The Integration of Direct Air Capture in Modern Society and Industry

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Direct air capture technology is currently a novel idea that involves directly capturing the air from the atmosphere and extracting out the carbon dioxide. The carbon free air is then returned to the atmosphere and the carbon dioxide is then purified so that it can be sold. It can easily be said that the main goal of a technology like this is to combat climate change and with a new technology that has the potential to make significant impacts on the world, it is important to research and track how the technology is integrating with society and industry. This paper will seek to evaluate the integration of direct air capture technology through the framework of the multilevel perspective. It will start by setting up the landscape of how climate change has led up to the need for these types of technologies before moving on to evaluating the regimes in support of direct air capture technology and ending with those against it. These regimes will primarily include policy-making and independent companies/industries. This evaluation will take place at the state, national, and international levels, and also will make predictions for how the technology will carry on in future.

Landscape

In December of 2015, the Paris Agreement was signed by 196 parties across the globe with the long-term goal of limiting the temperature increase of the planet. All the parties agreed to assist each other financially as well as share technologies to accelerate development of direct air capture. Though there are many parties involved, removing the necessary amounts of carbon from the atmosphere to limit the temperature increase to less than $2^{o}C$ by 2050 is a major challenge, particularly if it is meant to be cost effective (*The Paris Agreement)*. To reach this goal, 10 gigatons of carbon dioxide need to be removed from the air annually until 2050 and nearly 20 gigatons a year until 2100 (Ozkan, 2021). Based upon these numbers and evaluations

of well-known direct air capture plants, Climeworks, Carbon Engineering, and Global Thermostat, Ozkan (2021) was able to give an estimation on how many direct air capture plants would be required to meet the terms of the agreement. Assuming that a typical direct air capture plant can remove one megaton of carbon dioxide a year, nearly 13,000 direct air capture plants would need to be fully operational by 2024 and this would equate to $1.7 trillion dollars in capital investment. Operating costs, depending on the type of direct air capture, can range from $94 to $249 per ton of carbon dioxide removed from the air. Though these costs are very high, they can be lowered as more efficient systems are developed and as advances in solvent or sorbent materials are made in direct air capture processes. Energy costs also need to be evaluated when talking about direct air capture technology. The average direct air capture plant with the capacity to intake one megaton of carbon dioxide a year requires about 300 megawatts of power; to use renewable energy sources, nuclear, wind, geothermal, or solar, it would cost anywhere from $250 to $690 dollars per ton of carbon dioxide (Ozkan, 2021).

Supporting Regimes

As of 2019, there exists only 11 direct air capture plants in the world, the largest of which is in the United States in Wilsonville, Alabama (Larsen, Herndon, Grant, & Marsters, 2019). Given that Alabama is in the southern half of the United States, it is not clearly obvious as to why a ‘green’ technology has had success there. Known as the U.S. Department of Energy’s National Carbon Capture Center, this testing facility was built in 2011 to evaluate the application of the capture carbon technology in natural gas and coal-based plants. The location of this facility was likely chosen as it is directly next to Alabama’s Power’s Plant Gaston, a plant with a supercritical pulverized coal unit. As a result, the testing facility has had ample opportunity for research and development of carbon capture technology, technology that directly captures carbon

from traditional coal energy production. Over the last decade of research, 37 technologies have been evaluated with eight ready for scale up testing. With the success that the National Carbon Capture Center has had with carbon capture technology, they have begun expanding to direct air capture technology (*Our research*, 2022). The success of the direct air capture facility is a direct result of testing from the emissions of a coal plant. This shows that implementation of both carbon capture and air capture technologies can occur on other coal plants as well. These coal plants can begin with the implementation of carbon capture, the more well-known and cheaper technology, before moving on to direct air capture, where their efforts will help build and guide the development of direct air capture.

The United States currently appears to be making the push for this to occur with the federal government recently passing a $12 billion dollar infrastructure bill. This intention of this bill is to provide investment to technologies that involve removing or preventing carbon from entering the atmosphere by either capturing air directly or capturing carbon dioxide emitted from smokestacks. This bill has helped promote 55 projects thus far in the United States. Of which include ExxonMobil and Occidental Petroleum constructing carbon capture facilities and the revival of a coal power plant in North Dakota by attaching a carbon capture technology to its current processes (Kusnetz, 2022). These projects bare resemblance to what we have already seen occur in Wilsonville, Alabama. The carbon capture technology is getting implemented, thus making the implementation of direct air capture technology possible in the near future.

With the United States making advancements within its borders, it is positioning itself as a major player internationally. Larsen, Herndon, Grant, & Marsters (2019) in their report cite the United States as being a major regime in direct air capture for several reasons: the United States has the potential help disperse the technology around the globe, over four billion dollars a year of

federal funding is spent on technology research, and the United States has one of the largest economies on the planet with the ability to implement policy that will influence the global markets. The authors list a few key actions the United States would need to take for direct air capture technology to get the jump start that it needs: enact and fund a comprehensive research, development, and demonstration program for direct air capture, pursue federal procurement, overcome non-cost barriers (i.e., storage), and lower the cost of investment to finance direct air capture plants and establish infrastructure.

Kusnetz (2022) is another author that notes how the development in the United States can lead it to becoming a global leader internationally. This author believes that the development in the US can lead to accelerating the decarbonization processes that other nations are trying to develop. John Thompson is the technology and markets director at the Clean Air Task Force, an organization whose goal is to decarbonize the global energy system to help address climate change. In an interview Thompson stated that he believes 'if our retrofits in the United States shave five, 10 years off the time China takes to decarbonize, that's globally significant.' This is particularly important because while the United States is slowly beginning to close coal plants, China is doing the exact opposite (Kusnetz, 2022). China will continue to increase its carbon emissions in the coming years, but if the United States is able to make strides in direct air capture technology as it is expected to, China will have an easier and cheaper experience integrating direct air capture technology than if they were doing it on their own. And this remains true for all nations trying to follow in the steps of the United States,

Having analyzed the coal industry, it is important to also look at another large polluting industry, fracking. Globally, there are temporary prohibitions on fracking in a few nations such as France, Germany, and Ireland. While nations like the UK, Spain, and China have established

timetables to phase out fossil fuel use (Newell & Simms, 2020). Over time as these nations begin to phase out fossil fuels, this will open up room to integrate direct air capture technology as the carbon from these processes can be used to make fuel in place of the traditional methods.

Recent events have shown that the fracking industry is actually recognizing direct air capture technology as a strong ally. Canada's largest oil sands companies have formed an alliance to work towards what they call the "Oil Sands Pathways to Net Zero initiative." These companies make up 90% of Canada's oil sands production. They will be working with Canada's federal government and the Alberta government to achieve Canada's climate goals. While the exact goals and methods of the alliance are unclear, it is noted that the 'vision is anchored by a major Carbon Capture, Utilization and Storage truckline.' The CO_2 captured in this process has the potential to further enhance the current oil recovery applications, thus it becomes beneficial for large fracking companies to invest in this type of technology to advance their own processes (Post, 2021). The fracking industry has also begun to recognize that attaching carbon capture devices to their processes will lower their overall emissions. This is leading companies, like ExxonMobil, to make major investments in carbon capture. ExxonMobil has proposed a plan to build a 'carbon capture hub' in the Houston, TX area. This hub is expected to cost $100 billion dollars in total and will start with a carbon capture refinery complex in Baytown, TX. Because of the large cost of this 'hub' ExxonMobil will have to seek financial assistance from the United States government, and it has been reported that ExxonMobil has been lobbying more on carbon capture over any other issue in the last year (Kusnetz, 2022).

Some other companies that have been involving themselves with direct air capture include LGT Bank, Boston Consulting Group, and Rothesay. All three of these companies are prominent in the UK in their respective fields, which are largely unrelated to process facilities,

yet have signed 10-year air capture agreements with a company called Climeworks (Tiernan, 2022). A Switzerland based company, Climeworks is one of the prominent direct air capture facilities in the world. The goal of the deal with the Boston Consulting Group is for the group to reach a net-zero climate impact by the year 2030, while it appears the LGT bank simply seeks to help Climeworks permanently remove carbon emissions from the air (Tiernan, 2022). Regardless of the exact intentions of these deals, what is prominent is that the demand for carbon removal exists. It exists even outside of the processing industry where carbon is not a major issue and that these deals will help companies like Climeworks accelerate their scale-up of facilities and expansions to new locations.

In the Asian market, a recent joint venture between 8 Rivers Capital, LLC and SK Group valued at $100 million has been formed. 8 Rivers Capital, LLC is a United States based firm who is the premier net zero solutions company for industrial level decarbonization: their decarbonization technologies span hydrogen, direct air capture, and biomass carbon removal. The SK Group is based Seoul, South Korea and is a collection of multi-national manufacturing and service companies and stand as global leaders in semiconductors, telecommunications, energy, and life sciences. The SK Group made this investment to focus on the decarbonization of its Korean and key Asian markets; this investment will help accelerate the growth of pace and scale of 8 Rivers' technology. The SK Group's overall plan is to deploy clean hydrogen and zero-emissions power projects across all of its major energy centers. This joint venture could act as a foothold for direct air capture in the Asian market; this is particularly important considering the Asia-Pacific region emits more carbon in a year than all other regions of the world combined (Cision PR Newswire, 2022).

Another unexpected industry that has made deals with Climeworks, and thus the direct air capture industry, is the diamond making industry. Aether Diamonds is a startup that seeks to create lab-grown diamonds with carbon sourced from direct air capture. Aether is capable of producing Type IIa diamonds and typically sell their diamonds from $4,900 to $10,000 (Stone, 2022). Type IIa diamonds are considered to be the most chemically pure diamonds, lacking nitrogen and boron, and only 1-2% of natural diamonds in the earth are Type IIa (Ritani, 2020). The current Aether process involves transporting carbon purchased from Climeworks in Switzerland to the US to be converted to methane to grow in a lab, then to India for cutting and polishing, before final sale in New York City's diamond district. While these diamonds are comparatively more expensive than other lab grown diamonds, Aether is powered entirely by clean energy and is pulling 20 metric tons of CO_2 per carat of diamond they produce (Stone, 2022). It can be expected that as the lab-grown diamond industry continues to grow and as Aether grows as a company and gains investment, they will be able to lower production costs and in turn lower the purchase price of their diamonds to make their products more affordable for the average consumer. This method of growing diamonds may also continue to grow in popularity as it reduces the demand for blood diamonds that many people vehemently despise.

Opposing Regimes

While the proponents of direct air capture are strong, there are also significant regimes that will act as barriers against direct air capture's development. Brudinis, Krevor, Dowell, Brandon, & Hawkes (2018) address a few of these groups. Production and storage costs were some of the few issues listed, particularly storage in nations such as China, Japan, and South Korea. They also mention supply chain and building rate; even if the intake of air was steady and the equipment to convert air to carbon was readily available, skilled labor to perform the

necessary operations are hard to come by. While there are policies that currently exist to promote direct air capture in nations like Australia and Canada, there exists concerns about the clarity and direction of the policies from major oil and gas companies. These large petrochemical companies, like BP, fear "uncertainty about investment disparities" and the impacts of these policies on their business. To these well-established companies, the risk simply is not worth the investment; these large companies largely value their profitability above all else.

The last actor that Brudinis, Krevor, Dowell, Brandon, & Hawkes (2018) talk about is the general public. The public shows to have an understanding that climate change exists, but not a clear understanding of how to combat it and which methods work the best. The general public lacks the knowledge of where the risks truly lie, and it is due to the lack of adequate communication between the experts designing the technology and the public. This leads to misplaced public concern of public investments. They believe that the investments going toward direct air capture research reduces the budget for renewable alternatives that are actually able to reduce emissions as effectively, if not better.

They also make claims that not only are there more cost-effective ways to curtail emissions, but that future carbon-removing systems will be more effective, and that investments should wait until then. They believe that the current technology allows for an 'easy out for big polluters' (*The Direct-Air Capture Debate*, 2021). As stated by Carroll Muffett, the chief executive of the Center for International Environmental Law, carbon capture technology at the moment is a 'false solution.' On the surface, carbon is being captured, but the energy used to power the technology and store carbon is taken from fossil fuels. Muffett also points out that it is particularly worse when wind and solar power are already cheaper than fossil fuels (Kusnetz, 2022). The 'easy out' remains in place so long as these large companies look good on the surface

by capturing carbon, but in reality, continue to pollute the air when looking at their processes overall. Some progressive climate groups, such as Greenpeace and 350.org, suggest that carbon capture is a distraction to allow large oil and gas companies to avoid phasing out their products (Kusnetz, 2022).

These ideas can be contributed to 'greenwashing,' or the newly coined 'carbon washing.' Fairs (2021) makes claims that companies tend to take advantage of 'vague and meaningless terminology.' Companies like to use terms such as carbon-negative, without truly understanding the meaning. This leads to false claims that are made by companies where their products are not actually carbon-negative and not even carbon-neutral. Although this is supportive of the goals of reducing the effects of greenhouse gases, it can have the reverse affects. Allowing large 'polluting enterprises' to appear climate friendly, despite the nature of their processes and the harm it creates.

Environmentalists also make the argument that this type of technology is going to prolong the lifespan of power plants and petrochemical facilities which will lead to little reduction in the nation's emissions. This technology also removes the focus on other harmful chemical emissions that all kinds of facilities can produce, not just power plants and petrochemical facilities (Kusnetz, 2022). Environmentalists are basically arguing that there is an over emphasis on direct air capture technology and that is taking away from solutions that already exist and from the problems that actually need tackling.

Other environmental impacts will arise with the chemicals used in direct air capture processes. For example, the adsorbents used in these processes can harm the environment around it, marine and terrestrial, and it can harm humans as these chemicals can be toxic and cancer

causing. Naturally, all of the safety concerns with the energy industry will be brought up as well. The concerns with energy can include resource depletion, effects on the environments and ecosystems, and harm to human life (Ozkan, 2021). With the high demand of energy needed to run plants of this nature, it could be said that direct air capture facilities will potentially face higher scrutiny as they require more power to run.

Conclusion

In conclusion, direct air capture has the potential to be a critical aspect in the future of industry. Direct air capture can be involved in a multitude of industries including oil, gas, and even diamonds, as shown in this paper. The technology still has a long way to go to prove its worth considering how expensive the technology is, that there are cheaper alternatives, and it still has strong regimes against it. Yet, direct air capture technology has some powerful actors supporting it and given enough time it may make the right advancements it needs to become the leading method to tackling the climate crisis we already face.

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