Experimental Design Diagram

Nawah Ahmad, Jennine Faruque, and Sejal Sharma

November 11, 2021

Rationale

A readily increasing concentration of carbon dioxide in the environment has led to the major threat of the greenhouse gas effect. Excessive carbon dioxide essentially traps the sun's heat energy, increasing the overall temperature of the Earth and its atmosphere. This has resulted in changes within the Earth's climate that are predictably harmful for the future of this planet. However, many political leaders have not been taking this issue as seriously as they should be. There are various misconceptions regarding the effects of climate change, one of them being that the high levels of carbon dioxide are not increasing the temperature in the atmosphere. The goal of this project is to address and refute this misconception by building a model of an effective direct air capture system and evaluating its effects on the temperature in the atmosphere.

A 2006 article compares various carbon dioxide storage systems including: biological, oceanic, and geologic storage systems. Biological carbon dioxide storage has received the most attention in the environmental field. Another potential storage system is the oceanic storage system, which is seen as a potentially dangerous method, due to the ecological impacts of CO_2 in the ocean. This article finally establishes geological storage as a novel field requiring further research, which our project aims to address (Verma et. al 2006).

Supporting our proposed engineering design, there is a 2021 article that is centered around the effects of direct air capture (DAC) systems on carbon dioxide emission removal from the atmosphere. Climeworks, an organization in Switzerland, was one of the first groups to build a novel DAC system (Climeworks Latest Direct Air Capture). Through this system, carbon dioxide is separated from the atmosphere using amine adsorbents. An important aspect of DAC systems involves the practice of storing CO_2 underground and changing it to stone (Evans, 2019).

Moreover, a 2010 article elaborates on the specific technology used to separate carbon dioxide from flue gases (chemical byproduct of combustion reactions). The researchers used membrane gas absorption technologies for their research goal. Their method involved a fiber membrane contactor. Their methods provide a basis for the most effective CO_2 separation technologies (Zhang et. al, 2010). Our research project plans to employ these technologies within the Direct Air Capture system.

Additionally, a recent 2020 article highlights various studies done in Illinois using carbon capture storage methods to limit carbon emissions in the atmosphere. In one of their projects, data analysis was performed using seismic monitoring, through which the geographic terrain was analyzed to monitor the depth at which the carbon dioxide was buried underground. Their methods of data analysis provide a basis for how the storage of carbon dioxide in our proposed model can be examined (Dunlap et. al, 2020).

Ultimately, the purpose of this study is to address the misconceptions regarding climate change by engineering a system that reduces carbon emissions; hence, decreasing the atmospheric temperature through direct air capture. This project also aims to address the gap within research about geological storage of carbon dioxide. The implications of this project include a greater public awareness of the validity in climate change research.

Question and Hypothesis

Question

The scientific research question is the following: What is the effect of a developed carbon capture and removal system in an environment on the temperature cooling rate of that environment?

Engineering Goals and Expected Outcomes

We expect to observe a direct relationship between the removal of carbon dioxide and the decrease of temperature in an environment.

Hypotheses

The scientific alternative hypothesis is:

If carbon dioxide is captured and stored incrementally in a modeled Direct Air Capture environmental system, then the temperature levels in the atmosphere of the model will simultaneously decrease.

The scientific null hypothesis is:

If carbon dioxide is captured and stored incrementally in a modeled Direct Air Capture environmental system, then the system will have no effect on the temperature levels in the atmosphere of the model.

Materials and Research Methods

Materials listed

- LabVIEW software
- Glass enclosure
- Fan
- Thermocouple
- Carbon Meter
- Plastic container
- Ambient air
- Filter

Methods listed

A system will be created that will successfully capture and store CO_2 emissions in an enclosed glass environment. By January, we will begin to develop a physical carbon capture and storage system or will create a 3D model of the system, which will then go through preliminary trials to determine if CO_2 is being effectively collected. In a physical model, ambient air will travel through the system using a fan, then pass through a filter that chemically binds the CO_2 to it. The concentrated CO_2 on the filter will then be stored in a separate plastic container, and the free air will exit the system. After the overall effectiveness of the system is determined, actual testing on the effect of carbon removal on atmospheric temperatures in the closed environment will take place.

During this second round of testing, there will be two environments that will be tested. In the first environment, the initial temperature before carbon removal will be recorded, as well as throughout the entire carbon removal process using LabVIEW software. In the second environment, the temperature will be recorded throughout the trial period without the use of the carbon capture system.

Data Analysis

The primary data in this experiment will be analyzed through a software called LabVIEW, also known as Laboratory Virtual Instrument Engineering Workbench. In the preliminary dataset, the system's functionality will be tested based on the amount of carbon dioxide captured and stored in the modeled environment. We will analyze effectiveness of our created capture system, with which the CO_2 levels of the modeled environment will be determined based on the amount that will be either captured or released. This will be measured with a carbon meter, and the output will be recorded with the attained values.

Additionally, methodologically, the carbon levels entering the system after the preliminary testing will be maintained through the cylinder of CO_2 that will be purchased. As a varied amount, this carbon dioxide will be included in the final data's results as the independent variable. As the quantified dependent variable, the rate of change of temperature will be analyzed through the software LabVIEW. This will be in a continuous stream that will relay the temperature to the software as the Direct Air Capture process is occurring.

Additionally, as a means to measure the statistical significance of the system, either an analysis of variance or a correlational statistic will be used to determine the existence of a relationship between the carbon dioxide levels and the temperatures in the modeled environment.

Risk and Safety

A potential concern for safety is the management of the carbon dioxide bottles that will be used in the experimentation. They need to be used with caution, as large amounts can result in headaches and dizziness (Cunha, 2021). To prevent this, any CO_2 handling will be approved fully before implementation into the modeled environment and its mechanisms. There are no other human behavioral risks associated with this experimentation.

References

ClimeWorks. (n.d.-a). *Climeworks latest direct air capture plant*. Climeworks.com. https://climeworks.com/orca

Cunha, J. (2021). Carbon Dioxide (CO2) Poisoning: Symptoms, Uses, Harmful & Scuba Diving. Retrieved 11 November 2021, from https://www.emedicinehealth.com/wilderness_carbon_dioxide_toxicity/article_em.htm

Dunlap, L., Krupnick, A., & Gonzales, V. (2020, May 6). Carbon Capture and Storage 101. Retrieved October 20, 2021, from https://www.rff.org/publications/explainers/carbon-capture-and-storage-101/

Evans, S. (2019, July 22). *Direct CO2 Capture Machines Could Use "A Quarter of Global Energy" in 2100*. Carbon Brief. https://www.carbonbrief.org/direct-co2-capture-machines-could-use-quarter-global-energy-in-2100

Verma, P., & Stephens, J. C. (2006, May). Environmental advocacy groups' perspectives on carbon capture and storage. In 2006 IEEE EIC Climate Change Conference (pp. 1-5). IEEE.

Zhang, W., Wang, Q., Fang, M., Luo, Z., & Cen, K. (2010, March). Experimental study on the absorption of CO2 from flue gas by aqueous solutions of methyldiethanolamine+ potassium glycinate in hollow fiber membrane contactor. In *2010 Asia-Pacific Power and Energy Engineering Conference* (pp. 1-4). IEEE.