BostonPartners

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Carbon Capture and Storage

Introduction to Carbon Capture and Storage

As the global effort to combat climate change intensifies, the importance of developing low-carbon solutions to meet the goals of the Paris Agreement is vital to many companies and their investors. Carbon capture technologies will play an important role in meeting net zero targets, including being one of the few solutions with the ability to address emissions from heavy industry and remove CO_2 from the atmosphere. Increasing urgency and the strengthening of climate goals have led to significant momentum for carbon capture, with plans for more than 100 new facilities announced in 2021. According to the International Energy Agency (IEA), achieving net zero emissions will be virtually impossible without carbon capture operating at scale; however, estimates suggest that the solution will cost industry and government trillions of dollars through 2050.

Carbon capture, (utilization), and storage (or sequestration) ("CCS" or "CCUS") is the process of capturing carbon dioxide (CO_2) – the primary greenhouse gas emitted through human activities – at its source and either storing it permanently underground or recycling it for further use. CCS has the potential to reduce significantly the amount of CO_2 emitted to the atmosphere from the burning of fossil fuels at power plants and other large industrial facilities.

Long-term Outlook (JEF – CCS Renaissance)

The IEA Net Zero 2050 Scenario shows CO_2 capture accounting for roughly 22% of emission reductions through 2050 (7.6 billion tons). According to Jefferies[1] estimates, this level of CCS capacity could be equivalent to cumulative investments of ~$3 trillion over the next three decades. In this scenario, CCS could become a ~$600 billion EBITDA industry by 2050, with Integrated Oil & Gas companies commanding a ~50% market share, based on the current projects pipeline.

Carbon Capture Methods (NETL) (JEF – Flue Gas)

The three main CO_2 removal systems, in use or in development, are post-combustion, pre-combustion, and oxy-fuel combustion.

1. Post-combustion technology is the most common and has the longest history of the three methods. In a post-combustion system, the CO_2 removal device goes downstream from where the combustion process occurs. There are various methods of post-combustion capture including distillation, membranes, adsorption, and physical and chemical absorption. Absorption in chemical solvents, particularly amine[2] types, is a proven technology ready for commercial-scale deployment.

2. Pre-combustion carbon capture typically applies to coal-gasification power plants. Coal is gasified to produce a synthetic gas made from carbon monoxide and hydrogen, which is then reacted with water to produce CO_2 and additional hydrogen. The CO_2 is captured, while the hydrogen can be burned to produce electricity or utilized to power fuel cells. Unfortunately, the pre-combustion method cannot be retrofitted to older coal power plants.

3. Oxy-fuel combustion is the process of burning fuel using pure oxygen rather than air, which is 80% nitrogen and 20% oxygen. The use of pure oxygen during the combustion process yields flue gas that is nearly pure CO_2 and easily captured. However, the significant amount of oxygen required in oxy-fuel combustion leads to higher capture costs.

Geological Storage (Global CCS Institute) (IPCC – 2005 Report)

Geological storage is the process of permanently removing captured CO_2 from the atmosphere by injecting it into rock formations deep underground. Effective geological storage sites are rock formations with enough millimeter-sized pores to provide the capacity to store the CO_2. Additionally, the pores must be sufficiently permeable to allow the CO_2 to move and spread out within the formation. Finally, there must be an extensive cap rock or barrier at the top of the formation to permanently contain the CO_2. A 2005 report by the United Nations Intergovernmental Panel on Climate Change (IPCC) estimates the world's underground storage capacity at two trillion tons and the potential to be even higher. The report also suggests that appropriately selected and managed geological reservoirs are likely to retain 99% of the sequestered CO_2 for over 1,000 years.

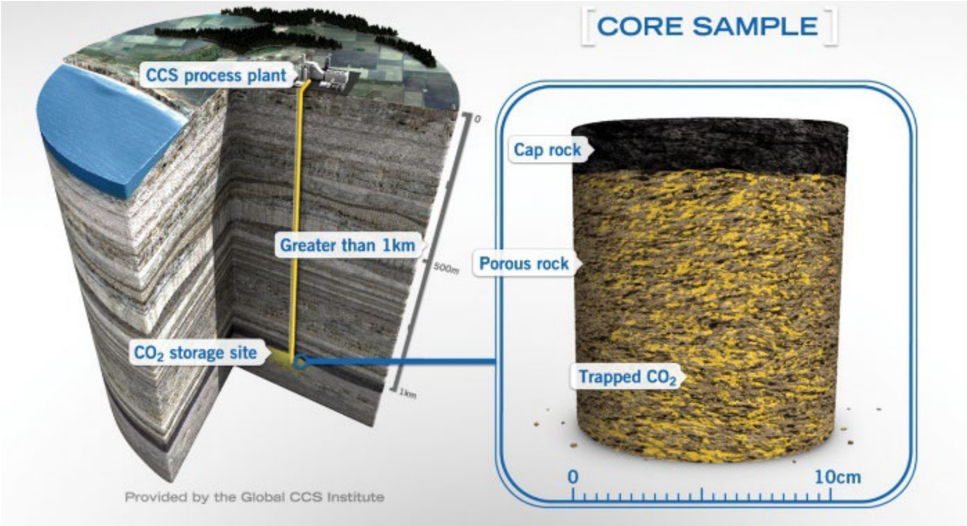

Exhibit 1: Geological Storage
Source: The Global CCS Institute

Enhanced Oil Recovery (Energy.gov)

Approximately 70% of the current global CCS capacity is used for enhanced oil recovery (EOR). EOR is the process of injecting captured CO_2 into partially depleted oil fields, following conventional production operations, to force out additional barrels of oil. This process results in the permanent storage of CO_2 underground and the recovery of 20-40% of the original oil in place. EOR works as an energy production and emissions mitigation tool. According to an industry estimate, EOR operations result in approximately 25% more CO_2 stored underground than the combined Scopes 1, 2 & 3 emissions from the production and use of the oil recovered (Natlawreview).

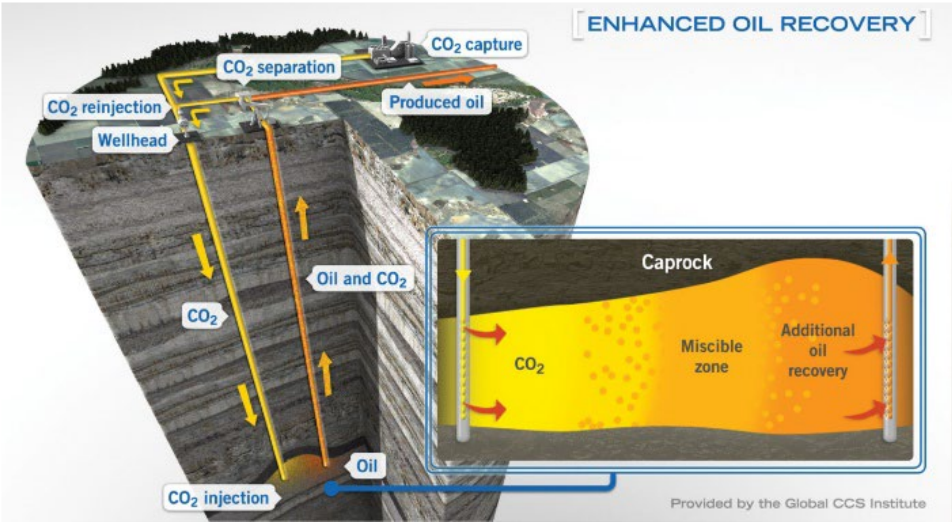

Exhibit 2: Enhanced Oil Recovery
Source: The Global CCS Institute

Carbon Utilization (NETL)

The U.S. Department of Energy's (DOE) Carbon Utilization Program aspires to develop technologies to transform CO_2 into valuable products. Through this program, the DOE addresses the challenges and opportunities associated with integrating a CO_2 utilization system with various power and industrial plants or CCUS systems – with the objective to make technologies applicable for near-term implementation. The Carbon Utilization Program currently identifies four primary carbon utilization pathways: (1) carbon uptake using algae; (2) conversion into fuels and chemicals; (3) mineralization into inorganic materials; and (4) CO_2 as working fluid and other services.

Capture Costs (JEF – CCS Renaissance)

The economic applicability of CCS depends on capture costs which are typically inversely correlated to carbon concentration levels. High carbon concentration industries with low capture costs have the lowest breakeven point and are able to shift their focus to the transportation and storage of their captured CO_2. Achieving widespread deployment of CCS technology will depend on capture costs falling to sustainable levels across all deployment segments. The power, cement, and iron & steel industries each have technologies approaching commercialization that will increase the carbon concentration in exhaust streams to allow for lower capture costs. Another way to improve the economic viability of CCS projects in low CO_2 content industries is through CCS Networks, which accelerate the deployment of CCS projects through the use of shared infrastructure to transport and store captured CO_2. CCS Networks aggregate the parts of the project development cycle that typically take the longest time including access to storage resources and providing transport and storage services to industries with limited competence in building pipelines and drilling wells.

Challenges

The energy intensity of carbon capture is a concern from both the emissions and cost perspectives. Carbon capture facilities that rely on significant grid electricity supplied by fossil fuels may be doing more harm than good. A key element to the successful adoption of carbon capture is identifying areas with ample low-carbon energy sources. Additionally, the amount of energy required to operate carbon capture technology can double the cost of electricity generation. For example, incorporating carbon capture into a power plant can reduce the efficiency of the plant's output by about 10% (JEF – Flue Gas).

Another challenge relating to CCS is the requirement of bipartisan support to pass the necessary government funding and regulatory policy to promote CCS investment. There are lingering concerns from both sides of the aisle. From one perspective, there is the moral hazard argument that if carbon removal technologies take off, companies may use it as an excuse to continue to emit at high levels. From another perspective, some climate change doubters may not agree that investment in CCS technologies is a productive use of government capital. In the US, the Bipartisan Budget Act of 2018, the Infrastructure Investment and Jobs Act of 2021, and the Inflation Reduction Act of 2022, all of which increased the support and incentives for CCS investments, suggest that bipartisan support is attainable.

Current CCS Projects (Exxon Q&A) (IEA – About CCUS) (IEA – Carbon Capture in 2021)

Carbon capture projects are currently operating or under development in 25 countries, with the United States and Europe accounting for three-quarters of the projects in development. Even with the increasing momentum and interest in CCS, the planned pipeline of projects remains well below the deployment level required to achieve the Net Zero Emissions by 2050 Scenario. According to the Net Zero 2050 scenario, global deployment of CO_2 capture capacity must reach 1.7 billion metric tons by 2030. The annual CO_2 capture capacity from power and industrial facilities was 40 million metric tons in 2021.

Exhibit 3 illustrates the significant growth in the CCUS project pipeline in 2021. Stemming from the growing recognition that CCUS is necessary to meet national, regional, and corporate net zero targets and new policy incentives. Since 2020, government and industry have committed more than $25 billion towards CCUS projects.

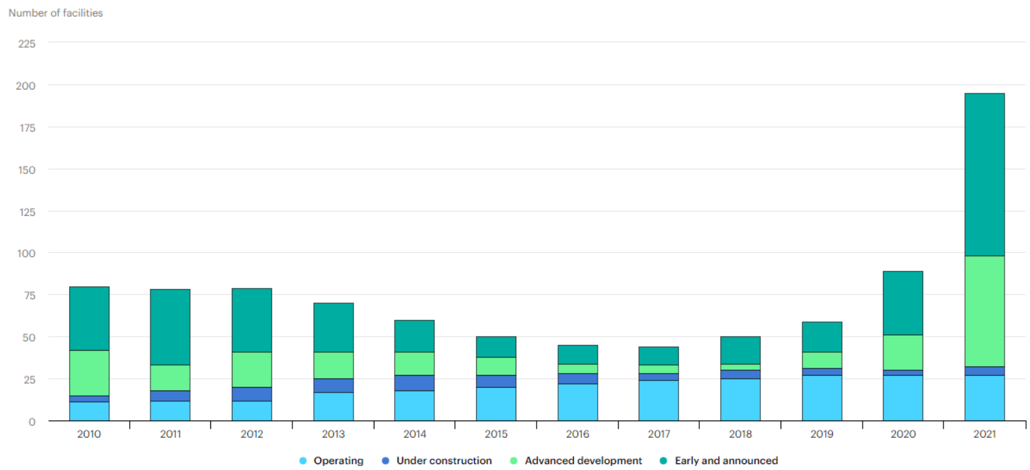

Exhibit 3: Global Pipeline of Commercial CCUS Facilities Operating and in Development, 2020-2021
Source: IEA, https://www.iea.org/data-and-statistics/charts/global-pipeline-of-commercial-ccus-facilities-operating-and-in-development-2010-20

Direct Air Capture (IEA – Direct Air Capture)

Direct air capture (DAC) technologies extract CO_2 directly from the atmosphere through either liquid solvents or solid sorbents. DAC should not be viewed as a substitute for traditional CCS technologies but rather a tool to draw down historic CO_2 emissions from the atmosphere once the net zero emissions ambition is achieved and CO_2 is no longer being added to the atmosphere. DAC has a higher capture cost and requires more sophisticated technology relative to traditional CCS due to the low concentration of CO_2 in the atmosphere. DAC credits currently cost upwards of $600/ton of CO_2 permanently removed from the atmosphere, with many companies and DAC start-ups aiming to drive down the cost to around $100/ton. As of 2021, there are 19 small DAC plants operational in Europe, the United States, and Canada. These plants combine to capture just over 0.01 megatons (Mt) of CO_2/year, with the largest plant capturing 4 kilotons (kt) of CO_2/year (0.004 Mt). The first large-scale DAC plant in the United States is in development and expected to become operational as soon as 2024, with a capture capacity of up to 1 Mt CO_2/year. According to the Net Zero 2050 Scenario, global deployment of DAC technology is responsible for capturing more than 85 Mt CO_2/year by 2030 and almost 1,000 Mt CO_2/year by 2050.

Investment Incentive (IEA – Carbon Capture in 2021) (JEF – CCS Renaissance)

The first use of CCS dates back to 1972 at the Terrell gas processing plant in Texas. The natural gas processing facility began supplying CO_2 to an oil field in West Texas through the first large-scale, long-distance pipeline (C2ES). However, further deployment stalled due to the lack of investment incentive for technology without a clear monetization framework. Increasing urgency to meet the goals of the Paris Agreement has led to the strengthening of government support in the form of tax credits, subsidies, and carbon trading systems. Additional investment incentive comes from the increasing demand for the technology and its subsequent profit potential.

United States | In the U.S., investment incentive is provided in the form of a tax credit (45Q) per metric ton of qualified CO_2 captured and sequestered. The value of the 45Q tax credit has increased significantly over the past few years from its original value of $31.77/ton to $50/ton as a result of the Bipartisan Budget Act of 2018, and finally, to $85/ton provided by the Inflation Reduction Act of 2022. The expansion of the 45Q tax credit has been a catalyst for new investment plans, as seen in Exhibit 3. Additionally, the 45Q tax credit can be "stacked" with other state-level incentives, such as the California Low Carbon Fuel Standard (LCFS), with the value of LCFS credits averaging around $200/ton of CO_2 in 2020. An additional $12 billion of support for CCUS investment was included in the Infrastructure Investment and Jobs Act signed by President Biden in November 2021. This investment included $3.5 billion towards establishing four regional DAC hubs across the country, each with the capacity to remove 1 million tons of CO_2 annually. (Global CCS Institute – IRA of 2022) (IEA – Direct Air Capture)

Canada | In April 2022, the Canadian government introduced an investment tax credit (ITC) for CCUS projects. Starting in 2022, the ITC for eligible CCUS expenses is expected to cost the Canadian government C$2.6 billion (~$2 billion) over five years and about C$1.5 billion (~$1.1 billion) annually from 2026 through 2030. From 2022 through 2030, the investment credit rates are set at 60% for direct air capture (DAC) projects, 50% for post-combustion CCUS or CCS projects, and 37.5% for investments in equipment to transport, store or use CO_2. From 2031 through 2040, these rates will be cut in half to attract immediate CCUS investment. Canada's ITC notably excludes projects which use CO_2 in enhanced oil recovery operations. (Gas Pathways) (Canada's National Observer)

European Union | EU-level and national government legislation, along with rising carbon prices, will further incentivize CCS investment. In July 2021, the EU introduced its "Fit for 55" legislation with the goal to encourage the deployment of climate technology, including CCS, to accelerate the path to reducing emissions in the EU by at least 55% by 2030. This proposed legislation would expand the area of application of the EU Emissions Trading Scheme (ETS) to further incorporate CCS technology. Carbon prices in the EU's ETS are expected to trade at €80-€90/ton (~$83-$94/ton) from 2022 to 2025, which should provide support to CCS projects. Additionally, "Fit for 55" aims to increase CCS investment by doubling the funding allocated through the EU Innovation Fund to €25 billion (~$26 billion). (JEF – CCS Renaissance) (Global CCS Institute)

SBTi | The Science Based Targets initiative's (SBTi) new net zero standard will provide further demand for carbon capture and thus provide an incentive for investment in the technology due to increased profit potential. One of the four key elements of the SBTi's new net zero standard is for companies to neutralize their residual emissions via permanent removal and storage of carbon from the atmosphere once they achieve their long-term science-based targets. Since the majority of long-term targets will cover approximately 90-95% of a company's emissions reductions, this requirement will help companies achieve net zero by using carbon removal technologies to neutralize the remaining emissions.

Engagement Insights – *Cenovus Energy*

In January 2022, the Sustainability and Engagement Team ("the Team") at Boston Partners had an engagement call with Cenovus Energy Inc. (ticker symbol: "CVE"). CVE is a Canada-based integrated energy company, engaged in producing, refining, and upgrading crude oil and natural gas primarily from oil sands. CVE's Chief Sustainability Officer provided the Team with valuable insight regarding the decarbonization of the Canadian oil sands sector, including the costs of implementing carbon capture technology and the collaboration with other Oil and Gas companies and the Canadian government. In 2020, CVE co-founded the Oil Sands Pathways to Net-Zero to establish a collaborative effort among the 6 largest Oil and Gas companies in Canada (representing 95% of Canada's oil sands production). The initiative is focused on moving faster in order to hit targets and satisfy investors. The CEOs of all 6 companies meet weekly and the Steering Committee meets 4 times each week to discuss environmental plans.

An important aspect associated with the implementation of carbon capture technology is government funding. The Canadian government has established its own Net Zero 2050 target, and not only is the Oil and Gas industry Canada's largest emitter but it is also Canada's largest exporter. The link between the two seems to indicate that the Canadian government would be willing to allocate significant investment into decarbonization efforts. CVE estimates the all-in cost of implementing carbon capture technology at approximately $1 billion per megaton of CO_2e reduced. Additionally, CVE estimates that it would cost roughly $75 billion to completely decarbonize the Canadian oil sands sector by 2050. However, CVE also estimates that the investment would yield $3 trillion to Canadian GDP over the same time span. CVE meets regularly with top levels of the Canadian government to discuss these issues and CVE is optimistic that the government and the Canadian Oil and Gas industry will be able to reach a deal in the near future.

Conclusion

CCS technology will have a crucial role in achieving the Net Zero 2050 Scenario. Commercial adoption of CCS will depend on driving down capture costs through technological developments and shared infrastructure and incentivizing investments through government support and rising carbon prices. New technology strives to reduce capture costs, specifically for low CO_2 content applications, while CCS Networks work to accelerate the deployment of CCS projects by using shared infrastructure to transport and store captured CO_2. Government support includes tax credits, funding, and strong legal and regulatory policies. Additionally, rising carbon prices in Europe make CCS a more attractive investment.

About the Author

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Mr. Corning holds a B.A. degree in Economics from Wesleyan University, where he was recognized as a Scholar-Athlete as a member of the baseball team.

Mr. Corning is a Research Analyst for the Boston Partners Sustainability and Engagement Team. He is responsible for original ESG/Sustainability research on companies held in Boston Partners' portfolios. Prior to joining the team, he was a member of the compliance team, managing the proxy voting process on behalf of the Governance Committee, and preparing all engagement materials with issuers regarding proxy matters.

About Boston Partners

Boston Partners specializes in traditional value investing, with an investment process and philosophy that was established more than 25 years ago. The source of our investment returns is security selection achieved through bottom-up fundamental analysis guided by quantitative methods. The team's process systematically blends fundamental research with quantitative screening to identify undervalued stocks throughout the capitalization spectrum.

Important Disclosure Information

Definitions

EBITDA: Or earnings before interest, taxes, depreciation, and amortization, is a measure of a company's overall financial performance and is used as an alternative to net income in some circumstances. ... This metric also excludes expenses associated with debt by adding back interest expense and taxes to earnings.

[1] Jeffries Financial Group Inc. is a financial services company. Jeffries' Global Research & Strategy business segment provides thought leadership across the financial markets, offering valuable insights and ideas to clients on market strategy, economics, equity, fixed income, and foreign exchange in the Americas, Europe and Asia.

[2] Any member of a family of nitrogen containing organic compounds that is derived, either in principle or in practice, from ammonia (NH_3).

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