GLOBAL CCS INSTITUTE

Brief

De-risking of CCS: A Primer for Investors and Businesses in the US

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1. Introduction

Carbon capture, utilisation and storage (CCS) comprises a wide range of technologies that involves capturing carbon dioxide (CO_2) produced by large industrial plants such as steel mills, cement plants, coal, and natural gas-fired power plants and refineries, compressing it for transportation and permanently storing it deep underground. Carbon capture technologies can also help remove CO_2 from ambient air.

Over the past year, the outlook for CCS has been positive, particularly in the United States (US). Thanks to broad bipartisan support at both the federal and state level, CCS in the US has seen growth exceeding that of any other nation. In 2020, the Global CCS Institute (the Institute) added 16 new US based projects to its CO2RE CCS Facilities database, with several more in the development pipeline.

Additionally, the Institute has seen an increase in new stakeholders looking to engage and explore the role of CCS in their emissions reduction strategies. These new stakeholders include sustainable investors who believe CCS projects can deliver strong returns while achieving environmental goals and mitigating climate change risk.

These new market entrants, however, often share a common concern; the need to de-risk CCS for investment.

This briefing will serve to summarise ongoing work by the Institute to communicate and educate stakeholders on the potential risk characteristics of CCS and to discuss these in the context of de-risking CCS investments and addressing challenges from a US perspective. These challenges range from queries about the cost of CCS to whether the November 2020 elections could disrupt vital policies supporting CCS to the future of pipelines. These efforts by the Institute, and other players advocating for CCS, have improved understanding clarity that should help both project proponents and investors feel comfortable moving forward on CCS.

As interest in CCS from the sustainable investment community gains momentum, common concerns amongst investors have arisen. The Institute has recognised key areas of perceived risk regarding the technology and its varied applications. A need for further information for investors to develop their understanding of these risks is required, enabling the process of risk mitigation and increased investor confidence in CCS in the US.

De-risking CCS begin with understanding the associated risks with CCS technologies, cost, the CCS process itself – including CO_2 storage and pipeline infrastructure – and the enabling policy and legal and regulatory environment. Arising from this year's global pandemic and related challenges, the impact of COVID-19 and associated investor risks must also be considered.

The following sections discuss and provide further detail on key areas for consideration regarding de-risking CCS investments.

2. CCS technology - Various stages of maturity tied to CO_2 concentration

The three primary capture methods used in the CCS process are pre-combustion capture, post-combustion capture, and oxyfuel combustion, with countless variations under each sub-category. The most prevalent capture type is post-combustion absorption with amines. Many investors and stakeholders consider the technology risk low for these types of projects.

Thanks to facilities around the world capturing and storing more than 40 million tons of CO_2 per annum, CCS technology[i], and primarily post-combustion capture with amines, have been proven at a large scale.

As technologies are being deployed as 2nd and 3rd of a kind, there are significant savings that fall into the category of "learning through doing." These improvements are driving down costs. This has been seen in Petra Nova and in similar, planned projects like San Juan (see Figure 1 below) which both utilise technology from Mitsubishi Heavy Industries (MHI)[1].

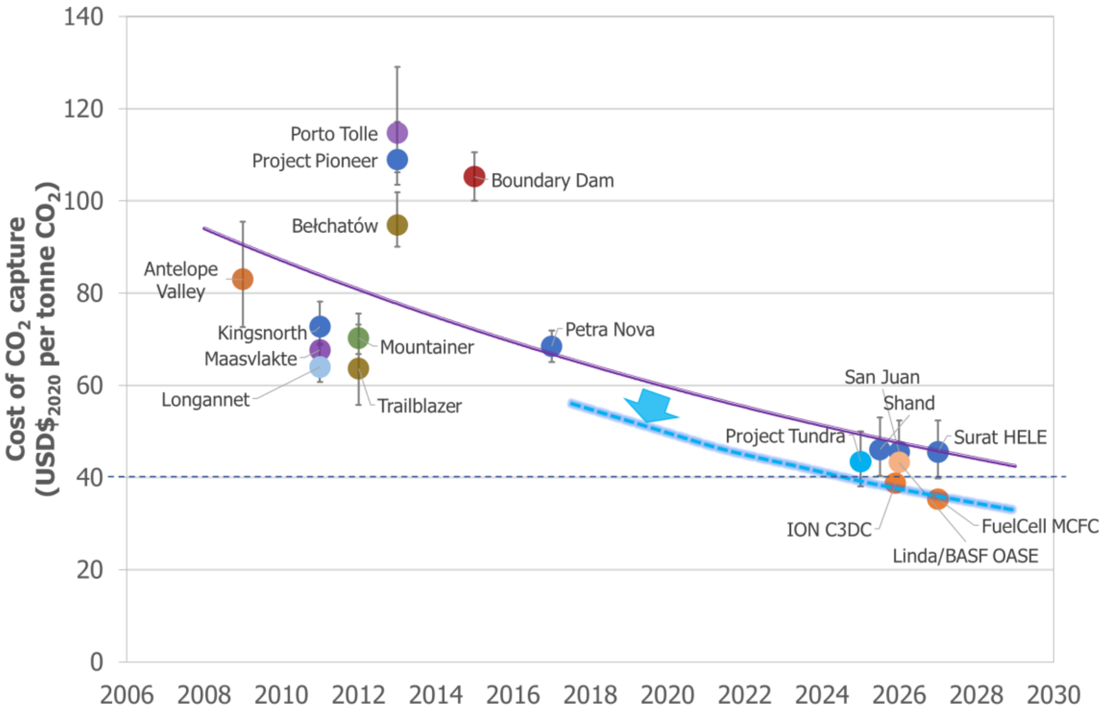

Figure 1: Levelised cost of CO_2 capture for large-scale post-combustion facilities at coal-fired power plants, including previously studied facilities from the Global Status of CCS: 2019[i]

However, the cost of CCS application is still high for many emissions sources, particularly those with low CO_2 concentration. One of the defining characteristics related to CCS cost is what percentage of the flue gas is CO_2, with many existing projects having very high concentrations of CO_2 including ADM's ethanol plant in Illinois.

Therefore, as industry proponents explore technology improvements to lower costs, they must consider technologies that address different emissions sources and concentrations. Prominent areas of exploration include:

- Incremental improvements for commercial technologies (post-combustion capture with amine)
- New variations of post-combustion capture with non-solvent technologies
- Fuel-cell technology
- Innovations in oxyfuel combustion, such as NetPower.

These innovation streams[2] are certainly not exhaustive of the activities around CCS technology innovation. The US Department of Energy and ARPA-E spend over a $100 million each year on technology innovation and cost reductions for CCS. Industry analysts have lobbied for even more money to be spent, however, to allow this set of technologies to grow more quickly to enable its essential role in mitigating climate change.

In addition, as technologies are being deployed as second and third of a kind, there are significant

[1] Operations at Petra Nova are currently suspended due to low oil prices. The facility remains an essential example of a CCS project deployed on-time and on-budget.
[2] For more information on the innovation streams please view the Institute's webinar on The Technology Cost Curve: https://www.globalccsinstitute.com/resources/audio-and-visual-library/ccs-talks-the-technology-cost-curve/

savings that fall into the category of 'learning through doing'. These improvements are driving down costs. The development of larger projects also drives down the cost per ton captured since the considerable capital costs can be spread across a large project base. For example, Boundary Dam in Saskatchewan, Canada, captures approximately 800,000 tons per year of CO_2, and San Juan plans to capture about six mtpa per year – making it about 7.5 times the size of Boundary Dam.

3. Storage risk – storage rocks in the US

The potential to safely and permanently store CO_2 underground is a critical component of the overall CCS value proposition. Government support and industry expertise in the characterisation and development of storage resources and supporting the legal and regulatory environment have already greatly de-risked geological storage. To meet the goals of the 2015 Paris Climate Change Agreement, the *IEA Greenhouse Gas R&D Programme (IEAGHG) 26* estimates that approximately 30-60 storage sites must be developed each year until 2050. With a potential storage capacity of 2,000 to 21,000 gigatons of CO_2 storage and a wealth of storage experience, the US is well-placed to lead the world in the development of geological storage.

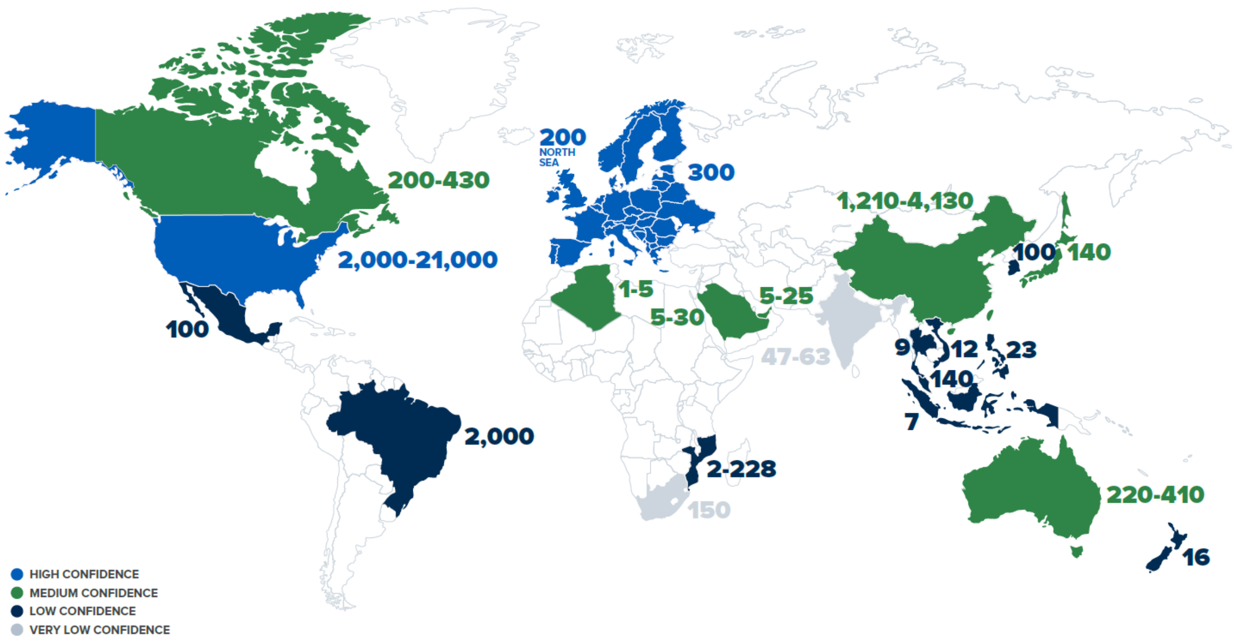

Figure 2: Global Storage Resource Estimates (Gigatonne) Around the World[i]

What makes a site suitable for geological storage?

It starts with suitable underground storage sites at depths of 1 kilometer or greater. CO_2 gas remains in its dense phase at this depth, making it possible to store more CO_2 in a given space. These deep storage sites could be on or offshore.

Secondly, the type of rock in these storage sites must be porous and permeable. One common misperception is that CO_2 is stored in an underground cavern. CO_2 is actually stored in rocks, and the formations that are suitable for storage are covered by cap rock that is not porous, thus creating a barrier to movement.

An essential element in geological CO_2 storage site characterisation is capacity. The goal is to find sites where over 50 million metric tons can be stored for economic and monitoring reasons. The US Department of Energy's CarbonSafe program has been developing these sites for over a decade – identifying them and creating best practices for screening, site selection, geological characterisation, modeling, and monitoring of both the surface operations and the injected CO_2.

To date, more than 260 million tons of anthropogenic CO_2 have been stored underground. These storage sites, many sponsored by government grants, have been used to test and prove that that CO_2 behaves as expected. A great deal of work has been done within the global CCS community to develop accepted monitoring and verification requirements for the safe and permanent storage of CO_2 underground in conjunction with government, private enterprise, and environmental NGOs. These processes play a vital role in ensuring storage practices meet operational, regulatory, and community expectations.

Companies with expertise in the sub-surface produce monitoring and verification (MRV) plans that use historical data and modeling to predict how the CO_2 will act sub-surface. These demonstration sites have enabled researchers to compare actual results to the submitted MRV plans pre-injection and verified the overlying cap rock keeping CO_2 contained. Additionally, monitoring of soil, groundwater, the air around the sites, etc., have proven that the risk of leakage is extremely low.

This experience with storage has helped build a body of legal and regulatory frameworks worldwide to govern the safe and permanent storage of CO_2. While governments, industries, and environmental NGOs are still working to develop common CO_2 monitoring standards, the work done to date has proven that CO_2 storage is safe and a necessary component of climate change mitigation. For more information on this topic, see this Institute webinar: *CCS Talks: All you need to know about CO_2 Storage*[ii].

While all this information has helped to build a body of data to use for regulatory development, there are still challenges that persist to commercial deployment of CCS related to storage. Two challenges related to storage are liability and pore space rights.

There is ample evidence of the safety of storage, but regulatory frameworks still must make clear which party owns liability for leakage during the project lifecycle – from the start of injection until post closure. A variety of mechanisms have been employed in the US that vary by state including, but not limited to, states assuming liability post-closure and states that require financial security for projects. The ultimate "financial costs" of these regulations varies by state and could affect deployment, where the cost is perceived as higher than associated risk.

Another challenge is the allocation of pore space rights. In the United States, subsurface ownership rights can vary between, with different parties owning the pore space and mineral estates. This certainly results in project complexity and has the potential to generate additional liability concerns.

Regulatory issues related to storage certainly have the potential to be limiting factors for accelerated project deployment.

Carbon dioxide management has the potential to be a billion, perhaps trillion, dollar industry with immense opportunities for job creation. The US job market possesses the business capabilities to commercialize geological storage. The majority of the 260 million tons of geologically stored anthropogenic CO_2 has been in the US and used for EOR by the Oil and Gas (O&G) sector. The O&G industry, including service companies, with experience in modeling the subsurface, applying for injection permits, building and, operating monitoring wells, was responsible for this storage.

This expertise is driving the thinking of many in the O&G sector. The necessity for CO_2 management is increasingly propelling business model transitions. Companies demonstrating their strategic commitment to moving their assets and expertise toward supporting a low-carbon economy are already becoming much more attractive to investors and can avoid asset-value erosion.

From the US's vast storage resources to its demonstrated experience of safe CO_2 storage and unrivaled business capabilities in CO_2 management, no country is better suited to be a leader in the secure and permanent geological storage of CO_2.

4. Policy risk – no party lines for CCS

Supportive policy, particularly a value on emissions, is essential to drive CCS deployment, and the US has one of the most supportive policy environments for CCS in the world.

Despite decreasing costs, CCS projects are major capital improvements that often provide no direct business value but are critical to achieving global climate change targets. In the US, 45Q creates that value, but concerns exist over future support of 45Q under different federal administrations and the ease by which corporations can access this incentive. Thanks to the hard work of a broad coalition of stakeholders, including private enterprise and environmental NGOs, 45Q specifically, and CCS more broadly, enjoys comprehensive bipartisan support in the US.

The re-tooled 45Q tax credit was passed as part of the Bipartisan Budget Act of 2018. It provides an incentive of up to $50 per ton with 45Q for pure geological sequestration and up to $25 per ton for EOR. These numbers increase gradually per Figure 3 and are limited to 12 years of credits. To qualify for tax credits, project operators must demonstrate secured geological storage as defined by the Internal Revenue Service (IRS) guidelines.

TYPE OF CO_2 STORAGE/USE	MINIMUM SIZE OF ELIGIBLE CARBON CAPTURE PLANT BY SIZE ($KtCO_2$/YR)			RELEVANT LEVEL OF TAX CREDIT GIVEN IN OPERATIONAL YEAR (USD/tCO_2)									
	POWER PLANT	OTHER INDUSTRIAL FACILITY	DIRECT AIR CAPTURE	2018	2019	2020	2021	2022	2023	2024	2025	2026	LATER
DEDICATED GEOLOGICAL STORAGE	500	100	100	28	31	34	36	39	42	45	47	50	
STORAGE VIA EOR	500	100	100	17	19	22	24	26	28	31	33	35	INDEX LINKED
OTHER UTILISATION PROCESSES*	25	25	25	17	19	22	24	26	28	31	33	35	

*Each CO_2 source cannot be greater than 500 $ktCO_2$/yr. Any credit will only apply to the portion of the converted CO_2 that can be shown to reduce overall emissions.

Figure 3: 45Q Tax Credit[i]

Additionally, in the US, projects that sell fuel in California under an approved fuel pathway or projects that capture ambient air anywhere in the world can qualify for California's Low Carbon Fuel Standard (LCFS)[iii]. LCFS was introduced by Executive Order in 2007 and a CCS protocol added in 2018. The CCS protocol sets out guidelines by which transportation fuels whose emissions intensity has been lowered due to CCS or projects that capture carbon from the air could qualify for LCFS.

The California Air Resources Board (CARB), which under the Clean Air Act has the authority to regulate greenhouse gas (GHG) emission in California, administers the program. The market-based program sets annual carbon intensity benchmarks that fall over time. Fuels with a carbon intensity lower than the relevant annual benchmark generate credits, and fuels with a higher carbon intensity than the benchmark generate deficits. The price of these credits fluctuates but typically has been around $200 per ton[iv]. Projects that qualify for LCFS also may be eligible for 45Q, allowing project developers to stack them.

When the 45Q tax credit was re-tooled in 2018, which has resulted in at least 16 new projects announced in the US, one of the most promising aspects of this feat was its broad bipartisan support. This comprehensive support has continued to be the case as numerous other bills addressing CCS have been introduced and roadmaps developed by both parties. This commitment is vital to project developers committing to multi-year billion-dollar investments, who are searching for assurances that policymakers will not retract the 45Q tax credit even if the administration changes later in 2020. They are also hopeful that any changes to 45Q could make funds more accessible, and future policy support could offer other CCS projects incentives.

With a value on carbon via 45Q, the US is experiencing an upswing in projects, particularly those with a high concentration of CO_2 in their flue gas and corresponding low capture costs. However, policy makers from both parties understand that more is needed to support widescale deployment of CCS.

In the recent comprehensive *Majority Staff Report from the House Select Committee on the Climate Crisis: Solving the Climate Crisis*[v], carbon capture was a key component of the outlined agenda, including as a tool to address climate change for industrial emissions; as part of a commitment to decarbonizing power with natural gas with CCS a viable option for utilities; and for carbon removal solutions including direct air capture (DAC) with geological storage and bioenergy with CCS (BECCS). Recommendations included expanded funds and support for research, development, and demonstration projects, development of national clean energy standards, and utilising private activity bonds for CCS.

Multiple other bills have been introduced in Congress that would postpone the start of construction deadline for 45Q, convert the tax credits to a direct pay option, give additional support to pipelines and utilisation, and more. COVID-19 recovery plans proposed by both parties included many of these elements.

Support continues at the state level. For instance, California has its attractive LCFS, and many other states have looked at ways to support CCS. Examples of state support include local financial incentives, assuming responsibility for granting Class VI Well approval from the federal government, incorporating CCS in clean energy standards, bills that address subsurface rights, and initiatives to create pipeline corridors. State support is occurring with both Democratic and Republican governors and legislative majorities. All this points to significant and broad support for CCS, but also demonstrates areas where increased support is still required to drive more projects.

Pledges for reductions in CO_2 emissions among the private sector may prove to be as significant a driver of CCS deployment as policy. Corporate commitments to become carbon negative are becoming more prevalent. Microsoft stepped up in 2020 with plans to remove *all its historical carbon* dioxide emissions from the atmosphere by 2050. A $1billion climate innovation fund accompanies this commitment, which can finance innovation in geological storage, carbon utilisation, and direct air capture. The Microsoft fund builds on Stripe's commitments of funding $1 million per year on carbon removal technology with several investments already announced, including support for CarbonCure, Climeworks, and Carbfix.

While not all companies are ready to make such bold statements around removing historical carbon, significant emitters in the O&G, chemicals, and power generation sectors have made pledges to have a net-zero carbon footprint by 2050 or earlier. BP and Shell are just a couple that fall into this category.

These pronouncements are being closely followed by investors who attribute risk to activities that do not conform to best practices around environmental, social, and governance (ESG) management as they are an indicator of the sustainability and viability of a company. Thus, ESG ratings increasingly influence a company's bottom line, which will ensure every company prioritizes meeting these carbon reduction commitments. CCS is a necessary component of carbon reduction strategies for the O&G industry, and also large industrial companies and utilities. This necessity should drive long-lasting support for new CCS projects.

5. Counterparty risk – What is the impact of COVID-19?

Counterparty risk refers to the challenge of multi-party deals where the creditworthiness or other economic risks could affect the overall project risk. CCS projects are complex infrastructure projects that usually involve two different leading players – the emitter producing the CO_2 and the party taking the CO_2 for storage – via EOR or dedicated geological storage, or for utilization. Both businesses are reliant on the other staying operational. There could be several factors that create uncertainty – such as the competitiveness of a coal-fired power plant or an ethanol plant – that must be considered when designing a project as this risk could discourage investors.

On a macro level, COVID-19 has amplified economic risk as a global recession is driving down demand for many products, including fuels as commutes and air travel have been reduced.

But at this time, this risk has not significantly affected the pipeline of proposed CCS projects. Most deals currently have investment-grade parties on both sides of the transaction, and commercial banks are continuing their interest in CCS and the accompanying tax credits as a result of 45Q.

In the CCS community, there has been increased talk of specialized insurance products that could support any number of the risks outlined in this report, including counterparty risk. However, given the strong balance sheets of the players involved in the demonstration projects, it is unclear if they will want to bear these added costs instead of ‘self-insuring'. However, these advances in insurance are welcome as they offer risk mitigation options for more industry players of various sizes looking to develop CCS projects, which is what is needed to create a robust industry around CCS.

6. CO_2 Pipelines – new challenges in 2020

While the US has abundant geological storage resources, a vast, nationwide network of pipelines will be required to move CO_2 from industrial emitters to those storage sites. Several recent announcements have demonstrated growing resistance to pipelines, which can be attributed to adverse outcomes in the past where methane and other leaks from pipelines have had severe consequences for both the climate and local environments. These adverse outcomes have legitimately fueled environment NGO concerns over monitoring and oversight of pipelines.

The map below (Figure 4) from *Transport Infrastructure for Carbon Capture & Storage* from the Great Plains Institute[vi] outlines a vision of how super-sized pipelines could be built to create a viable CCS infrastructure network. In creating super-sized pipelines, like the recently inaugurated Alberta Carbon Trunk Line in Canada, multiple emitters could benefit from a common pipeline, lowering their costs and risks for transportation of CO_2. This infrastructure is necessary for a robust CO_2 management business model in the US to emerge.

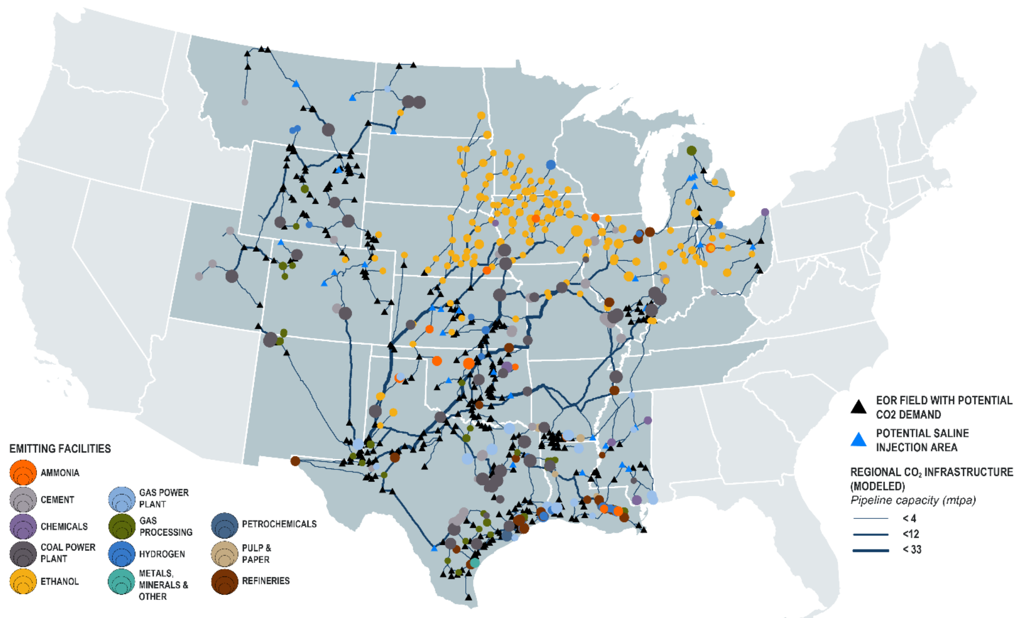

Figure 4: Optimized transport network for economy-wide CO_2 capture and storage[vi]

There is also a need for pipelines for more moderate distances as moving CO_2 by pipeline is cheaper than transporting it via truck or rail for even moderate distances. In some states, such as Texas, West Virginia, and Louisiana, public acceptance of pipelines is greater than others, like California, given the industries that have shaped those economies.

Recent announcements have highlighted how challenging the building of a nationwide CO_2 pipeline may be.

On July 6, 2020, Dominion Energy and Duke Energy announced they were canceling the Atlantic Coast Pipeline amid legal hurdles that were also driving up the $4.5 billion project costs. In the same week, a federal judge ordered the Dakota Access Pipeline in North Dakota to shut down by August 5, 2020, to conduct an in-depth environmental review. The fact that the pipeline is already operating makes this a rare shutdown, which can't help but cast doubt and concerns on future projects. This project had received an easement granted by the US Army Corps of Engineers to build a segment of the pipeline that was not covered by an Environmental Impact Statement. The court has said that the pipeline must be shut down while the report is prepared.

Despite these risks, policymakers understand that pipelines will be a critical part of a low carbon future and are exploring how to support them. The Senate passed the USE IT Act in 2019 with bipartisan support (S.383 and H.R.1166). Title III of the USE IT Act aims to foster collaboration among federal, state, tribal, and non-governmental interests to facilitate the planning and deployment of needed pipeline infrastructure to transport CO_2 for ultimate storage or beneficial use. While the House has not yet passed this act, other proposals on pipeline support at the state and federal level could be enacted as the country looks to support infrastructure growth in the post-pandemic recovery. Still, the outlook for success is not at all certain. In the meantime, projects closer to storage sites or in states with historical tolerance for pipelines will be the norm.

7. Conclusion – Progress, but more investment urgently needed

Even during a year of unprecedented global turmoil, commitment to climate mitigation remains strong, as does the CCS pipeline. Alongside CCS, achieving the goal of reducing emissions to net-zero by mid-century will require many technologies and new business models; scaling up of renewables, electrification, and grid efficiency will be necessary. The versatility of CCS's application across power, industrial, and fuel emissions will be vital in this technology's contribution to deep emissions reductions. The 16 facilities recently added to the CO_2RE database already span large scale-commercial projects across all three applications.

However, meeting global climate mitigation targets will require continued de-risking across most areas of CCS. An inter-state pipeline network, technology development for low CO_2 concentration sources and storage and legal and regulatory support for CCS are areas that still need ambitious policy support to mitigate associated risks. Further policy support will be necessary across these areas of CCS to sufficiently de-risk them and enable the continued commercial deployment of CCS. Questions over pore space and mineral rights will also need to be addressed, possibly at the state level to allow for rapid deployment.

Previous experience has shown these risks can be addressed. CCS technologies have already greatly matured and continue to progress. The development of natural gas pipelines and mineral drilling rights provide excellent precedents to what can be achieved to address pipeline and storage risks respectively.

The Institute will continue to be a resource for the investment community, in the US and internationally to work collaboratively across the public and private sectors on de-risking potential barriers to CCS to unlock investments and support for this vital climate change mitigation technology.

8. References

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