storage sites in certain countries. However, the rollout of CCS on a large scale is slower than anticipated despite the urgent need to achieve a net-zero target. This policy brief reflects on regional cooperation for CCS in Europe and Southeast Asia and several critical challenges in CCS implementation.

ANALYSIS

CCS as Decarbonisation Tools

The technology of CO_2 injection into the subsurface has been used since the 1970s in oilfields in the United States for enhanced oil recovery (EOR), which uses CO_2 to push more oil or gas out of fields. The CO_2-EOR method, often associated with carbon capture, utilisation, and storage (CCUS), has shown itself to be a way of storing CO_2. In *The Oil and Gas Industry in Net Zero Transition*, published in 2023, IEA reported that projects directly linked to oil and gas value chains account for over 90% of operational CCUS capacity worldwide and over 40% of CCUS investment since 2010.

However, CCS linked with CO_2-EOR is often under scrutinise because it potentially led to higher emissions because of increased oil and gas production. The method also contradicts the current global direction of "transition away from fossil fuels" as declared at COP28 in Dubai last year. Although COP29 in Azerbaijan this year has not put the emphasis on fossil fuel phase-down, the CCS deployment should not derail from the global effort to end fossil fuel use. From this standpoint, CCS must avoid producing oil, gas, and higher emissions during operations. CCS application in industrial facilities must be implemented strategically to become a genuinely effective tool for decarbonisation.

Regional Cooperation in Europe

The CCUS Forum hosted by EU Commission (EC) in November 2023 in Alborg, Denmark, committed to expanding CCS at both national and European levels, aiming for a "European market" for CCS as part of the green transition plan. It stressed the need for international cooperation, including cross-border infrastructure, regulatory support, and financial support, within the EU framework. A statement signed by ministers from Denmark, Germany, Sweden, France, and the Netherlands opposed the use of CCS to increase fossil fuel extraction. In addition, the Net-Zero Industry Act proposal aims for the EU to store 50 million tonnes of CO_2 annually by 2030, which requires member states to outline their CCS strategies.

Regional CCS cooperation projects are advancing with full- or parts-chain business models. The launch of Northern Lights in September 2024 marks the first cross-border, open-source CO_2 transport and storage network offering CO_2 storage under Norway's North Sea seabed for European companies. This project included capture plants from cement and waste-to-energy plants in Norway, ammonia and fertiliser plants in the Netherlands, and biomass power stations in Denmark. Industrial cooperation is also progressing; for instance, in June 2024, GRTGaz, a French gas transmission operator, announced a CO_2 transport infrastructure connecting the Dunkirk industrial area in France to Equinor's CO_2 Highway Europe, a 1000-km pipeline proposed to link Norwegian storage sites with France, Belgium, Germany, and the Netherlands.

Regional Cooperation in Southeast Asia

An IEA report published in 2021 estimated that the total CO_2 storage for six countries—Brunei Darussalam, Indonesia, Malaysia, Philippines, Thailand, and Vietnam —is 133.4 gigatonnes of CO_2 ($GtCO_2$), with the largest estimated volume in Malaysia (80 $GtCO_2$). Some countries are currently developing CCS projects domestically. Malaysia plans to operate a CCS project in Sarawak by the end of 2025, in which approximately 71–76 million tonnes of CO_2 ($MtCO_2$) will be injected into depleted offshore oilfields. In 2022, Sarawak released a state-level regulation related to land and carbon storage in CCS. In Indonesia, there are 15 CCS/CCUS projects in planning with different kick-off dates from 2026 to 2031. A CCS linked with enhanced gas recovery in West Papua, is expected to be deployed in 2026, operated by BP, with a potential capacity of 25-22 $MtCO_2$ for 10-15 years.

In addition to pursuing such domestic CCS projects, cross-border CCS has been discussed for Southeast Asia given that the development of shared CO_2 storage resources can support the limited storage capacities of certain countries. Both Indonesia and Malaysia have announced their interests in becoming regional CCS hubs. By adopting a hub approach, CO_2 capture from multiple industrial facilities in different countries can be achieved with the expectation of more efficient infrastructure planning and economies of scale for CCS deployment. Singapore and Indonesia signed a letter of intent regarding cross-border CCS collaboration on 15 February 2024. This bilateral agreement followed Indonesia's Presidential Regulation 14/2024, which permitted CO_2 imports up to 30% of the storage area capacity. Owing to the lack of suitable geological storage sites in Singapore, transboundary CCS was selected as the solution. This regulation reflects Indonesia's goal of attracting international partners and becoming a CCS hub in the region.

Cooperation between researchers and international industry partners, such as Japan and South Korea, has also been established. In 2024, several developments were made. For instance, Pertamina Indonesia and Korea National Oil Corporation signed a joint study to repurpose decommissioned offshore oil and gas platforms into CCS facilities. Japanese and Malaysian companies agreed to conduct joint studies for CCS, consisting of Mitsubishi Cement Corporation and Resonac chemical manufacture to capture CO_2, Mitsui Co to transport CO_2, and store it in the offshore storage site of Petronas.

Multiple Challenges Towards Cross-Border CCS

Despite the urgency to accelerate decarbonisation, the widespread deployment of CCS has taken longer than expected. According to the Global CCS Institute's *Global Status of CCS 2023*, there are approximately 41 operational CCS projects worldwide as of 2023, half of which are in North America. To date, there are no CCS facilities in Southeast Asia. Regional transboundary CCS has multiple challenges. Building a single CCS facility is not an easy task; furthermore, the transboundary scheme requires infrastructure development across jurisdictions. This section elaborates on the challenges of establishing a CCS facility from economic and technical aspects, then the regional transboundary scheme challenges, mainly in long-distance CO_2 transport and regulatory frameworks.

The high cost of CCS technologies is a significant obstacle to their economic viability. Depending on the sector, capture technologies, distance from storage, and storage location, the cost estimates for avoiding CO_2 through carbon capture, transport, and storage can range from 22 USD to 225 USD per tonne of CO_2. Capture costs are usually more significant, but CO_2 transportation costs can be substantial in other cases. Since the purpose of CCS technologies to reduce CO_2 emissions does not have direct financial benefits to investors, unlike CO_2-EOR, many CCS projects operate with substantial government subsidies. The Gorgon CO_2 injection project in Australia costs approximately 2 billion AUD, with the Australian government contributing 60 million AUD. The CCS Boundary Dam in Canada costs approximately 1.5 billion USD and received 240 million USD from the federal government. The Northern Light project building and operating expenses over ten years were estimated at 2.6 billion USD, with 80% of the funding coming from the Norwegian government. In this sense, cost reduction measures, such as grants, tax credits, and the involvement of state-owned companies, play a crucial role in facilitating operational CCS. A high carbon tax and tight emission regulations are equally crucial. The European Emission Trading System (ETS) exemplifies how an ETS can incentivise CCS by enabling entities to lower compliance costs through emission capture. ETSs with upstream coverage can promote collaboration with industrial point source capture by issuing units (allowances or offset credits) to entities that capture emissions, which can then be sold in the ETS market.

CCS requires a significant amount of energy for its operation. The inclusion of a capture unit in an industrial plant may result in additional energy use (energy penalty) and increased indirect CO_2 emissions. Capturing and compressing carbon is the most energy-intensive process, followed by its transportation and storage. Capture and compression processes require approximately 10-40% more energy than plants without capture, depending on the system type. The overall emissions during operation, including the extra energy and emissions needed to operate the facilities, must be considered to understand the benefits of CCS as a climate tool.

One of the main public concerns in CCS projects is geomechanical failure, which potentially leads to CO_2 leakage. The method and practice of monitoring injected CO_2 have been well understood in the geophysics and petroleum engineering fields, which should assure the public that potential CO_2 leakage and environmental damage are preventable. Developing regulations on storage assessment, monitoring, reporting, and verification plans, and the site closure process is an immediate urgency in the short- and mid-term roadmap of CCS deployment in ASEAN.

Transboundary CCS requires long-distance transportation networks to connect the emitter sources and geological storage in different countries. Several issues are associated with potential maritime vessel bottlenecks. Taking an analogy of LNG exports and their carriers, the volume of global LNG trade in 2023 was over 400 million tonnes per year, requiring more than 700 LNG carriers to operate globally. A large volume of CO_2 must be carried out using a significant number of CO_2 carriers, possibly hundreds or more. Assuming that 10% of the 2050 IEA's CO_2 CCS target will be transported via liquefied CO_2 vessels, the capacity of CO_2 carriers should increase by 15-30 million tonnes every year. Considering the worldwide production capacity of shipyards, obtaining a sufficiently large fleet of CO_2 carriers may require a long time.

Regulatory frameworks along the CCS lifecycle should be strengthened. A clear framework, both at the ASEAN level and country levels, would help countries comprehend risks and liabilities. Regulations for calculating the carbon emission reductions that benefit countries involved in transboundary CCS should be established. In the long-term stewardship phase, which spans hundreds to thousands of years, the host nation must fully understand the responsibility for the CO_2 stored in geological storage, and how emitter countries can contribute to that long-term period. Moreover, risk management capabilities must be developed.

CONCLUSION

Regional cross-border CCS requires solid international partnerships to effectively address and solve logistical, economic, and regulatory challenges. CCS infrastructure requires enormous investment and participation of industrial stakeholders from different countries and sectors. European countries have advanced sectoral, industrial, national, and regional cooperation, including the ETS. The regional governance body in Southeast Asia has the potential to catalyse regional collaboration. Taking the ASEAN Power Grid programme as an example, a regional governing body called Heads of ASEAN Power Utilities/Authorities (HAPUA) supports energy market integration in Southeast Asia. Such high-level bodies can assist regional CCS projects by encouraging concerted efforts with international partners and setting up common targets, policy support, joint investment, and technological development. Such efforts can lead to the creation of regional CO_2 markets. Regional-scale CCS may take years from planning to deployment. Therefore, long-term solid commitment and coordination across stakeholders are crucial.

WHAT TO LOOK OUT FOR

- More development of bilateral or multilateral agreements for CCS globally
- Various incentives for CCS acceleration
- More partnerships between Southeast Asia countries with various international industrial stakeholders

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