HOW CAN CCUS PLAY ITS NEEDED ROLE IN CLIMATE POLICY

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Overview

With climate concerns escalating, many are considering how to limit global temperature increase to less than 1.5 ℃ as set in the Paris Agreement in 2015. Most scenarios see a role for carbon, capture, use, and storage (CCUS) (National Petroleum Council, 2019). For example, IEA argues that to meet the Paris Agreement, 1/5 of industrial CO2 emissions or 28 gigatonnes will have to be sequestered by 2060 (IEA, 2019). Although much effort has been expended on CCUS's technical feasibility and cost, very little CO2 is yet to be sequestered (of the roughly 32 billion metric tonnes of CO2 emitted from fossil fuel combustion in 2020, only about 40 million metric tons were captured and sequestered (Global CCS Institute, 2021)). In our paper, we consider the status of existing commercial and pilot projects for sequestration to better know how far we still have to go to meet our targets and how we might get there.

There are some market forces such as investor pressure to sequester CO2. For example, ExxonMobil has committed to building a huge CO2 hub in the Houston Ship Channel (Blommaert, 2021). However, since CO2 emissions have negative externalities, markets alone are likely to fail and will sequester less than the optimal amount. Therefore, many governments are considering or passing policies to encourage CCUS. These include carbon pricing policies such as carbon emission taxes (e.g., Norway's carbon tax at Sleipner oil field) and cap and trade of emission permits (e.g., E.U. and Chinese carbon trading) or more specific policies toward CCUS (e.g., U.S. 45Q tax credits) (Global CCS Institute, 2019). One of our goals is to consider which such policies are best to meet these targets.

The paper's structure is as follows. Part II will provide an overview of existing commercial and prototype projects. Part III will survey CCUS policies, consider the pros and cons of the policies, and indicate the needed institutional framework for the policies to succeed. Cost is a crucial input into policy decision making and supporting economic modeling efforts of CCUS. In section IV, we will survey the most recent literature on costs by stage and the uncertainty around these cost estimates, while the economic models of CCUS that use such cost estimates are reviewed in part V. Part VI contains conclusions and suggestions for further work.

Methods

Literature on projects, policies, costs, and economic modeling has been collected. Within each topic, we focus on economic issues, but we categorize the topics in different ways. To date, there are about 135 CCS projects in the world, 27 of them are in operation, with 106 projects either under construction or in the development stage (Global CCS Institute, 2021). We categorize projects by region, capture type, and storage. Four main technologies are involved in capture: pre-combustion capture, oxy-fuel combustion capture, post-combustion capture, and industrial separation. Two main applications exist for storage: enhanced oil recovery (EOR) and dedicated geology.

Various existing policies and incentive programs for CCUS are in place. For example, tax credits, tax exemptions, grants, and loans exist in Canada, Australia, Europe, and the U.S., while CCUS projects are usually directly supported by state-owned enterprises in UAE, Saudi Arabia, China, and Brazil (Global CCS Institute, 2020). We present a summary of such incentive policies used around the globe, categorize them, and analyze whether the existing policies are detailed and clear enough to provide an accessible path for the future development and at scale deployment of CCUS. We then assess the current regulations and discuss if they are up-to-date and aligned with the framework needed for CCUS to help achieve the emission target.

We have collected current costs for the mature CCUS technologies - amine absorption, pipeline system, EOR, and storage in saline formations, discuss the potential for cost reduction due to adaptivity and learning rates, and compare them with anticipated costs of alternative technologies. Costs associated with uncertainties and risks for both mature and developing technologies are analyzed. The results will provide recommendations on current policies and regulations to ensure the future CCUS projects can be smoothly carried out at scale. In the limited number of economic models, CCUS may be modelled as an integrated process or one or more of the following three stages may be included: capture, transport, and storage (geological storage as well as utilization). Most are single objective optimization models to minimize cost, maximize profits, maximize oil or gas production, or minimize environmental impact using linear programming (LP), nonlinear programming (NLP), mixed integer linear programming (MIP), and network optimization models. A few models optimize over multi-objectives (e.g., cost and environmental impact). Such models can be static or dynamic, with or without uncertainty, and generic or geographically specific. We investigate whether these existing models provide adequate support for the existing policies.

Results

In looking at where we have been, we will consider what is currently considered optimal and suboptimal in each category. For example, the Terrell Natural Gas Processing Project, which began in 1972, is the oldest operating industrial CCUS project in the United States that has continuously captured and supplied CO2 for EOR. (Mantripragada et al., 2019). Alternatively, at least 6 coal-based CCUS demonstration projects have never seen the light of day from lack of funding or local opposition (Mulligan, 2020).

Efficient CCUS policies need to specifically consider the different conditions across regions, industries, and the corresponding stages of CCUS. For example, while tax credits are a well-established policy mechanism in the U.S. and great incentives for mature CCUS technologies, they are not as effective for countries at earlier stages of development. In heavy industry with international competition (e.g., cement, iron, and steel), applying CCUS technologies is especially challenging, requiring more policy interventions. In contrast, for industrial processes such as ethanol production, CCUS is a lower-cost, mature, and scalable option for capturing and reducing CO2, making it more economically viable and requiring relatively less interventions (IEA, 2021). Since models are, also often designed for a specific situation or question, model recommendations will more likely offer suggestions on which models best inform stake holders for given situations, along with any new modeling recommendations.

Our overall objective and contribution based on the information collected and analysis completed is to present the current state of CCUS to stakeholders (e.g., government policy makers, privately and government owned companies along the CCUS supply chain, interested nongovernment non-profit companies (NGOs), financial investors such as hedge funds, and society). So within our four CCUS related topics, we will consider weaknesses and strengths for different situations. Based on this analysis and where we have been, we will suggest current best practices in projects, policies, costs, and supporting modeling. Where quantitative measures are reported, we will summarize available information, provide some measure of uncertainty, note where needed information is missing, and recommend which information is most crucial for informed decision making. Where available, we will suggest promising near term incremental changes to improve CCUS as well as suggesting more innovative long-term alternatives.

Conclusions

The industry already has the technologies for all stages of CCUS, but implementation at-scale will require economic viability and public acceptance. For economic viability, the framework has to include comprehensive, compatible, and accessible financial support and regulatory guidance. For public acceptance and reassurance to reluctant investors, relevant uncertainties and concerns about safety and risks will need to be addressed. Specific policies for CCUS in different stages, industries, and regions will be needed. Further, the policies need to provide consistent support for innovation to ensure continuous scaling and cost reductions of CCUS technologies. The current costs for CCUS are still relatively high, especially for heavy industry and direct air capture. However, the technology has demonstrated an exceptional learning rate with costs having already fallen 35% in the power sector (IEA, 2020). With scaling, adequate storage space, and appropriate policy, we expect economies of scale and learning to yield even further reductions.

References

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