Global warming solutions: Carbon capture and storage

Hengyang Fei¹, a, *, †, and Chaoyue Zhang², b, *, †

¹Shanghai Weiyu International School, Shanghai, China
²Ulink College of Shanghai, Shanghai, China
*These authors contributed equally.

Abstract—Global warming (GW) is a severe problem that needs to be resolved, but how can scientists contribute to this issue? Carbon capture and storage (CCS) technology is a way of reducing the enhanced greenhouse effect. Here, we introduce two methods of CCS technology, including corresponding scientific proofs for each one being viable, the merits and demerits of each measure. Moreover, there are oppositions against the implementation of CCS projects. We also summarize some perspectives and possible solutions for societal opposition against CCS projects. This review will enhance the understanding of the strategies of CCS and the solutions of GW.

1 Introduction

Global warming (GW) is just realized and felt in recent years, and most of this issue is a result of the enhanced greenhouse effect. Enhanced greenhouse effect, as the main factor of GW, is to be addressed because human beings are possibly still going to live and develop on the planet Earth for five decades or even longer, and if not putting effort into solving the problem by that time the climate will be an enormous challenge that makes it difficult for humans to live above the ground. From observing the more frequent hurricanes to detecting the destruction of glaciers, the problem of GW urges human beings to focus on environmental issues and to work on finding possible solutions while minimizing the cost.

There is one way that focuses on carbon dioxide (CO₂) which is one of the carbon fluorides chlorides (CFCs) and at the same time is a greenhouse gas that plays a role in keeping the heat in the atmosphere. By reducing the CO₂ emission, we can have the enhanced greenhouse effect addressed, carbon capture and storage (CCS) is a possible way to limit the amount of CO₂ emitted into the atmosphere, to keep CO₂ under control, and ideally to convert CO₂ into useful resources.

With the development of science and technology, more and more methods have come into people's vision [1].

In this review, we introduce two approaches, including using ocean and sorbents, the pros and cons of each approach, and ways to overcome societal opposition to CCS implementation.

2 Ocean

The first method, which is the most ideal solution to capture and storage the gas is to use basic ocean water to scrub CO₂ (carbon sequestration) out of power plant fumes, as the oceans are already the largest CO₂ sinks and are still capable of more. Carbon sequestration is the process of capturing, securing, and storing carbon dioxide from the atmosphere. The idea is to stabilize carbon in solid and dissolved forms so that it does not cause the atmosphere to warm. The process shows tremendous promise for reducing the human “carbon footprint”. Oceans absorb a third of the carbon dioxide emitted each year by humans.

The first reason for the ocean to absorb so much CO₂ is that CO₂ is soluble in water and the mole ratio means the ocean can hold the same mole amount of CO₂ if it exerts no impact under the water. The biological cycle in the ocean can be seen as the second reason. Algae absorb carbon dioxide from the air and use photosynthesis to release oxygen. After absorbing carbon dioxide, algae will also release methane, an energy source for human use. The easy growth of algae makes it possible for algae to become fuel. Carbon goes in both directions in the ocean. When carbon dioxide is released into the atmosphere from the ocean, it creates what is called a positive atmospheric flux. A negative flux refers to the ocean absorbing carbon dioxide. Think of these fluxes as an inhale and an exhale, where the net effect of these opposing directions determines the overall effect [2].

2.1. Harms to the biological cycle

Colder and nutrient-rich parts of the ocean can absorb more carbon dioxide than warmer parts. Therefore, the polar regions typically serve as carbon sinks. By 2100, most of the global ocean is expected to be made up of carbon dioxide, potentially altering the ocean chemistry and lowering the pH of the water, making it more acidic. Ocean acidification threatens the growth of Marine coral reefs. Coral reefs are made up of the bones of polyps of
the order stony coral. These bones are mainly made of calcium carbonate. The tips of the coral are growing on the bones of dead polyps. Many other creatures that live on coral reefs also have skeletons made of calcium carbonate, and they also contribute to the formation of coral reefs, but the polyps are the most important. Especially in places where the waves are strong, structures made by polyps are predominant. They thicken the reef layer by layer, giving the reef its structural strength. Crustaceans attach to the coral to further strengthen the reef, preventing it from being destroyed by waves. These carapaces tend to form a protective layer around the edge of the reef. This indestructible structure is eroded by carbon dioxide, a gas in the air that dissolves in seawater to form carbonic acid. The carbonic acid increases the acidity of the ocean, making corals and crustaceans unable to get enough calcium carbonate to build their shells, thus impeding their normal growth and even death [2].

2.2 Harms to people

Many crustaceans that humans like to eat, such as abalone, mussels, and oysters, depending on the seawater to provide enough calcium carbonate for their shells to grow. And high levels of carbon dioxide accumulation not only inhibit the growth of these organisms but even high acidity seawater can erode their shells and kill them. Coral reefs near the coast are a natural breakwater, absorbing and dispersing the force of the pounding waves. With the acidification of the ocean, the degradation of coastal coral reefs is particularly serious, especially those close to areas of human activities. At the same time, the massive exploitation of coral by human beings to make lime further causes devastating damage to coral reefs. In Wenchang County, Hainan Province, the coast has retreated by more than 200 meters due to the exploitation of coral reefs, causing a large number of coconut trees to be dumped by the sea. The shores of Bangtang Bay suffered severe erosion and rapid retreat, with the shoreline receded 230 meters inland in just 10 years at an average rate of 20 meters per year. The sea hit the village, causing serious economic losses. Dozens of families moved. At this rate, within three to five years, Gangmen, Langtang, Nangang, and other villages near Bangtang Bay will be eroded by the sea. Under the action of hydrodynamic force, a large amount of sediment eroded by seawater enters the bay with the tidal current, and some of it falls and silts in the main channel of Qinglan Port, causing serious silting in the main channel. The Qinglan port, which used to be capable of handling 5,000-ton ships, is now restricted to ships of less than 1,000 tons. Due to the indiscriminate exploitation and indiscriminate excavation of coral reefs, the homes for the survival of marine animals and plants have been destroyed, and many coral reef fish and shellfish resources have decreased sharply. Coconut forests onshore are seriously damaged along with coastal erosion, and the value of the coastal tourism landscape is greatly reduced.

2.3 CO2 in the soil

Carbon is also highly sequestered in soil by plants through photosynthesis and can be stored as soil organic carbon (SOC). Agroecosystem can degrade and deplete the SOC level but this carbon deficit opens up the opportunity to store carbon through new land management practices. Soil can also store carbon as carbonates. Such carbonates are created over thousands of years when carbon dioxide dissolves in water and percolates the soil, combining with calcium and magnesium minerals, forming “caliche” in the desert and arid soil. Carbonates are inorganic and can store carbon for more than 70,000 years, while soil organic matter typically stores carbon for several decades. Scientists are working on ways to accelerate the carbonate forming process by adding finely crushed silicates to the soil to store carbon for longer periods. While forests are commonly credited as important carbon sinks, California’s majestic green giants are serving more as carbon sources due to rising temperatures and the impact of drought and wildfires in recent years. Grasslands and rangelands are more reliable than forests in modern-day California, mainly because they do not get hit as hard as forests by droughts and wildfires, according to research from the University of California, Davis. Unlike trees, grasslands sequester most of their carbon underground. When they burn, the carbon stays fixed in the roots and soil instead of in leaves and woody biomass. Forests can store more carbon, but in unstable conditions due to climate change, grasslands stand more resilient.

3 Sorbent

Another way of capturing carbon dioxide is to apply sorbents that ideally can be designed and constructed to make full use of their characteristics [3].

3.1 Characteristics

For better use of the sorbent, here are some characteristics that this sorbent should ideally have [4]:

First of all, the sorbent should have a porosity that allows carbon dioxide to freely pass through the pores to undergo diffusion and create a room for free gas exchange so that the sorbent can absorb carbon dioxide with the highest efficiency [5].

Then, the sorbent ideally should have a high capacity of carbon dioxide. This enables the sorbent to capture more carbon dioxide per mile. The higher this capacity is, the more efficient the sorbent is, all else being equal [6].

Because of the risk of carbon dioxide leaking out, the sorbent should therefore be able to be used over and over again at least 1000 times which means the sorbent can capture carbon dioxide back. At the same time, the sorbent should be able to construct at a low cost which decreases the difficulty of constructing sorbent so that it can be put into wide use [7].

The sorbent should ideally keep its function of capturing carbon dioxide under a sudden rise and fall of temperature, humidity, and pressure. For an ideal sorbent, it should capture carbon dioxide infinitely selectively [3].
For these characteristics, some main challenges need to be overcome simultaneously. One of them is that a huge amount of sorbents is required to outweigh the enormous carbon dioxide emissions, which is a big challenge because the sorbent should be of very low cost to construct. Another challenge is that to realize reusability, selectivity, and high capacity at the same time [3].

3.2 Advantages

The sorbent can be achieved with a relatively low cost although the construction is not yet cheap enough to be an ideal sorbent, as well as the sorbent can be developed and improved with further research and experiments taking place in the future to reduce the cost in practice. Moreover, applying ideal sorbents to capture and store carbon dioxide is a sustainable method because of its infinite selectivity and the ability to repeat the process for a long period [8].

3.3 Disadvantages

There are many difficulties in designing an ideal sorbent because an ideal one would include all six characteristics as listed and explained above. It might also take too long to resolve the enhanced greenhouse effect by the time an ideal sorbent is finished designing and ready to be put into use. The third is that in practice, it is usually not sustainable because of the high cost [3].

4 Societal opposition

After having considered the scientific ways, here come some social issues. One difficulty in applying CCS technology, according to the articles we have seen through, is that many measures need to be implemented widely in cities and even within the regions of housing estates. Citizens have never heard of such processes which cause worries about security insurance, as a result, these measures are very likely to be opposed. One research (Alexey et al., 2020), however, suggests a variety of possible methods of educating stakeholders about the purpose of CCS technology implementation as well as the advantages of implementing CCS technology to raise their awareness on this topic [9].

The root aim of preventing carbon dioxide from being further emitted is to improve the surrounding environment of human society. Interacting with stakeholders is a very important step to take while taking into consideration the characteristics of target stakeholders: income level, age, gender, and social status. It is necessary to know the features above for the benefits of developing a strategy for the popularization of CCS technology. For example, people on a higher income level tend to have more sources of information and from that, those will need more information from the project to be convinced. They generally have more time and resources, and their children can get a good education in schools from which the idea of enhanced greenhouse effect is introduced to a certain extent. By contrast, the working class theoretically has less time at their disposal for things other than their work, which means they need to know a general frame from us to have a rough picture of the issue of GW [9].

Level of education more or less means how much do people know about the harm of greenhouse gas emissions. For instance, people who have a high level of education tend to know more about the hazards of greenhouse gas emissions and the idea of GW. Therefore, for those people, we should provide more information to convince them that CCS technology is necessary to be implemented. Another case is that when there is a low level of public awareness on CCS projects, stakeholders would choose to believe in the most trustful authority in the project. Stakeholders would be more favorable to the implementation of CCS [9].

To have concerns on local stakeholders is also required as implementations of CCS technology predictably negatively affect the locals the most in their daily life. Therefore, their needs should be investigated and to some extent should be met as well. Analysis of suitable applications on a local basis. At the same time, convincing the local authority can be helpful as well, because it makes stakeholders more favorable to the popularization of CCS technology. Along with corresponding merits and demerits, here are some methods of letting stakeholders know what CCS projects are [9].

Lectures and speeches taking place in schools about CCS projects allow creative thoughts to be heard and at the same time, there is communication with questions and answers which allows the project to be understood better. However, for disadvantages, there is only a simple kind of listener, making the presentation less broadly functioning. Founding websites is a good way of providing information and general knowledge on CCS projects, which has convenient and permanent access to information. On websites, it is also possible to update the latest news which allows a wide range of problems to be covered. On the other hand, for stakeholders who cannot get online resources, that information might not be available [9].

Information centers on a local site provide long-term access to information and the room for other events such as lectures to take place. By contrast, there is not a variety of people of different characteristics necessarily and it costs a lot to maintain the center as well. One possible event is to have meetings with stakeholders to talk about CCS projects. It is able to cover a broad series of problems and at the same time, some suggestions from the stakeholders can be helpful to improve the events and strategy. Nevertheless, there is a limited range of audiences and it can be difficult to meet every aspect of the CCS projects [9].

5 Conclusion

In this review paper, we have introduced two potential solutions to global warming. We have analyzed both methods of CCS with their characteristics, advantages and disadvantages. Furthermore, we also suggest some possible difficulties in actual application of CCS projects, including societal oppositions, corresponding analyses and solutions to them. Global warming is to be resolved and this review has the purpose to help collect a few facts, start to understand the effort in previous period of time and
update previous information.

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