## Introduction

Southeast Asia, as with all regions, continues to manage the "Energy Trilemma" — balancing Energy Security, Energy Equity and Environmental Sustainability (World Energy Council 2022).

The regions broad, diverse geography makes the implementation of large-scale energy transition technologies, such as solar, wind and electric vehicles challenging. As such oil and gas will remain a significant part of Southeast Asia's energy mix and carbon capture (utilization) and sequestration (CC(U)S) will be a key emissions mitigation measure.

That same broad geography is home to multiple sedimentary basins, over 140 depleted fields, 25 identified saline aquifer units and well-developed oil and gas infrastructure (S&P Global 2024a).
Indeed, Indonesia's estimated storage capacity ranges from 400 gigatons to 600 gigatons — the equivalent of 300+ years of emissions (Pertamina 2023a).

Analysis of the announced projects, where CO2 source, sequestration site and annual injection capacity have been published (Fig 1), indicates an annual injection capacity of over 13 million metric tons of CO2 per year (MMtCO2/y) by 2030. This is small compared to overall emissions (expected to be over 2,500 MMtCO2/y for Indonesia alone) (S&P Global 2024b), but a significant and necessary first step as sequestration capacity is expected to accelerate from 2030 to 2050.

## Project Pipeline

### Kasawari

The Kasawari project in Malaysia's Central Luconia Province is due to come online first with a scheduled startup of late 2025. In addition, the project has the largest expected injection rate of 3.3 $MMtCO_2/y$. The Final Investment Decision (FID) for Phase 2 of the project was taken in late 2022. $CO_2$ at the Kasawari field will be transferred from the $CO_2$ sequestration platform to the M1 injection platform via a 135-km pipeline. A total of 71 $MMtCO_2$ to 76 $MMtCO_2$ will be reinjected onto the depleting M1 gas field. (S&P Global 2024a)
In 2027, three projects; Tangguh, Sakakemang, and Arthit are expected to come online, with combined injection capacity of over 5 $MMtCO_2/y$.

### Tangguh

In August 2021, SKK Migas approved the plan of development for the Tangguh LNG CCUS project in Indonesia's Bintuni Basin (BP 2021a). The project will include an onshore plant for $CO_2$ removal, processing and compression and a shallow-water CO2 injection platform with three wells injecting into the Vorwata reservoir to provide EGR. Injection rates are expected to be 3 $MMtCO_2/y$ for a total of 25 MMt by 2035. This will half the Tangguh emissions and contribute to the production of an additional 300 Bscf (BP 2021b).

### Sakakemang

In the South Sumatra Basin, the 474 Bscf Kaliberau Dalam field is being developed, with an expected onstream date of 2025 (S&P Global 2024a). The field is located in the Sakakemang PSC and contains a $CO_2$ content of 26%. Also being assessed is an associated CCS project aiming to capture $CO_2$ from the raw gas stream and inject into the depleted Gelam and Dayung fields (Repsol 2021). The project is anticipated to have an injection rate of up to 2 $MMtCO_2/y$ with approximately 30 $MMtCO_2$ stored by 2040 (S&P Global 2024c).

### Arthit

FID for the CCS project at the Arthit field in the Gulf of Thailand is expected in 2025 with first $CO_2$ injection planned for 2027. The project involves capture of $CO_2$ at the processing platforms and injection into saline aquifers or depleted reservoirs. An injection rate of 0.5 $MMtCO_2/y$ is envisaged (S&P Global, 2024a), (PTTP, 2021).

Noteworthy projects planned for later this decade are Papua LNG, Sukowati CCUS enhanced oil recovery (EOR), Arun CCS and Lang Lebah.

**Papua LNG**
Front-end engineering and design studies are underway at the Papua LNG project. Feedstock gas will be sourced from the Elk-Antelope field which contains approximately 5.8% $CO_2$. Also under review is the potential to capture $CO_2$ from startup and inject, into the Elk field for storage. Injection volumes of approximately 1 $MMtCO_2/y$ are expected. Final investment decision on the project is due at the end of 2025 with first gas possible by 2028/29 (S&P Global, 2024a).

**Sukowati**
A $CO_2$ based EOR trial was undertaken at Sukowati in late 2024. The test involved the injection of 100 tons of $CO_2$ per day for 25 days. The field was then to be monitored for approximately three months to assess both the $CO_2$ sequestration capacity and increased oil productivity from the surrounding wells. The Field is in the onshore East Java Basin. When fully operational $CO_2$ will be sourced from the nearby Jambaran-Tiung Field (Pertamina, 2023b), (S&P Global, 2024a). Injection is expected to commence in 2029.

**Arun**
When producing, the Arun gas stream had over 15% $CO_2$ (S&P Global 2024a), hence much of the existing infrastructure was built to withstand corrosion from high pressure, high temperature, $CO_2$ containing fluids. Preliminary estimates indicate the field can store up to 1.2 Bt $CO_2$ at 1.5 $MMtCO_2/y$ — although this rate could be significantly higher. The project is proposed to operate as a hub for storage of $CO_2$ from multiple sources (Stein, 2023), potentially including the offshore Peusangan B gas and condensate field which is being developed and NSB R 1 and 2 both being appraised as tiebacks to NSO A (S&P Global 2024a).

**Lang Lebah**
The FID for the Lang Lebah field in Malaysia's Central Luconia Province is targeted for 2027 with first gas expected by 2030. Preliminary indications are, the raw gas steam (18% $CO_2$) will be piped 159 km to the Lang Lebah Onshore Gas Plant 2. From there $CO_2$ will be extracted and piped back offshore to a proposed platform to be installed at the depleted Golok field for injection. Injection rates are expected at 2 $MMtCO_2$/year (S&P Global, 2024a).

**Discussion**

The successful implementation of these, and many other projects in the region will depend on regulation, stakeholder engagement and costs.

A stable regulatory environment is required to provide clarity for investment in advancing project developments. In March 2023, Indonesia's government issued new legislation encouraging CC(U)S including, financial incentives such as potential tax incentives and implementation costs to be reimbursed as operating expenditure , and storage services to be made available to third parties (S&P Global 2024b). In 2024 it was announced that Indonesia is allowing operators to set aside 30% of their capacity for imported $CO_2$ (Presidential Regulation of the Republic of Indonesia, 2024), making $CO_2$ management a more regional effort.

Management of public and landowner concerns will be required, including perceived risks around the environmental impact of carbon disposal, the integrity of subsurface structures and safety controls and measures.
To 2030, CC(U)S capacity is expected to increase driven by low-cost projects such as natural gas processing and ethanol production. This is expected to put pressure on existing supply chains with equipment and material costs to increase by 17-33%. This represents an opportunity for suppliers, but supplier companies can be hesitant to accept projects that are not yet financed (S&P Global 2024b).

Beyond 2030 an acceleration in CC(U)S is expected, driven by hydrogen production and power generation. With increasing injected volumes comes increased potential for cost reductions through economies of scale and hub development. In addition, significant cost reductions are expected post 2030, initially through standardization and modularization in construction and in the longer term through improved technology in capture and utilization (S&P Global 2024b).

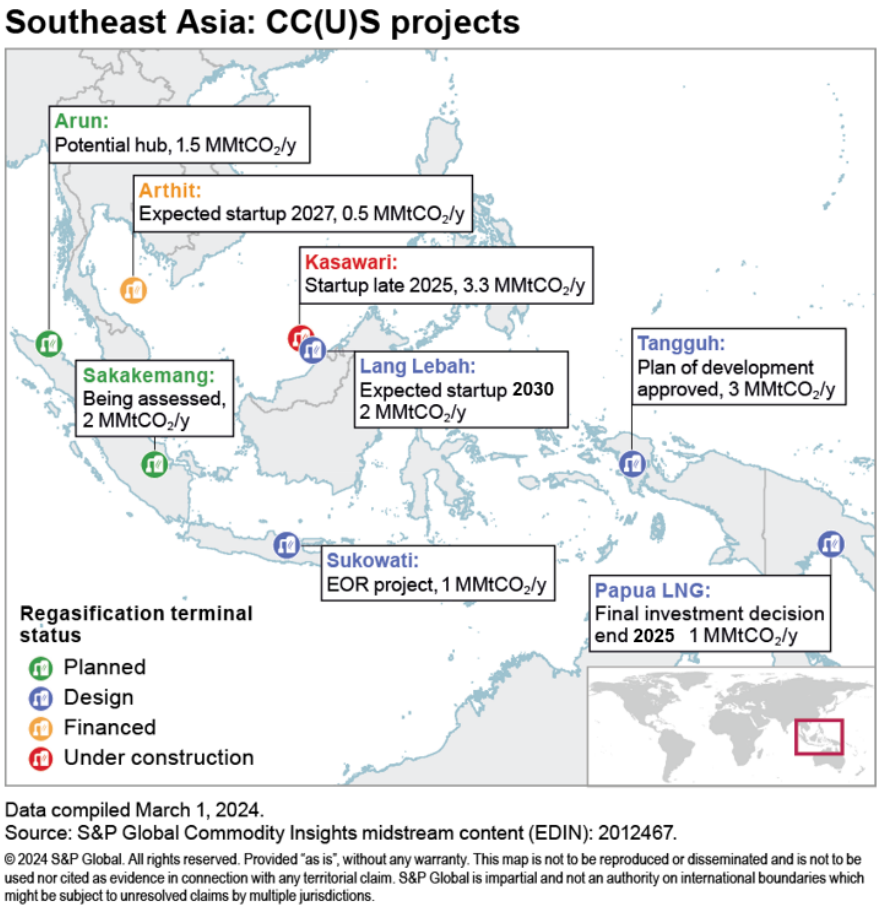


*Fig 1: Southeast Asia CC(U)S projects*

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