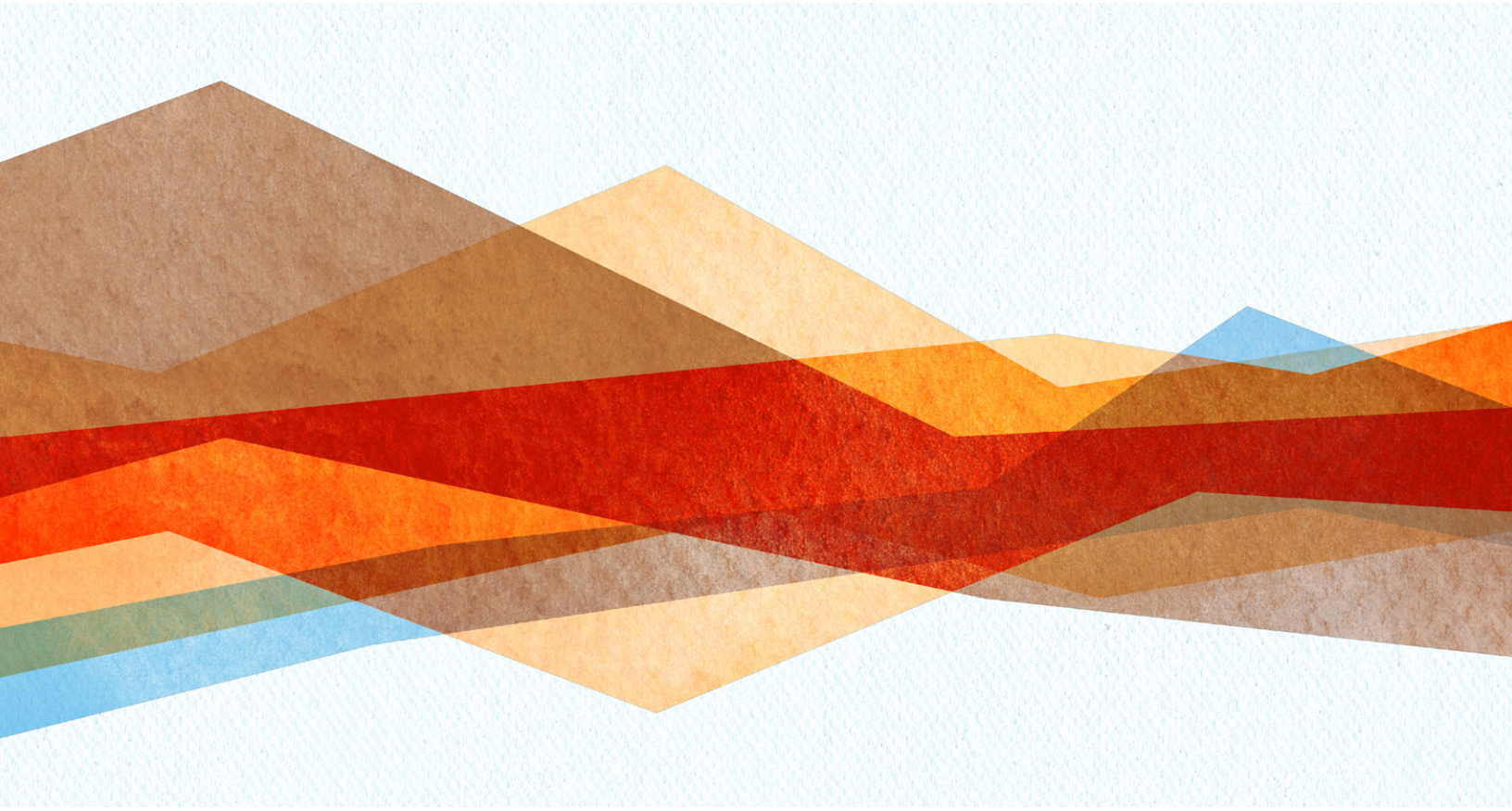
McKinsey & Company

Oil & Gas Practice

Unlocking Asia–Pacific's vast carbon-capture potential

Asia–Pacific has vast CCUS potential—but substantial challenges remain. With eight assertive actions, regulators and companies can boost CCUS in the region.

by Darius Chen, Ed Lock, and Jess Lyn Low



February 2023

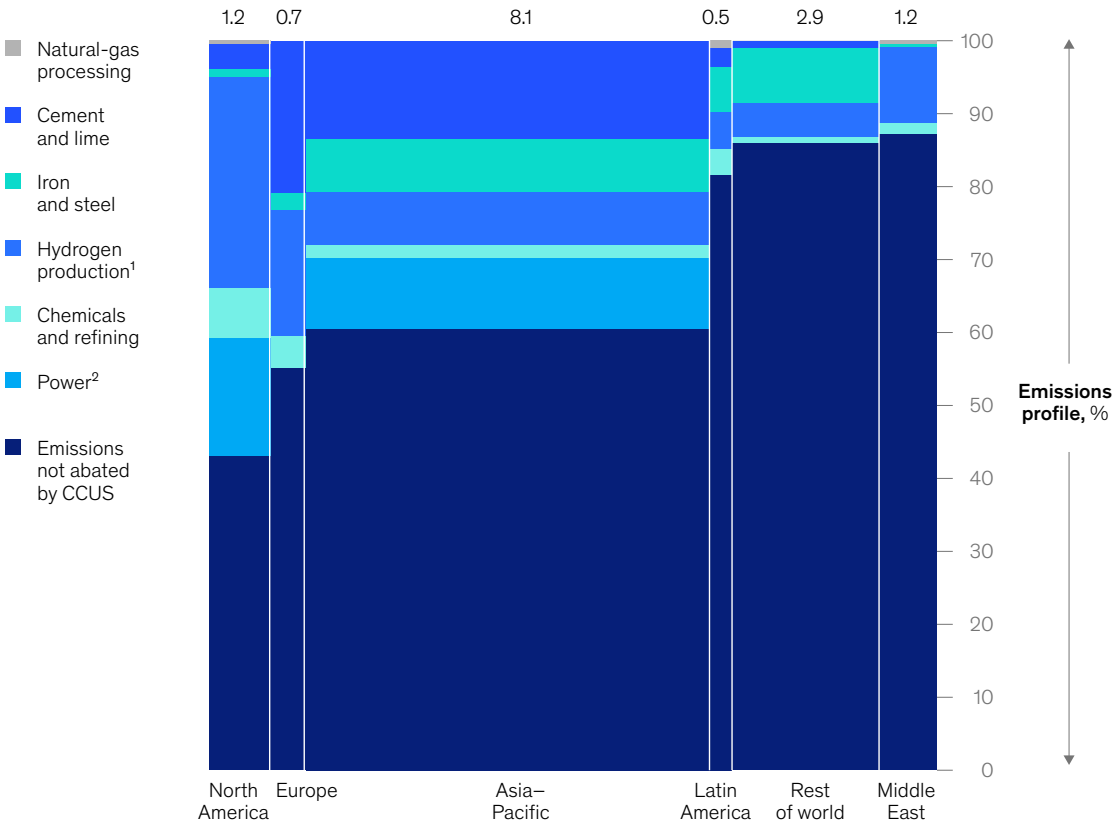
The significant role carbon capture, use, and storage (CCUS) plays in meeting global energy and climate goals is well-established—from decarbonizing hard-to-abate sectors and enabling blue-hydrogen production, to delivering negative emissions from biomass energy and direct air capture.

The potential of CCUS is concentrated in the Asia–Pacific region. The region has more than 1,300 emitter companies and more than 20 potential hubs. In McKinsey's "achieved commitments" scenario, more than 60 percent of future CCUS abatement is predicted to come from the region—representing more than three gigatons per annum of abatement by 2050 (Exhibit 1).

Exhibit 1

Asia–Pacific could account for 55 percent of global carbon capture, utilization, and storage by 2050.

Global emissions profile and carbon capture, utilization, and storage (CCUS) uptake by 2050, gigatons of CO_2



[1]Hydrogen production, excluding H_2 for ammonia, methanol, and refineries.
[2]Power figures represent the average value across power scenarios (high and low carbon capture, utilization, and storage uptake).
Source: "Global Energy Perspective 2022," McKinsey, April 26, 2022; Energy Insights by McKinsey

McKinsey & Company

However, unlocking CCUS potential in Asia–Pacific is not an easy task. To realize its potential, the region needs to deliver exponential growth: at least 450 times its current operational CCUS projects. It is also characterized by inequitable access to viable domestic underground storage, and varying levels of regulatory maturity.

Asia–Pacific has the fundamentals for successful CCUS development

Although most global CCUS progress is found outside Asia–Pacific, the region has started to galvanize into action. Five years ago, only two of 23 operational projects across the world were here, but this number has more than tripled. There are now nine CCUS facilities operating in the region, principally in China and Australia, focused on the sequestration of emissions from natural-gas processing and the chemical sector.

Several fundamentals required to continue this momentum are present in the region, including:

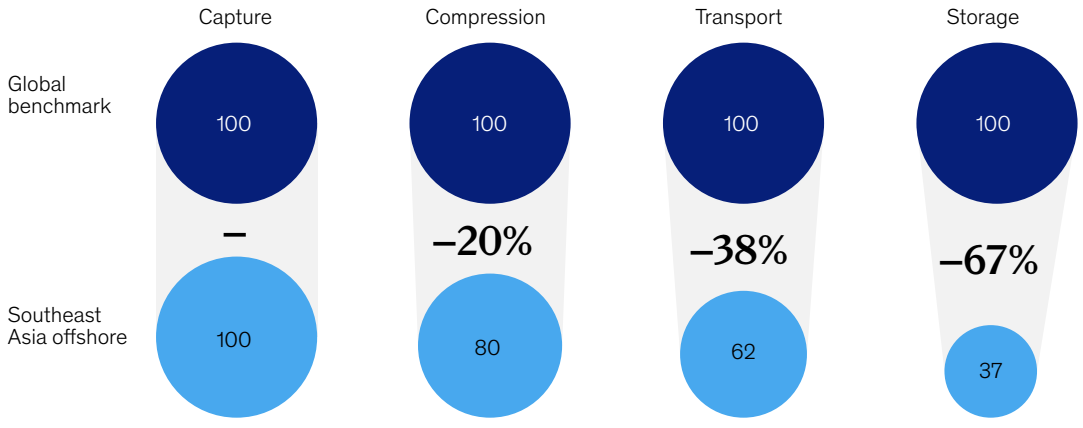
Competitive cost structure: The CCUS value chain overlaps with the upstream oil and gas industry, where the region has many advantages—mature local supply chains; efficiencies in wells delivery; established operational, maintenance, and health, safety, and environmental (HSE) practices; and proven track records from state-owned and independent oil companies.

These characteristics are present in many locations across geographies, such as the onshore Cooper Basin (Australia), onshore Sumatra (Indonesia), offshore Bohai Sea (China), and offshore Gulf of Thailand sites. In one Southeast Asian offshore basin, unit-abatement costs are comparable to global benchmarks at the capture stage, and the rest of the CCUS value chain is even more cost-efficient. Most significantly, costs at the storage stage are estimated to be 65 percent lower than the global average (Exhibit 2).

Exhibit 2

Carbon capture, utilization, and storage costs in Southeast Asia measure well against global benchmarks.

Carbon capture, utilization, and storage costs, % difference from benchmark



Source: Global CCS Institute; National Petroleum Council; Energy Insights by McKinsey; Westney Capital Analytics by McKinsey

McKinsey & Company

Leading engineering, procurement, and construction (EPC) capabilities: Asia boasts world-leading EPC companies and has the world's largest shipbuilding capacity, with China, South Korea, and Japan holding more than 80 percent of the global market. These companies have deep track records, proprietary technologies, and economies of scale. These capabilities are significant for CCUS, which requires major new and refurbished infrastructure, rapid technology maturation, and scale economies.

Potential for economic-growth enablement: CCUS is not antithetical to long-term economic growth. On the contrary, it has the potential to create jobs, catalyzes innovations, drives trade, monetizes low-carbon product manufacturing, and sustains existing industries with decarbonization. For example, the International Energy Agency (IEA) and the Asian Development Bank (ADB) estimate that CCUS could create additional value of between 0.2 percent and 0.6 percent of China's 2019 GDP by 2030. This represents up to $100 billion annually.

A culture of partnerships and relationships: CCUS hub clusters are essentially mega-projects, with extensive regulatory engagement and multihorizon infrastructure investments. These involve complex, interlinked commercial arrangements between public and private institutions.

The Asia–Pacific region has experience in these types of ecosystems, with some of the world's leading special economic zones, major industrial parks, and megalopolis developments. Aligning strategic interests, fostering trust, and building win–win relations are core to these successes and are ingrained in the way the region operates.

State-owned enterprises, common across Asia–Pacific, are well positioned to lead these developments. They hold existing interests across various CO_2 point-emission businesses, and can access government support to align national climate policies, bring strong technical and commercial capabilities, and reach across countries and sectors.

Delivering full CCUS potential in Asia–Pacific has its challenges

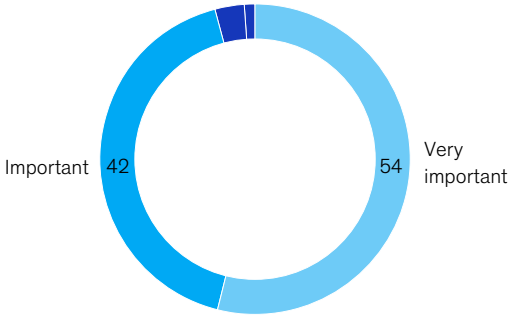
When McKinsey recently surveyed more than 70 CCUS players across Asia–Pacific, almost all recognized decarbonization and CCUS as strategic imperatives. However, CCUS was ranked lower than other decarbonization levers (Exhibit 3).

CCUS has the potential to create jobs, drives trade, monetizes low-carbon product manufacturing, and sustains existing industries with decarbonization.

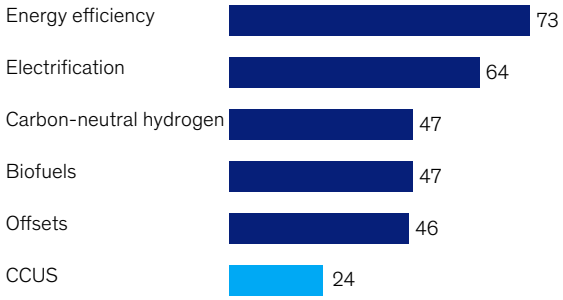
Exhibit 3

Asia–Pacific companies see carbon capture, utilization, and storage as important but less viable than other decarbonization levers.

Importance of a strong decarbonization agenda in Asia, % of respondents (n = ~70)



Carbon capture, utilization, and storage (CCUS) levers, % of respondents (n = ~70)



Source: McKinsey Global Survey on Carbon Capture, Utilization, and Storage, 2022

McKinsey & Company

The biggest CCUS challenges the region faces are:

Access to close-proximity, long-term sequestration sinks: Global carbon capture and storage projects typically use nearby depleted oil and gas reservoirs or geological formations to inject and store captured CO_2. At the Gorgon liquefied gas plant on Barrow Island in Australia, for example, separated CO_2 is injected into a storage facility only seven kilometers away.

However, in Asia–Pacific, many major industrial point emitters do not have access to viable sites of this kind. With combined annual CO_2 emissions of 840 million tons, Japan, Korea, Taiwan, and Singapore in particular face this challenge.

Lack of supporting regulations and incentives: Asia–Pacific countries score an average of 34 on the Global CCS Institute readiness index—compared with 41 for Europe and 71 for North America (Exhibit 4).

There has been tangible progress in Australia and China in this area. However, more needs to be done to establish a detailed government policy on national climate goals, fit-for-purpose operations, and HSE regulations. Without a clear, enabling regulatory environment, at-pace CCUS deployment is unlikely.

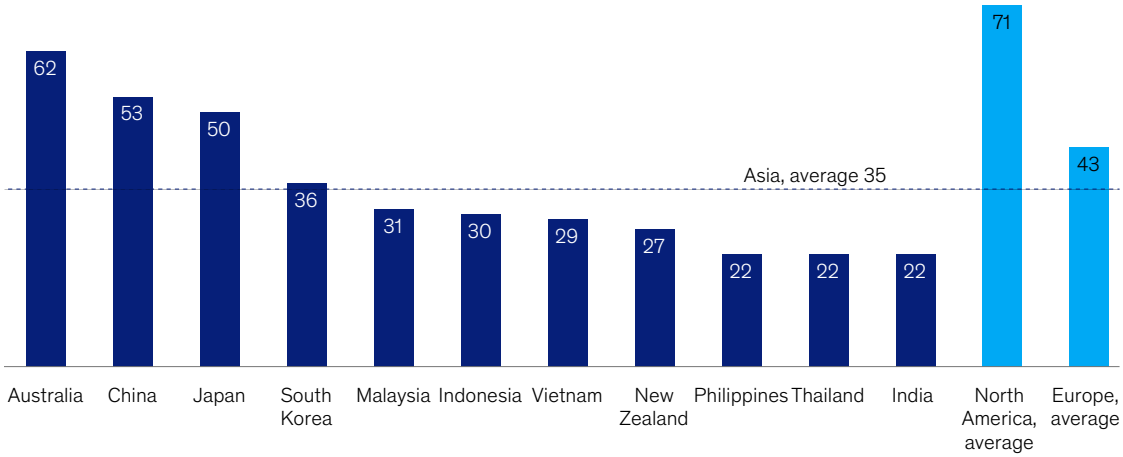
Limited technical and technology proof points: The majority of CCUS value-chain activities (such as gas compression and transport, injection-well delivery, and subsurface monitoring) are familiar to companies operating in the oil and gas sector. But outside this sector, the level of technical understanding of CCUS is low.

Partly because of this, Asia–Pacific does not have a deep pool of pilot and operational-project proof points across sectors and countries to demonstrate technological readiness (such as CO_2 separation and capture) and key technical de-risking (such as the ability to reuse existing wells without compromising integrity). This risks creating a "wait

Exhibit 4

Asia–Pacific locations score below North America and Europe on carbon capture and storage readiness.

Carbon capture and storage readiness, by location,[1] index (100 = ready)



[1]Carbon capture and storage (CCS) readiness in each location is evaluated individually across several metrics, including need of CCS, development on regulations, policies, and sink resources.
Source: Global CCS Institute

McKinsey & Company

and see" mindset for governments and companies, dampening momentum for CCUS.

Access to funding: External capital pools play a critical role in helping companies finance their CCUS ambitions, but the scale of investment required to unlock CCUS is significant. Global projects currently in development require billions of dollars of capital. But the challenges described here impact projects' commercial viability—and outside of CO_2 and enhanced oil-recovery applications, CCUS is often stymied by emitters' lack of willingness to pay.

Government intervention here would be critical. The Northern Lights project in Norway, for example, benefited from a carbon-pricing regime (current price of about $\$70/tCO_2$, anticipated to reach about $\$230/tCO_2$ by 2030) and direct government funding of more than $1 billion.

Across Asia–Pacific, carbon-pricing regime and related mechanisms are supported in Singapore, South Korea, Japan, China, Australia, and New Zealand. However, they are not sufficient to underpin compelling economics for CCUS and attract funding.

Eight actions regulators and companies can take to scale CCUS in Asia–Pacific

The challenges Asia–Pacific faces in CCUS are not insurmountable: there are eight actions governments and companies can take to unlock the potential of CCUS. While progress is being made in some areas, increased and accelerated efforts are needed.

1. *Secure cross-border CCUS agreements:* Governments and companies need to broaden their horizons beyond domestic point-source-to-sink projects and start thinking about the requirements of a future cross-border CO_2 transport and storage market.

   This can be kick-started by setting up government-to-government working groups to address gaps in international laws on CO_2, defining how cross-border CCUS offsets contribute to national targets, initiating mutually beneficial projects for joint funding, and partnering with private-sector champions to drive deployment. The vision is for a vibrant Asia–Pacific CO_2 market that connects emitters, storage providers and service companies across the region and with the rest of the world (Exhibit 5).

2. *Fast-track CCUS demonstrations:* Defining long-term decarbonization policies, developing all-inclusive legislation, and setting up government funding takes time. It involves multiple government agencies, implicates different regulations, and is often delayed by political cycles.

   Governments could start supporting CCUS pilot studies with project-specific approvals and clear objectives around demonstrating technical viability; awarding provisional storage licenses; leveraging current petroleum regulations; and temporarily broadening the scope of existing government agencies.

3. *Create market mechanisms in phases:* CCUS is a fundamental, material abatement lever for industrial emitters. But without a cost attached to CO_2 emissions or an incentive to reduce them, there is no willingness to pay for CCUS.

   Governments can support CCUS development by attaching a cost to carbon emissions, implementing carbon-market systems, and introducing tax allowances and other related mechanisms. This would help incentivize investment and create confidence for external capital injection into CCUS.

4. *Establish cross-sector end-to-end CCUS value-chain partnerships:* The rationale for cluster developments is clear when one considers the abatement impact CCUS could offer to concentrated industrial emitters across Asia–Pacific, and the economic benefits of shared transport and storage infrastructure.

   Companies could form partnerships and lean forward together, creating materiality to increase government buy-in, accelerating technology development, bringing together capabilities across the value chain, and de-risking execution.

5. *Innovation and market development for CO_2 uses:* Asia–Pacific has been at the forefront of many types of innovation, from technological capabilities that enabled the region's relatively speedy and efficient response to COVID-19 to contactless payments that have outpaced all global regions over the past few years.

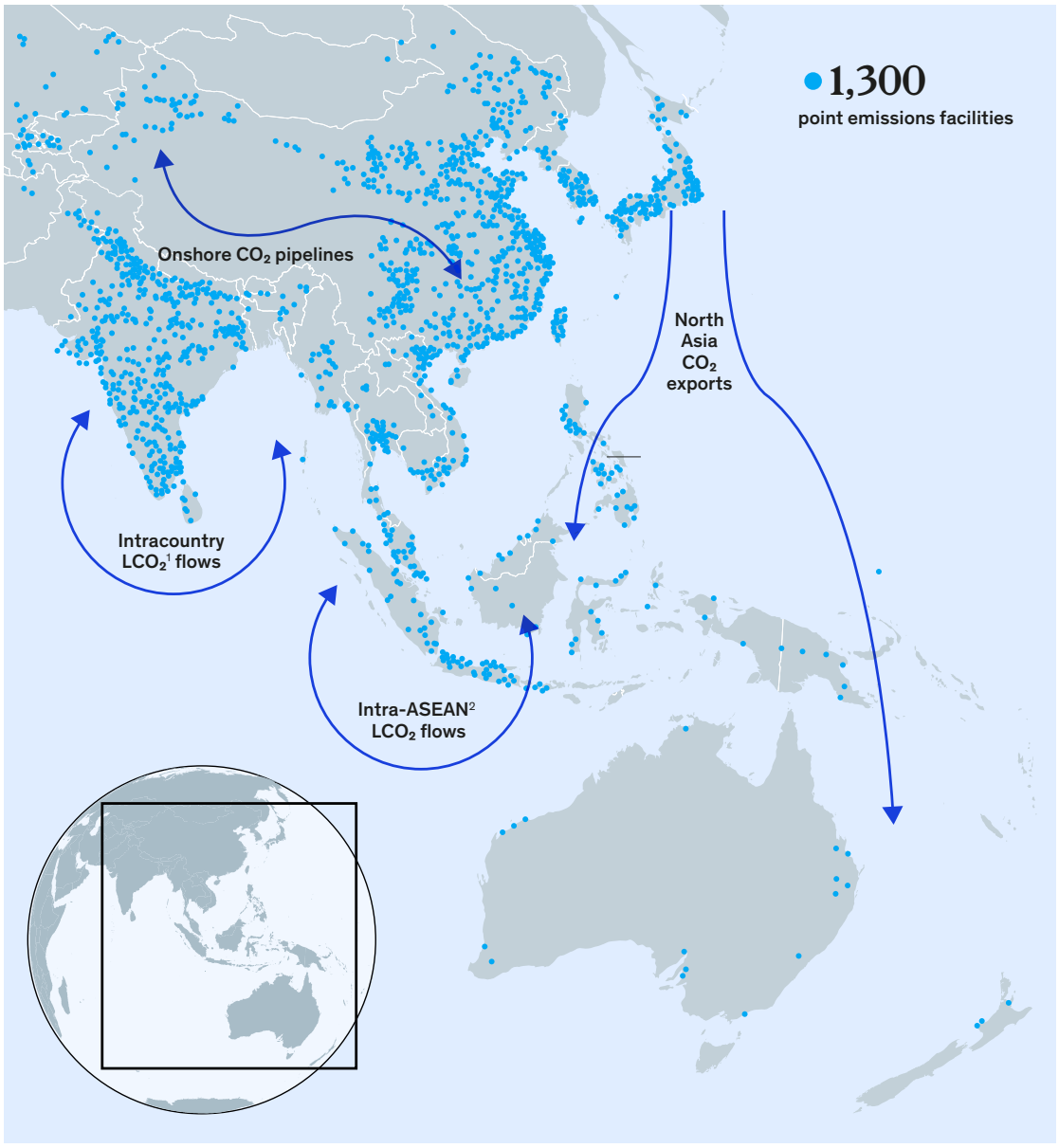
   The region has the largest global market share in several CO_2 use cases, offering an ideal test bed for research, development, and commercialization (Exhibit 6). Focusing the region's innovation capabilities on CO_2 use cases might prove to be the most decisive unlock for CCUS.

6. *Institutionalize CCUS policies:* In global regions where CCUS has taken root, governments have been the main catalyst, offering a road map for the region. The role of CCUS must be clearly defined in the overall decarbonization pathway, with an accountable ministry and agency appointed to shape holistic, CCUS-specific provisions across various scopes (such as permitting and licensing, environmental protection, and liability management); drive cross-ministerial alignment and coordination; and set the government budget for this to happen.

Exhibit 5

The potential pan-Asia CO_2 carbon capture and underground storage network could include more than 20 carbon capture and underground storage hubs.

Potential pan-Asia CO_2 carbon capture and underground storage network



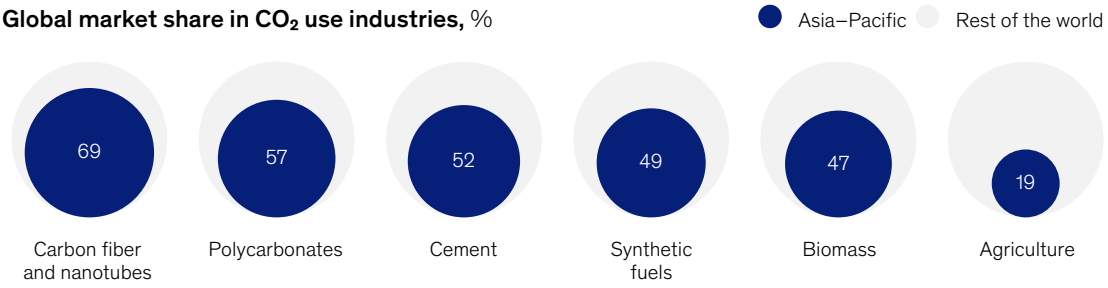
Note: The boundaries and names shown on this map do not imply official endorsement or acceptance by McKinsey & Company.
[1]Liquefied CO_2.
[2]Association of Southeast Asian Nations.
Source: McKinsey analysis

McKinsey & Company

Exhibit 6

Asia–Pacific is a major region in many CO_2 use industries.

Global market share in CO_2 use industries, %



Source: S&P Capital IQ

McKinsey & Company

7. *Raise consumer buy-in:* Increasing public awareness and support is critical to ensuring grassroots support for government CCUS policies and budgets (such as tax incentives and direct funding) and potentially passing on carbon-abatement costs to consumer end-products. This requires collaboration with academic institutions, nongovernmental organizations, local community leaders, and the media, in order to share information about CCUS contributions toward decarbonization. This can be achieved through joint environmental-research studies, field trips, public consultations, and community road shows.

8. *Direct government investment:* CCUS clusters provide long-life infrastructure (such as common CO_2 pipeline transport to sequestration sites) that serves multiple-sector decarbonization and delivers at-scale economic and environment benefits. CCUS projects can be seen as crucial public infrastructure, akin to airports and toll roads. Aligning interests with defined policies and carbon-market mechanisms, governments can invest directly in CCUS projects. This helps to offset the significant capital required and imbues the projects with confidence.

CCUS potential in Asia–Pacific is clear but not without challenges. While momentum is encouraging and the long-term fundamentals are strong, most governments and companies are still on the sidelines. Decisive actions will give the region a competitive advantage in the global decarbonization journey.

Find more content like this on the
McKinsey Insights App
Scan • Download • Personalize

Darius Chen is an associate partner in McKinsey's Singapore office, **Ed Lock** is a partner in the Bangkok office, and **Jess Lyn Low** is a solution analyst in the Kuala Lumpur office.

Designed by McKinsey Global Publishing
Copyright © 2023 McKinsey & Company. All rights reserved.