EXECUTIVE INSIGHTS

Carbon Capture, Utilization and Storage: A Strategic Imperative To Reach Net Zero

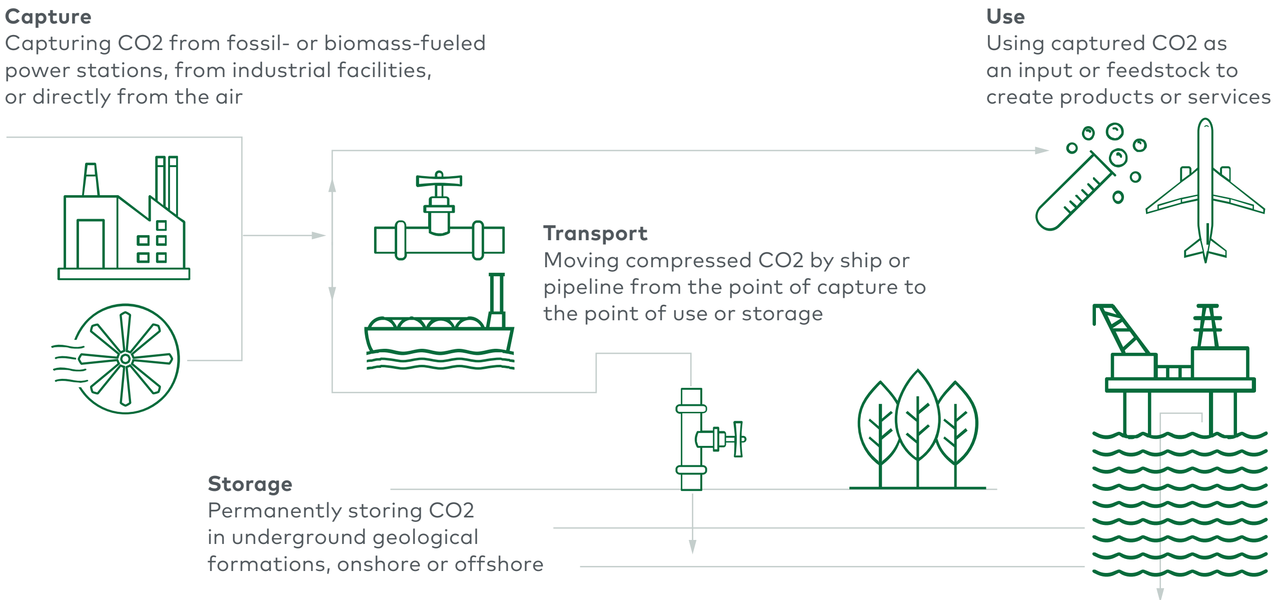
Carbon capture, utilization and storage (CCUS) is gaining importance as a strategic imperative to decarbonize various industries and to achieve net zero. Along with the use of carbon offsets and trading, CCUS will address emissions that cannot be fully mitigated through traditional techniques — the energy mix shifting toward renewables, fossil fuel asset portfolio optimization based on carbon intensity, and energy efficiency and demand-side management.

Approximately $30 billion in capital has been deployed toward 30 CCUS projects since 2017, with another 40 projects recently announced in the U.S. alone. The total abatement potential of these projects amounts to more than three times the current operational capacity. However, policy incentives and a widespread acceptance of the CCUS model have historically fallen far short compared to other decarbonization and energy transition solutions. This raises the question: Will CCUS live up to its potential as a bridge to the net-zero future?

CCUS: A primer

CCUS refers to a set of technologies that entail the capture of carbon dioxide (CO2) from high-emitting sources such as fossil fuel-based power generation or industrial facilities that use fossil fuel or biomass for fuel. According to the International Energy Agency (IEA), the captured CO2 can be used on-site or compressed and transported via pipeline, rail or other means to be used in a variety of applications or injected into geological formations for long-term storage (see Figure 1).

Figure 1
The technologies comprising CCUS



Source: IEA; L.E.K. research and analysis

The geological formations best suited for storing CO2 include salt domes and depleted oil and gas reservoirs. The CO2 can also be captured directly from the atmosphere, as in the case of direct air capture (DAC) — a promising technology that is attracting investments for scale-up beyond the current early stages of deployment (presently, there are 15 DAC plants operating worldwide pulling in 9,000 metric tons of CO2 per year). This captured CO2 is used in industrial applications, providing a source of revenue for investors in CCUS facilities. Most CCUS projects so far, at least in the U.S., have provided the CO2 for enhanced oil recovery (EOR) operations in upstream oil and gas. As of 2020, EOR amounted to approximately 75% of the total captured carbon use. There are other uses for captured CO2, and enhanced incentives from governments are now targeting industrial uses such as the production of chemicals, synthetic fuels and industrial materials.

Increasing numbers of countries and organizations have committed to net-zero emissions targets, highlighting the need for CCUS. Global emissions targets set by governing bodies and corporations cannot be met by just expanding the use of renewable energy and fuels; there is a critical need for negative-emission technologies, including carbon capture and offsetting projects. In view of the fact that fossil fuels will continue to be part of the energy mix through 2050 — with some experts projecting that as much as 60% to 70% of the primary energy supply in 2050 will still be from fossil fuels due to various structural constraints — CCUS takes on a greater importance in reducing emissions as the global energy system transitions to a lower carbon mix. Further, CCUS can help address emissions in sectors where technical solutions for abating or eliminating emissions are still not developed or are prohibitively expensive, including cement plants, steel plants and fossil fuel-based power generation.

The benefits of CCUS

The advantages of using CCUS in the transition to net zero include the following:

- Enabling the retrofitting of existing power and industrial plants
- Addressing emissions in sectors where other technology options are limited (e.g., cement, iron, steel, chemicals, synthetic fuels)
- Enabling low-carbon hydrogen production
- Removing CO2 from the atmosphere to offset unavoidable emissions

A long history with mixed results

So far, CCUS deployments have fallen short of expectations and face specific barriers that must be addressed. Several CCUS projects are achieving only a fraction of their targeted emission abatement objectives. The total capacity of CCUS deployments is about 40 million tons of CO2 per year, which pales in comparison with the global CO2 emissions of about 32 gigatons per year. However, more substantial climate targets and incentives are changing the trend. The 30 CCUS projects announced since 2017 comprise roughly $30 billion of investment, and more project announcements are expected as governments and corporations expand funding to further the development and deployment of CCUS (see Figure 2).

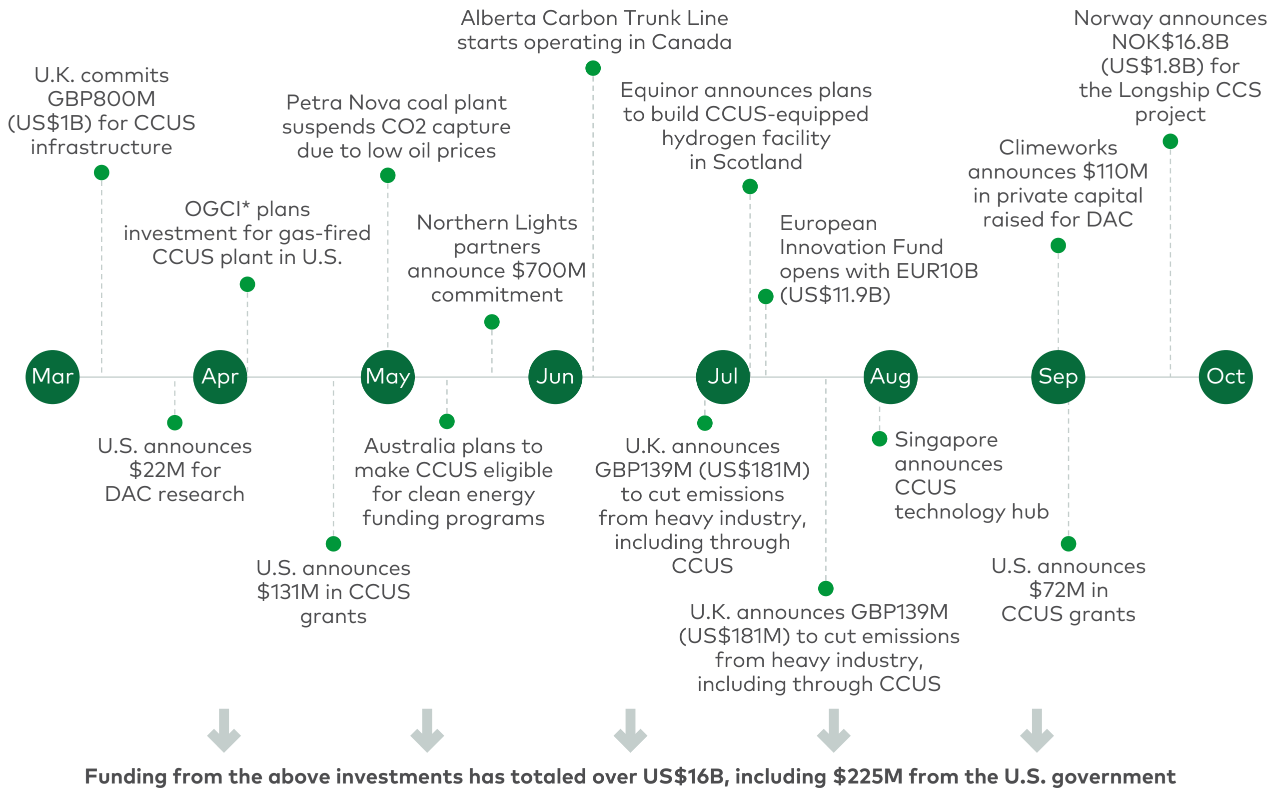
The problem

A key barrier to expanding the use and deployment of CCUS is the cost of carbon capture and sector-specific applications. In various sectors such as energy, power generation and industrials, and specific applications within those sectors, the levelized cost of carbon capture (LCOC) ranges from $20 to $100 per metric ton of CO2, and thus, targeted incentives are needed to support deployment.

For instance, the U.S. Section 45Q federal tax credit is expected to prompt new capital investments of as much as $1 billion for CCUS over the next five to six years. This performance-based tax credit for carbon-capture projects can be claimed when an eligible project has a) securely stored the captured CO2 in geologic formations, or b) used the

Figure 2

Timeline of major CCUS-related investments announced in 2020



Note: Equinor, Shell and Total were major strategics behind the $700M Northern Lights offshore CO2 storage project investment
*OGCI=Oil and Gas Climate Initiative
Source: IEA; L.E.K. analysis

captured CO2 or carbon monoxide (CO) as feedstock to produce fuels, chemicals and products such as concrete that result in emission reductions.

The credit amount depends on the project type — $35 per ton for CO2 geologically stored by its reinjection in oil fields for the purpose of EOR, or if the CO2 is used as feedstock to produce fuels, chemicals and products such as concrete. The amount increases to $50 per ton if the CO2 is stored in geologic formations and not used for EOR. Still, the credit amounts aren't substantial enough to make several applications of CCUS economical, particularly for industrial applications. However, with the projected increase in carbon prices and potentially tighter regulations related to carbon emissions — including the introduction of carbon taxes — in certain jurisdictions, the combination of incentives and penalties/costs may push more CCUS applications toward economic viability.

In the absence of further incentives, the development of "hubs" is being explored as a means to scale carbon capture through an integrated system of localized pilot projects. Calpine, Chevron, Dow, ExxonMobil, INEOS, Linde, LyondellBasell, Marathon Petroleum, NRG Energy, Phillips 66 and Valero are among those in a group evaluating a Houston hub that will capture up to 50 million metric tons of CO2 per year by 2030.

The solution

To achieve the full potential of CCUS, several barriers and challenges need to be addressed:

- The lack of clarity and consistency in policies, regulations and incentivized support has contributed to the delays of various projects; how to change these issues must be looked into
- Further incentives need to be designed and must take into consideration the various sector applications, the presence or lack of required infrastructure, and the implications for current LCOC capture and storage
- To address public resistance to CO2 storage, particularly storage in onshore reservoirs, policymakers and thought leaders need to highlight the importance of CCUS to enable the energy transition and complement investments in renewable energy, particularly hydrogen and synthetic fuels
- The scaling of CCUS requires investments in various enabling infrastructure and facilities, so areas that lack the full infrastructure backbone but that have elements key to CCUS (e.g., geologic formations for storage, potential industrial customers for the use of the CO2) would benefit from incentives targeted at infrastructure investments

Signposts for investment stakeholders to monitor

Investors and operators that are interested in applications of CCUS and deployments in various industries need to keep an eye on signposts and key drivers that will expand the adoption of this technology. These signposts include carbon prices, government regulations and incentives, climate commitments, and expanded CCUS infrastructure investments.

- **Carbon prices** obtained either from cap-and-trade market mechanisms or through the introduction of a carbon tax will be a primary driver in expanding the deployment of CCUS, particularly in areas with a high LCOC.
- **Government regulations and incentives** are already helping spur investments in applications in areas with relatively low LCOC. As we move forward, government regulations and incentives in combination with higher carbon prices will help the higher-cost applications attract investments.
- The increased number of **climate commitments** from governments and corporations is another signpost, as those will indirectly spur tighter regulations on behalf of governments and increase investments in emission-reduction solutions (including CCUS) on the corporate side.

- Another mechanism that governments can use to nudge **CCUS investments** and expand the use of the technology is addressing the **infrastructure** requirements in areas where they are lacking (e.g., transport pipelines).

The role of CCUS in the transition to net zero

CCUS will play a central role in the transition to net-zero emissions in five key dimensions:

1. Reducing and/or eliminating emissions from sectors and processes with hard-to-abate emissions
2. Enabling cost-effective retrofitting of existing assets in power generation and industry to reduce emissions; otherwise, the alternative would be more expensive, entailing retirement and replacement of a large stock of installed facilities
3. Expanding the production of low-carbon hydrogen from natural gas or coal (e.g., blue hydrogen), as it may take several years for green hydrogen to be cost competitive
4. Removing carbon from the atmosphere through DAC or through bioenergy with carbon capture and storage
5. Providing a hedge or mitigation mechanism when the rollout of emission-reduction technologies is slower than anticipated and in locations where the world needs to rely more on CCUS and DAC

The expansion in deployment of CCUS facilities will push the technologies further along the learning curve and contribute to the energy transition. The costs of CCUS have been declining, and the technologies for CO2 capture and use have been advancing and attracting investments. The cost of emitting CO2 — driven by CO2 taxes or quotas (or both) and regulations and societal costs, including the "license to operate" — compared to the cost of capturing, transporting and storing CO2, varies by industry and geography. That's why the price of carbon and any applicable regulatory regimes and incentives, together with specific industry and location factors, will play important roles in driving the adoption of CCUS.

Due to technology, market and regulatory uncertainties that may impact the pace of the energy transition, CCUS will play a critical role as a strategic lever to mitigate various risks, particularly for the energy and industrial sectors. CCUS would enable a rapid and cost-effective retrofitting of a significant portion of the legacy assets in the energy industry and the industrials sector to ensure we reduce carbon emissions in line with a 1.5°C science-based trajectory.

Under various scenarios where either the rollout of renewable energy investments falls short of envisioned plans or emission reduction measures underdeliver, CCUS provides a strategic option and a mitigation measure that governments and companies can pursue through greater investments in order to counter such adverse outcomes. Governments and regulators can play an important role in structuring incentives to enable accelerated deployment of CCUS and help the industry move forward on the learning curve.

For more information, please contact industrials@lek.com.

About the Authors

Nilesh Dayal
Nilesh Dayal is a Managing Director in L.E.K. Consulting's Houston office. Nilesh is head of the firm's Energy practice and is also focused on the oil and gas and chemicals sectors. He has more than 20 years of experience advising clients on growth strategies related to acquisitions, divestitures and new business venture launches; corporate restructurings; supply chain management; public sector and regulatory strategy; profitability and operations improvement; and post-merger integration and planning.

Franco Ciulla
Franco Ciulla is a Managing Director in L.E.K. Consulting's Houston office. Franco has 25 years of experience working for the oil and gas industry in technical, operational, commercial and strategic roles, with a focus on upstream activities and oil-field supply chain strategies. He specializes in aboveground risk assessment, oil and gas asset performance analysis, cost and supply chain strategies, fiscal benchmarking and optimization, competitiveness assessment, M&A support, and corporate growth strategy.

Amar Gujral
Amar Gujral is a Managing Director in L.E.K. Consulting's Houston office. Amar is focused on growth and commercial strategy, M&A, and due diligence in the energy sector. He has supported strategy engagements and M&A processes with major and midsize E&Ps, oil-field service companies, utilities, equipment manufacturers, private equity firms, and other financial institutions. Prior to L.E.K., Amar was on the energy deals team at Strategy& and covered oil-field services at Guggenheim Partners.

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