REQUIREMENTS

- Must be a modular, direct-air capture mini-plant that can both absorb and regenerate
- Must fit inside a cube that is 1-foot in length, width, and height
- Must capture the carbon dioxide from the surrounding atmospheric air, and any carbon dioxide emissions from the mini-plant must be low
- Maximum budget of $1,500 dollars
- Must be marketable as being modular
- Only run off of DC Current to allow for use of off-grid power sources such as solar or wind power
- The mini-plant must use exactly 12 Volts
- Must pull air via suction from the air inlet ballast tank into the system (air will not be pumped into the system)
- PVC tubing at the outlet must be 1/8th inch inner diameter and a 1/4th inch outer diameter to ensure proper connection with the carbon dioxide meter
- Must not smell or emit foul odor
- Temperature of exhaust stream may not exceed 75 Fahrenheit

SOURCES REFERENCED

Dutcher, B.; Fan, M.; Russell, A. G. Amine-Based CO_2 Capture Technology Development from the Beginning of 2013—A Review. *ACS Appl. Mater. Interfaces* **2015**, *7* (4), 2137–2148. https://doi.org/10.1021/am507465f.

Gambhir, A.; Tavoni, M. Direct Air Carbon Capture and Sequestration: How It Works and How It Could Contribute to Climate-Change Mitigation. *One Earth* **2019**, *1* (4), 405–409. https://doi.org/10.1016/j.oneear.2019.11.006.

Ma, C.; Pietrucci, F.; Andreoni, W. Capture and Release of CO_2 in Monoethanolamine Aqueous Solutions: New Insights from First-Principles Reaction Dynamics. *J. Chem. Theory Comput.* **2015**, *11* (7), 3189–3198. https://doi.org/10.1021/acs.jctc.5b00379.

Onyeaka, H.; Miri, T.; Obileke, K.; Hart, A.; Anumudu, C.; Al-Sharify, Z. T. Minimizing Carbon Footprint via Microalgae as a Biological Capture. *Carbon Capture Science & Technology* **2021**, *1*, 100007. https://doi.org/10.1016/j.ccst.2021.100007.

Rahimalimamaghani, A.; Ramezani, R.; Tanaka, D. A. P.; Gallucci, F. Carbon Molecular Sieve Membranes for Selective CO_2/CH_4 and CO_2/N_2 Separation: Experimental Study, Optimal Process Design, and Economic Analysis. *Ind. Eng. Chem. Res.* **2023**, acs.iecr.3c00719. https://doi.org/10.1021/acs.iecr.3c00719.

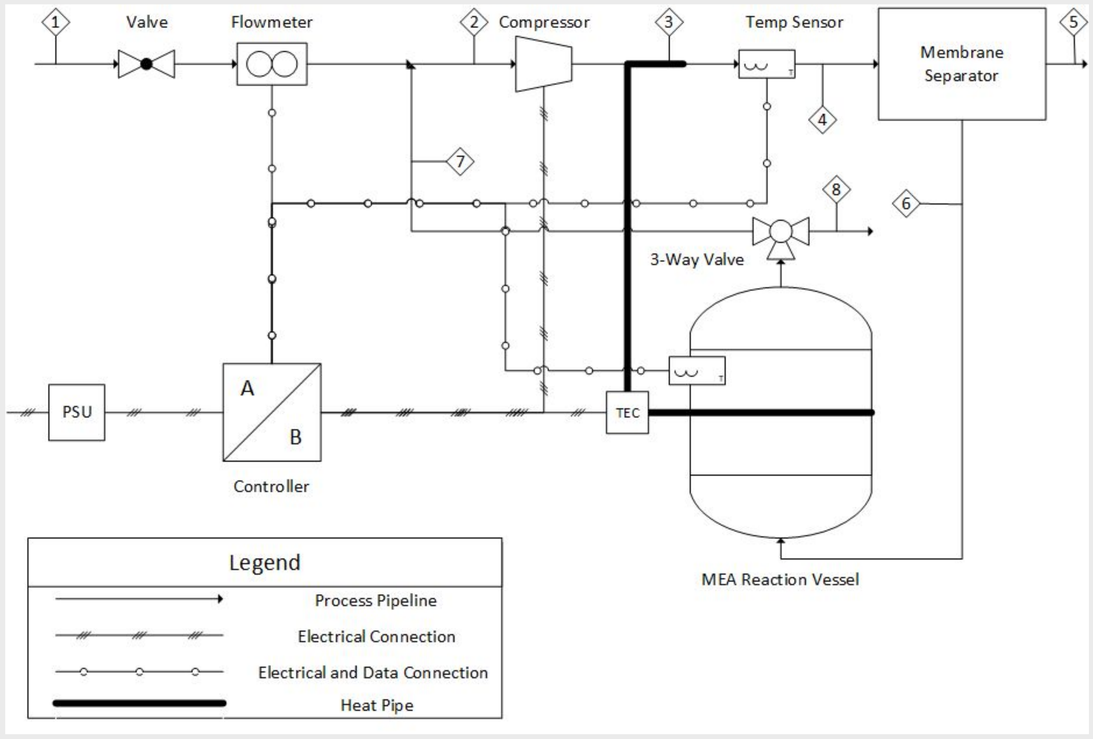
Wagner, M.; Von Harbou, I.; Kim, J.; Ermatchkova, I.; Maurer, G.; Hasse, H. Solubility of Carbon Dioxide in Aqueous Solutions of Monoethanolamine in the Low and High Gas Loading Regions. *J. Chem. Eng. Data* **2013**, *58* (4), 883–895. https://doi.org/10.1021/je301030z.

What Is Direct Air Carbon Capture and Storage (DACS)?, 2021. https://www.drax.com/carbon-capture/what-is-direct-air-carbon-capture-and-storage-dacs/ (accessed 2024-04-07).

Oregon State University

CO2 CAPTURE VIA MEA ABSORPTION

A cube able to intake carbon dioxide from the environment and convert it to clean air in a non-harmful process for the AIChE Design Competition.



APPROACH

After reviewing several strategies for direct air capture including algae photosynthesis, amine-based capture, utilizing strong basic solutions, and solid direct air capture, it was determined that membrane separation would be best.

The reasoning behind this being that membrane separation would provide a financially feasible option to use and carbon dioxide-selective membranes and MEA are relatively inexpensive. Additionally, this route is environmentally-conscious and main energy consumption would come from the compressor unit of the mini-plant as well as the thermoelectric cooler (TEC). This design also allows us to regenerate the MEA onsite by heating the MEA reaction vessel via the TEC.

FEATURES

Some features of our specific approach include the ability to easily control the flow rate via easily changing the compressor pressure which creates a way to dynamically adjust to the environment (if there is more, or less carbon dioxide present).

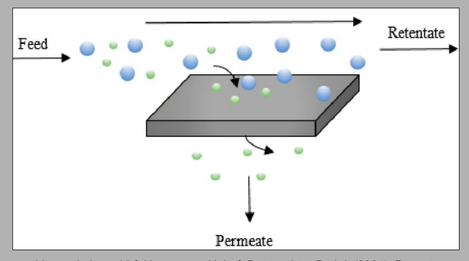
Both heating and cooling is created from the thermoelectric cooler (TEC) which means space inside the mini-plant can be conserved and saved for other devices needed as well as saving costs associated with utilizing multiple elements.

Additionally, the overall mini-plant is relatively cheap with some of the largest costs coming from the membrane. The MEA used for carbon dioxide storage can be purchased by the gallon and offers cost-efficient storage solution.

PROCESS

1. Carbon dioxide and air is sucked into the mini-plant
2. The air is moved to the compressor and warmed before moving to the membrane separator. The air being warm creates better separation of clean air and carbon dioxide
3. The air is pulled through the membrane separator where clean air will re-enter the atmosphere and carbon dioxide is sent to the MEA Reaction Vessel for storage
4. Carbon dioxide is stored in this vessel until the MEA requires regeneration

Membrane Separation Process



Vermaak, Leandri & Neomagus, Hein & Bessarabov, Dmitri. (2021). Recent Advances in Membrane-Based Electrochemical Hydrogen Separation: A Review. Membranes. 11. 127. 10.3390/membranes11020127.

ACKNOWLEDGEMENTS

A special thanks to:
American Institute of Chemical Engineers
Patrick Geoghegan, PhD

CHEME CUBE TEAM

Moises Barajas Serrano
barajmoi@oregonstate.edu
Charles “Rain” Zheng
zhengch@oregonstate.edu
Tristan Kryl
krylt@oregonstate.edu
Carly Thorkildson
thorkilc@oregonstate.edu