Way Down in the Hole, Part 2 — Incentives, Technology Have Carbon Capture Poised for Global Breakout

Projects targeting CO_2 emissions seen as essential in meeting net-zero goals

- **The proposed Houston CCS Innovation Zone alters the scale of carbon-capture efforts.**
- **Projects in the Midwest, Great Plains target emissions from ethanol production.**
- **Direct air capture shows promise, but faces significant economic, technical hurdles.**
- **Inflation Reduction Act helps clear the path for carbon capture.**
- **Carbon-capture industry set for enormous growth by 2050: Exxon, Oxy**

1. Introduction

Not long ago, many considered carbon capture to be a pie-in-the-sky concept. But capturing carbon dioxide (CO_2) and permanently storing it underground is not new and it's not conceptual — naturally occurring sources of CO_2 have been used in enhanced oil recovery (EOR) for decades. With new financial incentives and a renewed sense of urgency regarding climate action, things are changing fast — so quickly, in fact, that the carbon-capture industry may be poised for exponential growth, both in the U.S. and abroad.

When U.S. lawmakers introduced the 45Q tax credit in 2008 to encourage the development of carbon-capture projects, they were planting a seed they hoped would one day sprout into a flourishing industry. As the years wore on and the number of successful projects remained small, they added a little fertilizer in 2018, by not only enhancing the value of the credits but easing some of the limitations in the earlier legislation. This summer's passage of the Inflation Reduction Act (IRA) is intended to reap a harvest of carbon-capture projects designed to reduce greenhouse gas (GHG) emissions and help the U.S. advance its plans to achieve net-zero GHG emissions by 2050. The passage of the IRA certainly brightens the future for carbon capture. In addition to the enhanced 45Q tax credits, the legislation also has several key provisions that are seen as

favorable to the industry — including lower emissions thresholds for qualifying facilities and the option to receive the tax credit as a direct payment — but that doesn't guarantee success.

The key theme when it comes to the 45Q tax credit and carbon-capture projects in general is potential. As we detailed in **Part 1** of this report, the ongoing energy transition and clean-energy goals have set the stage for carbon capture's growing importance, but advances in technology, long-term commitments to decarbonization and enhanced government incentives have the industry poised for a global breakout. Here are four reasons why.

Bigger Projects on the Way

The plans by the Biden administration, the International Energy Agency (IEA) and others to reach net-zero GHG emissions by 2050 rests largely on the expansion of carbon capture from industrial sources, with enormous increases from today's levels and requiring carbon capture at a scale not happening today. But the limited scope of carbon capture in today's energy environment hasn't precluded others from thinking much, much bigger, thanks in part to projects like the proposed Houston CCS Innovation Zone, which is outlined in Section 2 of this report.

The project is by far the most ambitious to date and envisions a large-scale collaboration between private industry and the government to create a platform to dramatically accelerate CCS progress. It would capture the CO_2 emitted from petrochemical, manufacturing and power generation facilities along the Houston Ship Channel and eventually pump it thousands of feet below the Gulf of Mexico floor. It would permanently store up to 50 metric tons per annum (MMtpa) of CO_2 by 2030 — equivalent to about 2.6 Bcf/d — with plans to store 100 MMtpa (about 5.2 Bcf/d) by 2040.

Talos Energy also has big plans for sequestration and is a partner in two CCS hubs taking shape along the Gulf Coast. The Bayou Bend hub, which could see its first injections by late 2005, could sequester 5-15 MMtpa offshore near Port Arthur and Beaumont, TX, with a total storage capacity of 225 million to 275 million MT. Talos has partnered with Carbonvert on Bayou Bend and they have had discussions with Chevron about joining the project. Talos is also developing the River Bend sequestration hub in Louisiana, which could sequester 5-15 MMtpa along the Mississippi River near Baton Rouge and New Orleans, with a total storage capacity of at least 500 million MT. Talos has partnered with Storegga, which focuses on carbon reduction and removal, and EnLink Midstream on River Bend. Like the Houston CCS Innovation Zone, both projects aim to capture emissions from heavily industrialized areas.

Almost all the CO_2 captured by active projects today comes from what the IEA categorizes as fossil fuels and processes. The CO_2 from these projects totals about 39 MMtpa, considerably less than the eventual annual goal of the Houston project. To meet the IEA's targets, the global annual total would have to reach 1,325 MMtpa by 2030 and 5,245 MMtpa by 2050.

Targeting High-Purity Sources

Facilities emitting CO_2 can generally be put into two buckets: high-purity and low-purity. For the most part, high-purity sources include processes with a highly concentrated CO_2 stream, generally where CO_2 is a byproduct and is much easier to separate and capture. (In low-purity sources, the CO_2 is generally a product of combustion or is commingled with other emissions and is therefore harder to separate and capture.) As we explain in Section 3, some of the biggest projects set to come online in the next couple of years focus on capturing emissions from a high-purity source that is prevalent in much of the Midwest — ethanol production.

Ethanol production may be a significant contributor to CO_2 emissions but it's also one with a lot of potential for carbon capture. The U.S. has the capacity to produce about 17.5 billion gal/year of ethanol, which puts total CO_2 emissions from those plants as high as 52 MMtpa (equivalent to about 2.7 Bcf/d). Importantly, the CO_2 that results from the ethanol production process is nearly

100% pure, making carbon capture an attractive option, especially for facilities looking for an additional revenue stream.

The report looks at three carbon-capture projects taking shape in the Midwest, plus another that stretches from the Midwest across the Great Plains to Wyoming. All of them focus on capturing CO_2 emissions from ethanol/biofuel production for permanent sequestration, sometimes hundreds of miles away.

We should note that there are other projects being planned that target high-purity sources as well, including natural gas processing. NextDecade says it will make a final investment decision (FID) on its Rio Grande LNG project in the second half of 2022. The site near Brownsville, TX, would produce about 11 MMtpa of LNG — including an agreement to supply Shell with 2 MMtpa over 20 years — and sequester about 5 MMtpa of CO_2.

New Technology

Any ramp-up in carbon capture volumes is going to depend to a large degree on improvements in technology. As we noted above, it's especially difficult (and expensive) to capture emissions from low-purity sources, like iron and steel production and refining. But those low-purity sources account for a large percentage of overall GHG emissions, so finding an economical way to address that issue is paramount in the long term. That's also where direct air capture (DAC) could come into play.

DAC essentially acts as a giant air filter and is the focus of Section 4 of this report. The technology is still in its nascent stages and has significant barriers to greater implementation, including high power requirements, questionable commercial viability in today's economic landscape, and access (often via pipeline) to a suitable location for deep geologic storage. The central challenge for DAC technology is that CO_2 makes up only about 0.04% of regular air — putting it at the opposite extreme of projects that target high-purity sources like ethanol production.

The DAC projects in operation today are extremely limited in scale but the technology does have a couple of major points in its favor in the long-term. While DAC's small scale may be a major limitation at the moment, it should benefit from economies of scale in the long run. Most DAC systems are modular in design, so adding to their size and scale should be as simple as adding more modules, which should become more efficient and less expensive to manufacture over time.

DAC also has one big selling point over other carbon-capture projects: It doesn't really matter where you put it. Since the CO_2 is being pulled directly from the atmosphere, and removing the gas has the same overall benefit regardless of where it's done, DAC facilities can deal with CO_2 without needing to be near the generation source.

Tax Credit Enhancements

Tax credits have long played a key role in federal energy policy. When it comes to carbon capture, the government's main tool has been the 45Q tax credit. It was created in 2008 and expanded in 2018, but its limited reach was a big reason why carbon-capture projects have remained at a small scale to date. However, as Section 5 details, the recent passage of the IRA, which includes substantial increases to the tax credit and other provisions sought by the industry, could help propel things forward.

The expanded credit's biggest impact could come from industrial, low-purity sources of emissions such as cement, refining, and iron/steel production. Under the previous credit structure, those types of projects remained mostly uneconomic for carbon capture and sequestration (CCS), with average breakeven costs far above the level of the tax credit. But those types of projects are now closer to making financial sense, with breakeven costs right around the new $85/MT level established under the IRA, even if they might not be there yet. As the credit rises with inflation in

future years and the breakeven costs to capture those emissions fall, those projects should increasingly become economically viable.

Where Are We Headed?

Most, if not all, long-term plans for decarbonization include carbon sequestration as a major feature. And while that suggests significant growth in the sector over the next few decades — from a $2 billion/year market today to expectations that it could be a multitrillion-dollar market by 2050 — there are numerous factors that could accelerate (or slow) that growth, including government incentives; expanded use of EOR; the level of acceptance of and commitment to net-zero targets; the level of public acceptance for both carbon sequestration and CO2 pipelines; and the cost of CCS technology.

The Table of Contents for "Way Down in the Hole, Part 2 — Incentives, Technology Have Carbon Capture Poised for Global Breakout" is included on the following page.

Table of Contents