Improving Air Quality Through Carbon Sequestration in Phoenix, Arizona

Justin Francisco, Amanda Scudder, Thuan Le, Magdi Alameen, Yadira Rodriguez, Nayera Ahmed

Abstract — Carbon sequestration is the process of taking Carbon Dioxide from the atmosphere and storing it through different processes to reduce the harmful effects that Carbon Dioxide can impose on the environment as well as in cities. [3] Improving and/or implementing carbon sequestration processes in Phoenix, Arizona is very important because this city is currently the 8th most polluted city in the United States. [2] Carbon Dioxide emissions by cars, coal plants, and other systems are harmful to the environment and to the people of Phoenix's health. Sequestering some of the high amounts of Carbon Dioxide present in Phoenix's atmosphere could not only mitigate the health problems associated with pollution but can also clean up the surrounding environment. Some methods to sequester Carbon Dioxide include the implementation of scrubbing towers, storing Carbon Dioxide in special concrete, CaO and MgO-rich industrial streams, and the use of Ionic Liquid. Determining which solution will have the best effect on the city of Phoenix will be done through finding a healthy balance between the relative cost and effectiveness of each idea.

REFERENCES

[1] J. K. Stolaroff, G. V. Lowry, and D. W. Keith, "Using CaO- and MgO-rich industrial waste streams for carbon sequestration," *Energy Conversion and Management*. 2005.
(This source is about attempting to produce negative emissions through altering steel and cement processes).

[2] P. G. Billings, J. E. Nolen, L. Alexander, L. K. Bender, and Z. Jump, et al. "State of the Air Report," *American Lung Association*, 2018. [Online]. Available: www.lung.org. [Accessed: 10-Sep-2018].
(This source documents all of the air quality rankings across the United States).

[3] R. Lal, "Carbon sequestration.," Philos. Trans. R. Soc. Lond. B. Biol. Sci., 2008.
(This source explains the concept of carbon sequestration).

[4] T. Mulukutla, G. Obuskovic, and K. K. Sirkar, "Novel scrubbing system for post-combustion CO2 capture and recovery: Experimental studies," J. Memb. Sci., 2014.
(This source discusses how scrubbing towers use monoethanolamine to remove Carbon Dioxide from the atmosphere).

[5] A. Rathi, "The material that built the world is also destroying it. Here's a fix," *Quartz*, 29-Jan-2018. [Online]. Available: https://qz.com/1123875/the-material-that-built-the-modern-world-is-also-destroying-it-heres-a-fix/. [Accessed: 12-Sep-2018].
(This source talks about altering the composition of cement to intake and store Carbon Dioxide).

[6] D. Y. C. Leung and G. Caramanna, et al. "An overview of current status of carbon dioxide capture and storage technologies," *Egyptian Journal of Medical Human Genetics*, 02-Aug-2014. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1364032114005450. [Accessed: 12-Sep-2018].
(This article gives a general overview of the current technology humans possess that store Carbon Dioxide).

[7] S. Moret, P. J. Dyson, and G. Laurenczy, “Direct synthesis of formic acid from carbon dioxide by hydrogenation in acidic media,” *Nature News*, 02-Jun-2014. [Online]. Available: https://www.nature.com/articles/ncomms5017. [Accessed: 12-Sep-2018].
(This source talks about converting Carbon Dioxide into a useful product by changing it into formic acid).

[8] E. D. Bates, R. D. Mayton, I. Ntai, and J. H. Davis, “CO2 Capture by a Task-Specific Ionic Liquid,” *C&EN: WHAT'S THAT STUFF? JELL-O*, 01-Sep-2002. [Online]. Available: https://pubs.acs.org/doi/pdf/10.1021/ja017593d. [Accessed: 13-Sep-2018].
(This source discusses the capture of Carbon Dioxide through Ionic Liquid).

[9] Person, “8 future technologies for carbon capture | Carbon & Sustainability,” *JWN Energy*, 08-Mar-2017. [Online]. Available: https://www.jwnenergy.com/article/2017/3/8-future-technologies-carbon-capture/. [Accessed: 13-Sep-2018].
(This source talks about implementing metal organic frameworks into power plants in order to sequester Carbon Dioxide).

I. INTRODUCTION

- CO2 is a leading factor in climate change, and its effects are even worse in places like Phoenix, Arizona, where the heat and amount of CO2 present creates health problems for Phoenix’s residents. As such, we need to find ways to store the CO2 in a safer environment so that it is no longer in the atmosphere and cannot continue to create health and environmental problems for Phoenix.

II. STATUS OF CARBON SEQUESTRATION

- Current technologies:
    - Post-combustion: removes the CO2 in the flue gas after the combustion in power plants
    - Oxyfuel combustion: Uses oxygen for the combustion to reduce the amount of Nitrogen. The flue gas (included CO2) is removed and stored.
    - Crude Oil Recovery: using excess CO2 to inject into mostly empty oil wells, which pushes out usable crude oil from hard-to-reach places.
- Downfall for these technologies:
- Increase the cost in electricity and may lead to the corrosion in the system.
- Crude Oil: this technology is not cost-effective, and the injected CO2 can escape into the atmosphere again.
- Oxyfuel combustion: a high risk of chemical emissions

III. PROPOSED DESIGNED SOLUTION:

- Thuan Le - Concrete storage: changing the chemicals composition of the concrete. We can reduce the amount of CO2 from the chemical reaction and the heat for the process. They can also capture the CO2 from the outside by the rate of 24%. [5]
- Amanda’s Ionic Liquids sequestration design: chemically trap the CO2 by way of ammonium carbamate formation, storing the gaseous CO2 away from the atmosphere. Basically, Carbon Dioxide is reacted with ammonia and then with ammonium carbamate to produce a solid salt. This has been tested for use in natural gas operations, but I am not yet sure how this strategy will be of use outside of that application. [8]
- Magdi Alameen - CaO and MgO-rich industrial streams: Ca(OH)2 and CaO from steel slag or concrete wastes can be dissolved in water and reacted with CO2 in the atmosphere to capture carbon in the form (CaCO3). [1]
- Nayera Ahmed- The direct catalyzed hydrogenation of formic acid from carbon dioxide while later reducing the formic acid into methanol which can be used as a fuel is an efficient way to reduce CO2 from the atmosphere while converting it into fuel. [7]
- Justin Francisco - multiple scrubbing towers, or artificial trees, can be set up around the city of Phoenix whose sole purpose is to sequester Carbon Dioxide. The system works by intaking Carbon Dioxide and capturing it via

monoethanolamine, and then stripping away later. [4]

- Yadira Rodriguez- Metal Organic Frameworks can be installed in power plants or into vehicles to capture CO2 before it is released into the air. NOFF is the perfect type of MOF to capture CO2, that will end up with a product of water. This can allow for that water to be recycled. [9]

IV. DESIGN CRITERIA AND DESIGN PROCESS DISCUSSION:

- Our design must be cost-efficient, meaning that the cost of implementing this technology will not be too expensive. It would also have to be energy efficient. Our design must also be environmentally friendly.
- Some problems we may run into include: a) having a solution that is very inexpensive but does not sequester enough carbon to make a difference in the Carbon Dioxide levels, or b) we may find a solution that is amazingly effective at sequestering Carbon Dioxide but is too expensive to be a viable solution.