

Clean Crop Technologies:

Clean Crop Technologies (CCT) is a Holyoke, MA based startup with the goal of decontaminating food from dangerous fungal toxins. They use a cold plasma system and a proprietary gas mix to do this. Their current prototype has no means of recycling exhaust gases. Recycling the exhaust would reduce operating expenses and carbon emissions of the system.

Project Goals:

Design of proof of concept system for gas separation for CCT's prototype

Prototype and test the separation of CO₂ from a gas mix

Provide insights for how to integrate and scale up prototype

Design Process Overview:

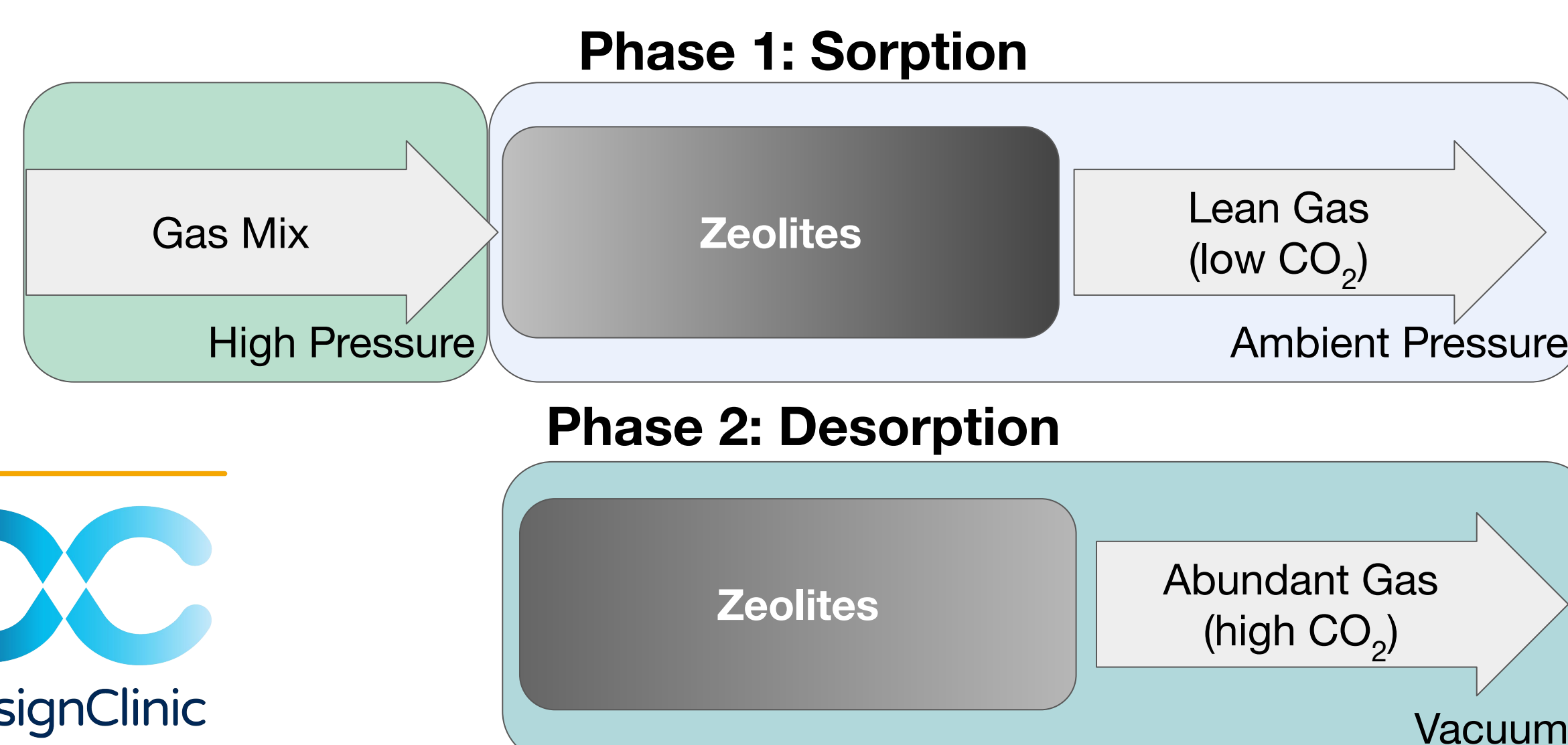
1. Preliminary Research
2. Current Methods Research
3. Conceptual Design
4. Simulation
5. Prototype
6. Final Recommendation

Prototype Design Requirements:

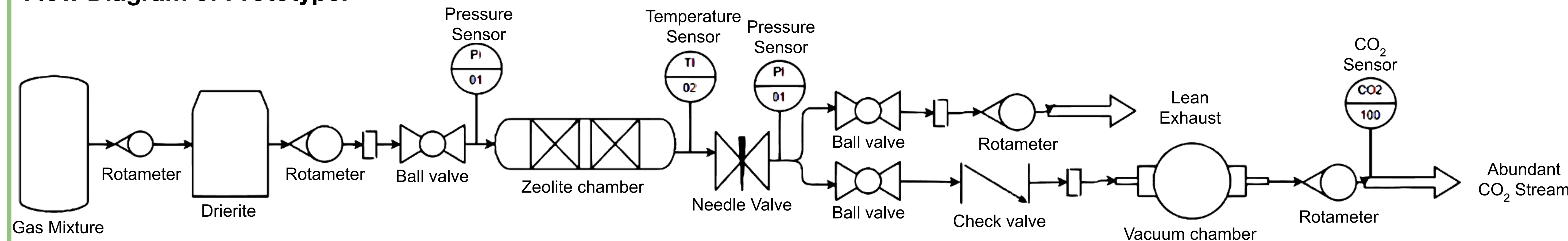
- ☒ Modular design
- ☒ Functions at CCT's flow rate
- ☒ Separates 70% of CO₂ from mix
- ☒ Separated CO₂ is 80% pure
- ☒ No gas leaks in prototype
- ☒ Doesn't affect ambient air temperature
- ☒ Doesn't affect gas mix temperature

Gas Separation and Sorption:

After in-depth research into many types of gas separation, sorption was chosen as the most viable option for this project based on availability, effectiveness, and cost. Sorption is a process by which certain types of gas, in this case, CO₂, stick to a specific material, in this case zeolite 13X. Certain environmental changes, such as a shift in pressure, triggers desorption and causes the zeolites to release the CO₂ and the gas can be isolated and recycled.



Flow Diagram of Prototype:



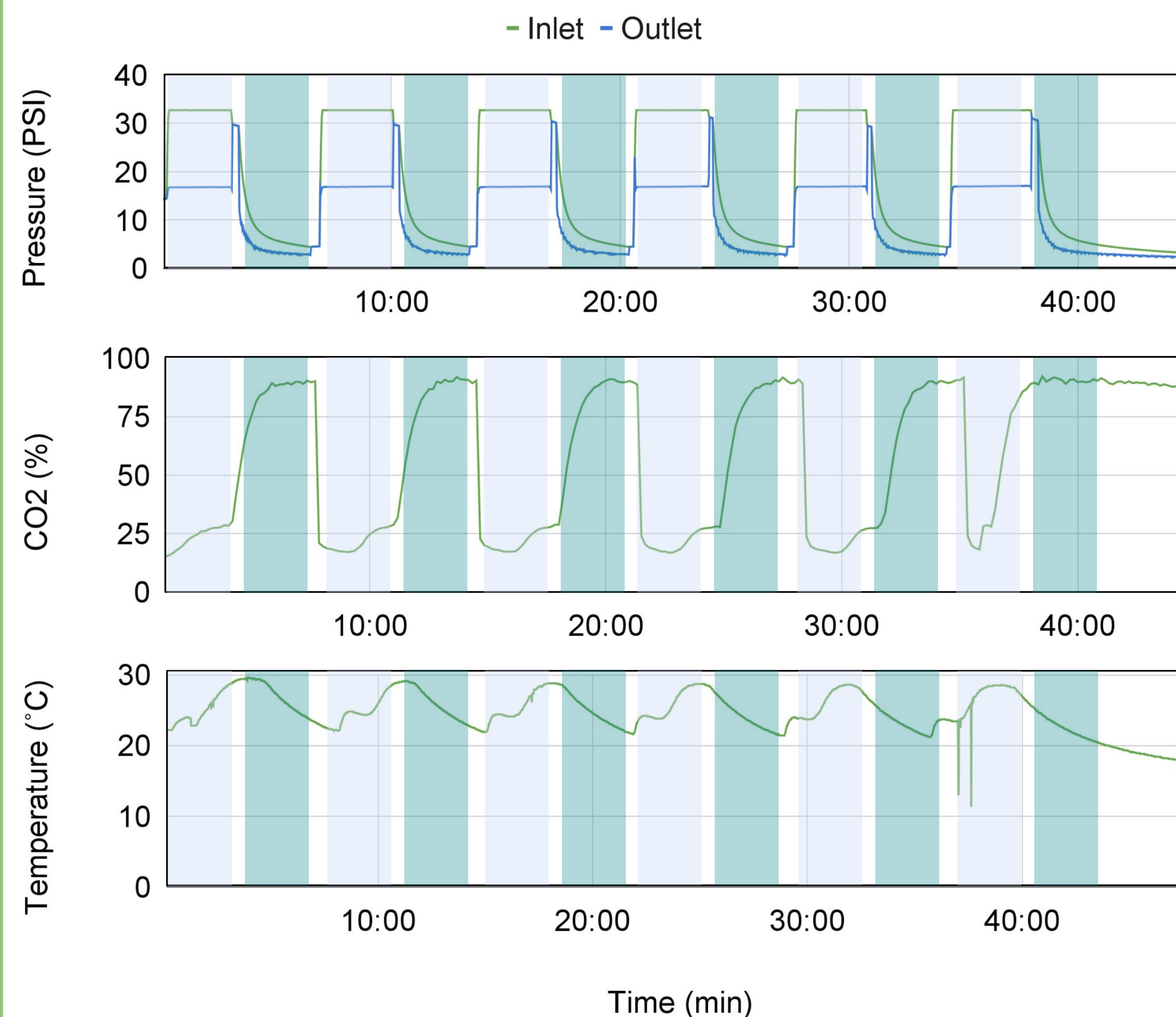
Prototyping Design:

Components of the sorption system include a chamber to hold the zeolites, drierite to dry the gas mix, valves to switch the direction of gas flow, a vacuum to trigger pressure swing desorption, and sensors to collect data on temperature, pressure, CO₂ concentration, and flow rate.

Testing Set Up:

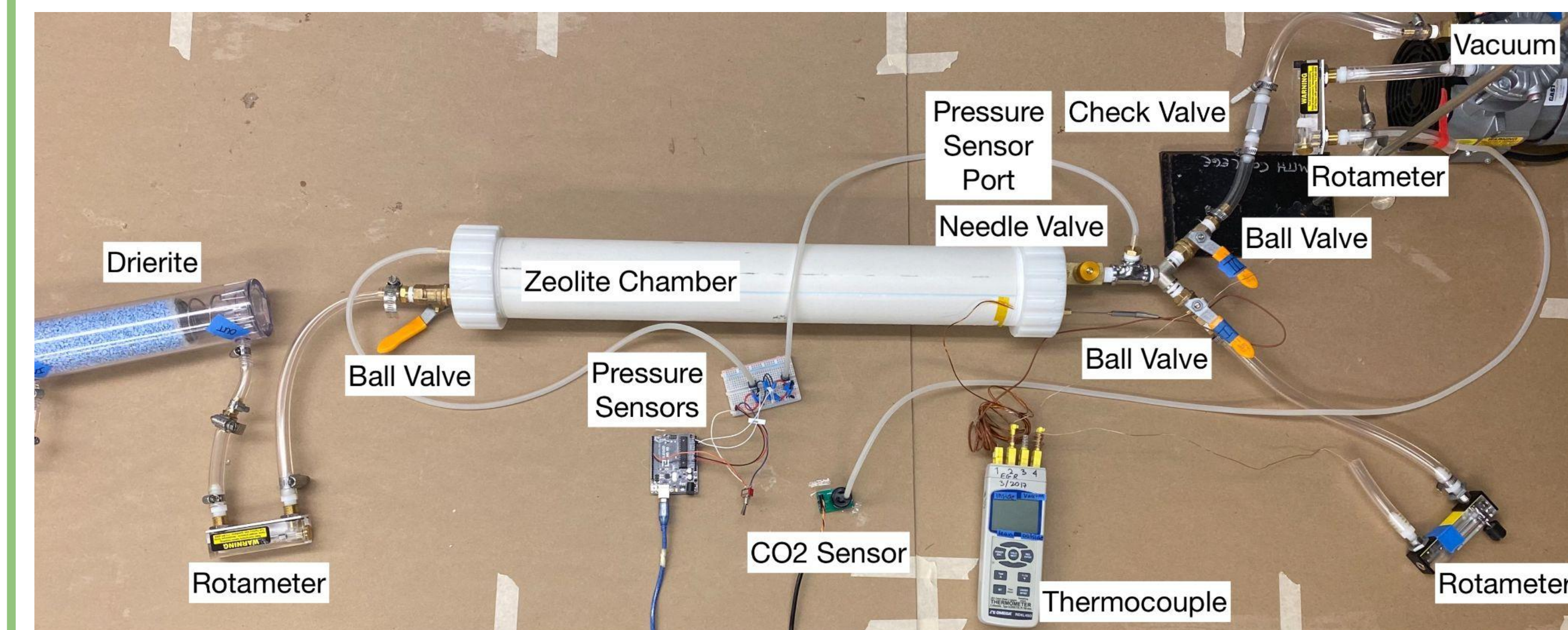
Testing was done with zeolite chambers to test adsorption and desorption.. There were three phases of testing, one to test sorption, one to test desorption, and one to test sorb-desorb cycles of varying lengths.

Results for Six Consecutive Sorb-Desorb Cycles:



The three graphs above show pressure, CO₂ concentration, and temperature data collected during a trial of 6 consecutive adsorb-desorb cycles (3 minutes adsorb, 3 minutes desorb). Adsorption cycles are marked by the lighter blue regions and desorption cycles are marked by the teal regions. These graphs show similar behavior of the gas and zeolites over multiple cycles.

Prototype:

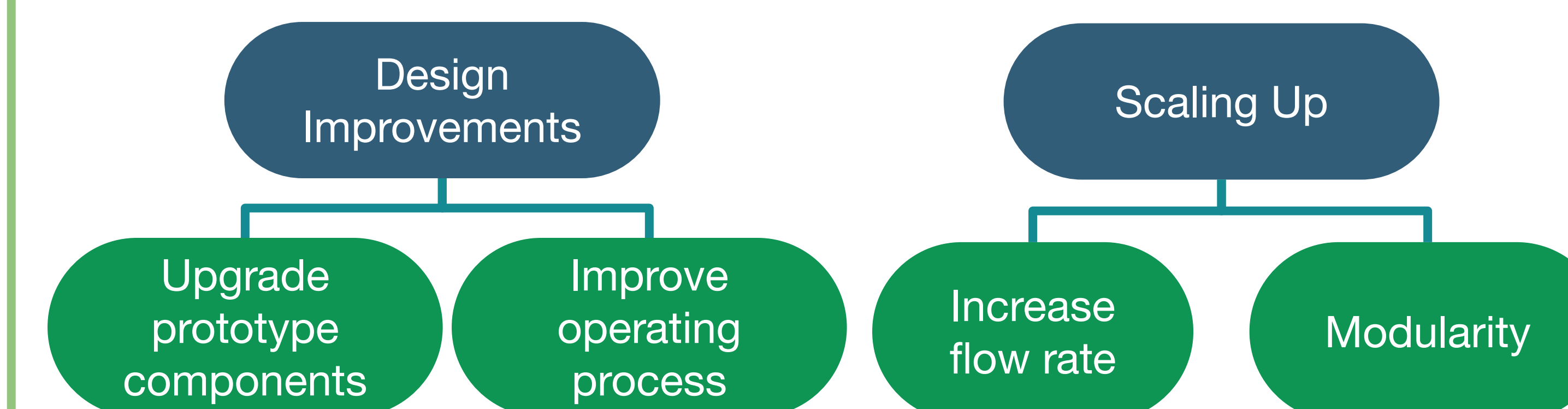


Conclusions:

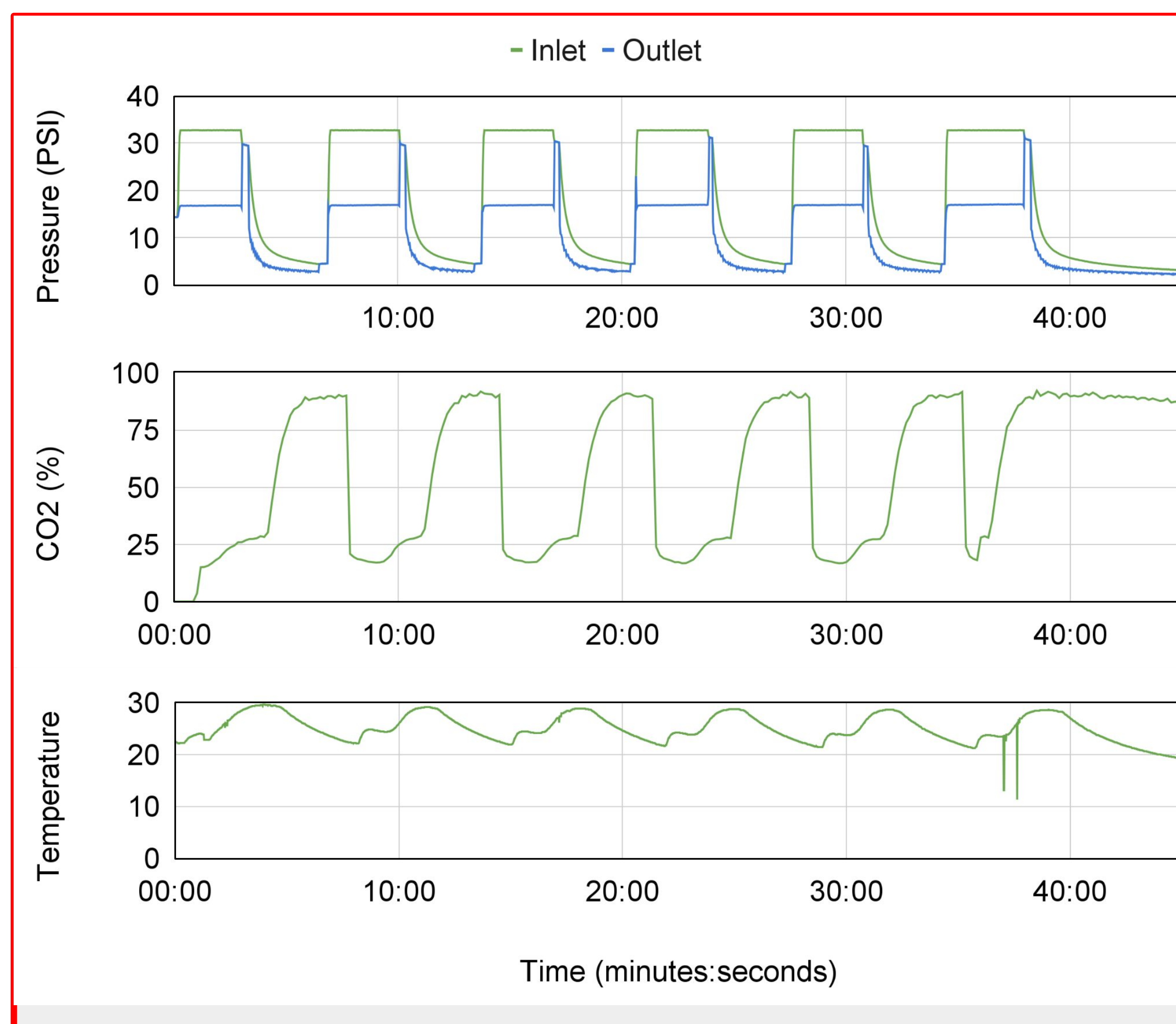
Cycle	% Mass Desorbed
1	71
2	67
3	65
4	106
5	90
6	96
Average	83

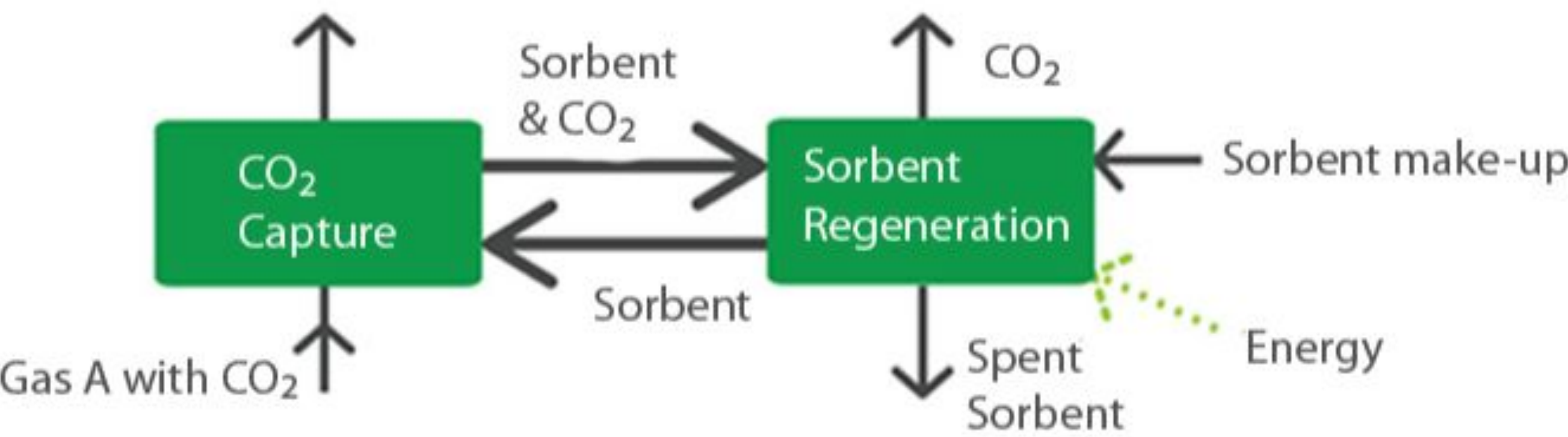
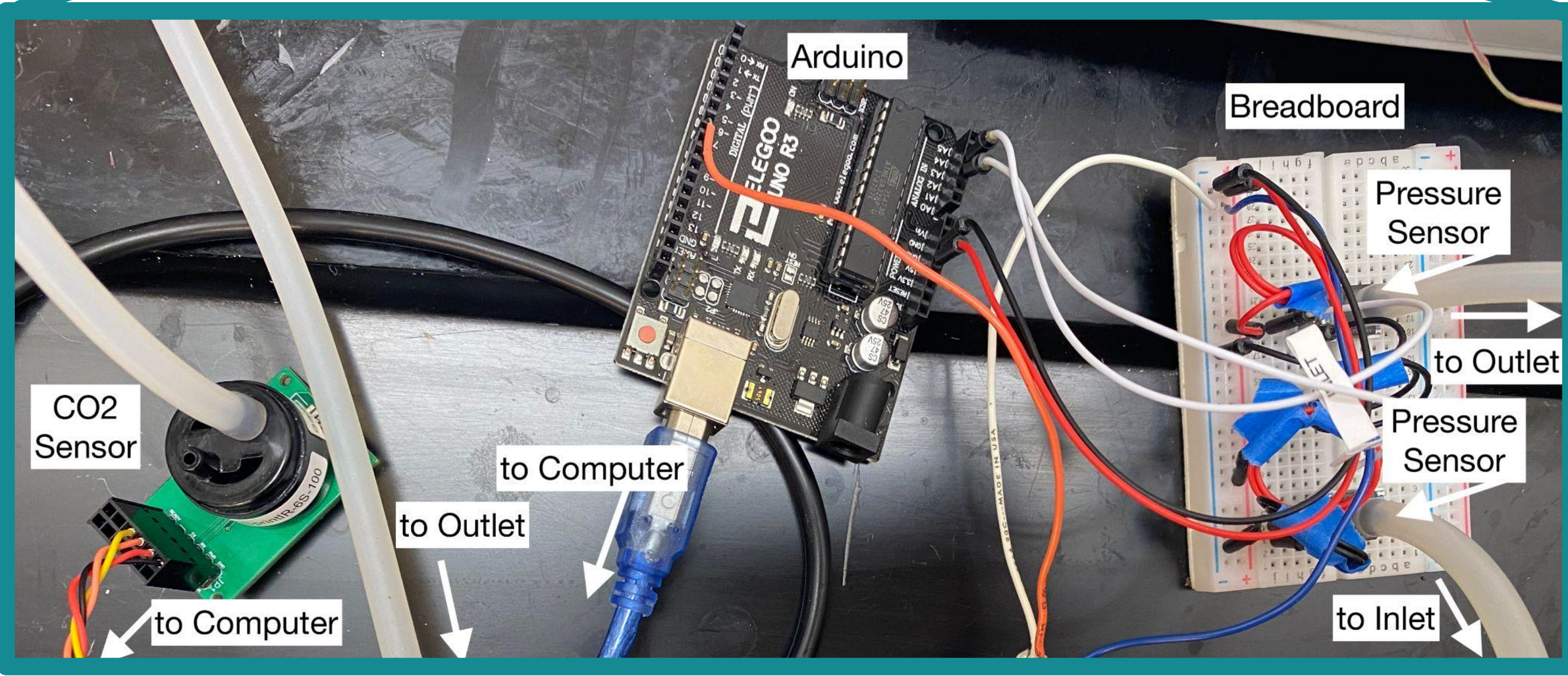
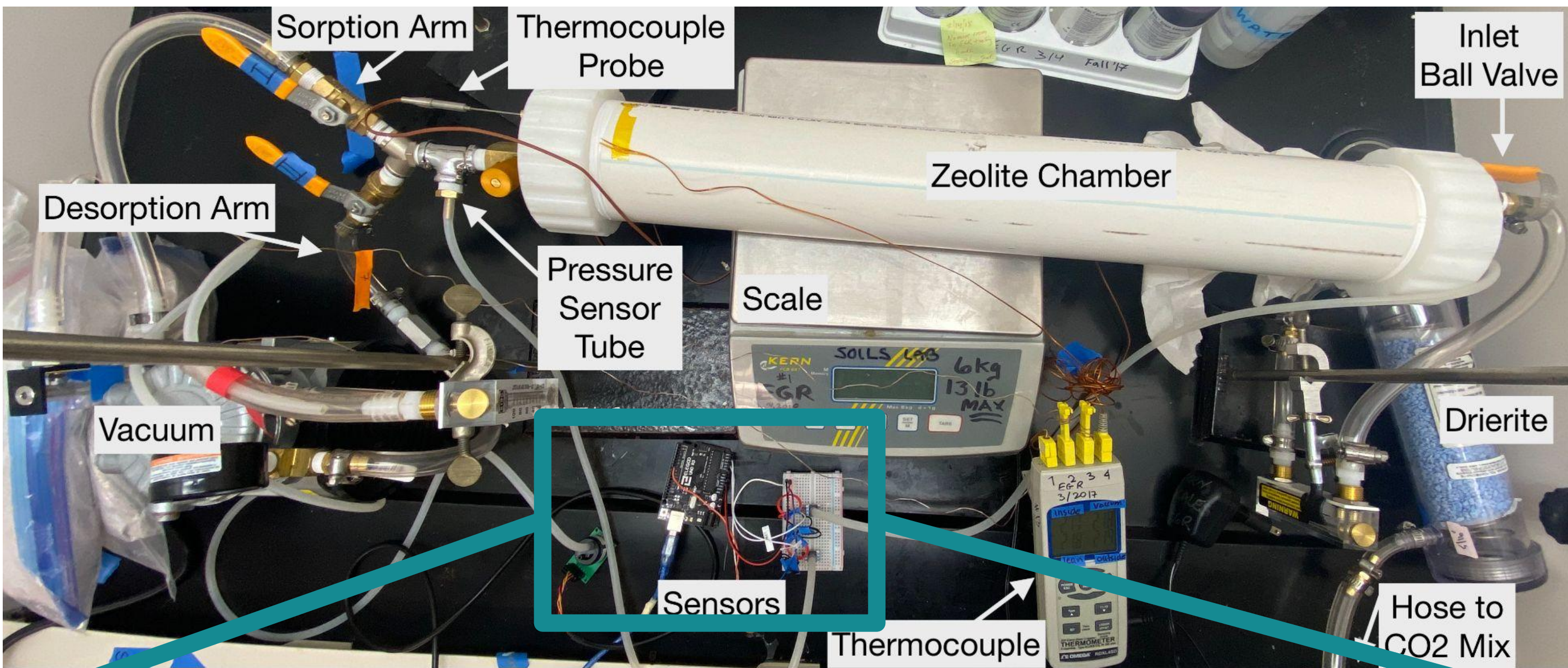
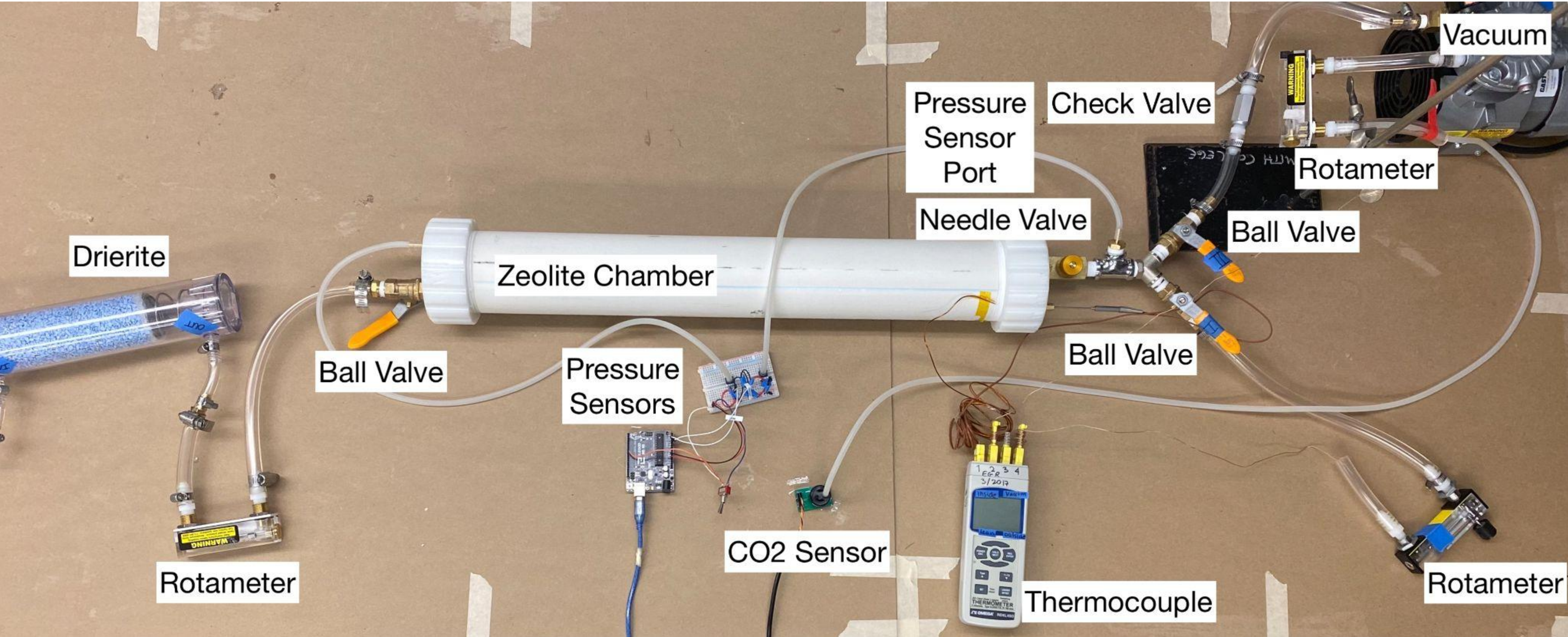
- Zeolites are able to capture CO₂ from the gas mix
- The longer chamber is more effective than short chamber
- The vacuum is able to desorb some of the CO₂ from the zeolites
- Desorbed CO₂ is about 90% pure
- Temperature and pressure change throughout the cycle, but similar trends are seen each cycle

Implementations and Next Steps:

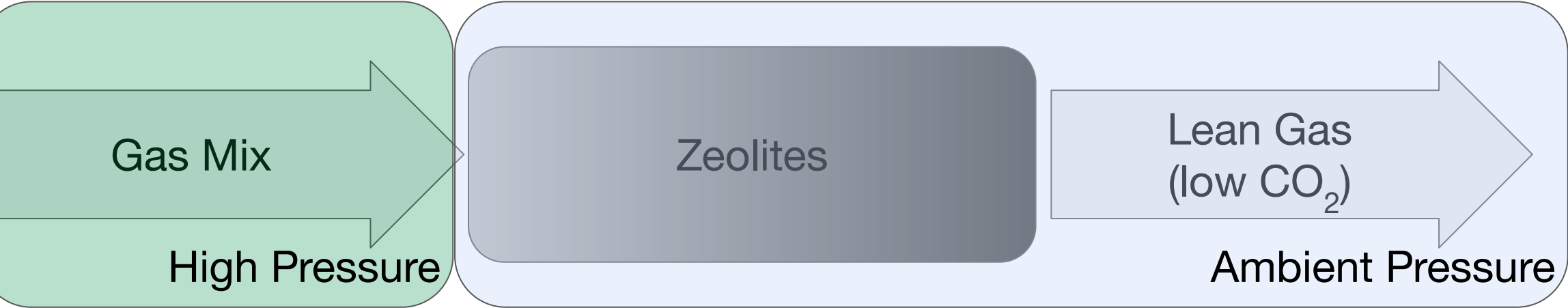


Thank you to our Design Clinic Coaches, Mike Kinsinger and Susannah Howe, our Project Sponsor Liaisons, Daniel Cavanaugh, Mike DiFrancesco, Yaqoot Shaharyar, and Lauren Steis, as well as Eric Jensen from the Smith College Center for Design and Fabrication, and the Picker Engineering Program Lab Supervisor, Sue Froehlich!





Phase 1: Sorption



Phase 2: Desorption





Design for Gas Exhaust and Recycling in a Food Preservation System

Nana Adjoa Ansah, Lilly Farah, Hannah Platter, Ysatis Tagle
Smith College, Clean Crop Technologies

Liaisons: Daniel Cavanaugh, Mike DiFrancesco, Yaqoot Shaharyar, and Lauren Steis



Clean Crop Technologies (CCT):

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Project Overview:

Proof of concept for bench-scale gas separation for CCT's cold plasma prototype

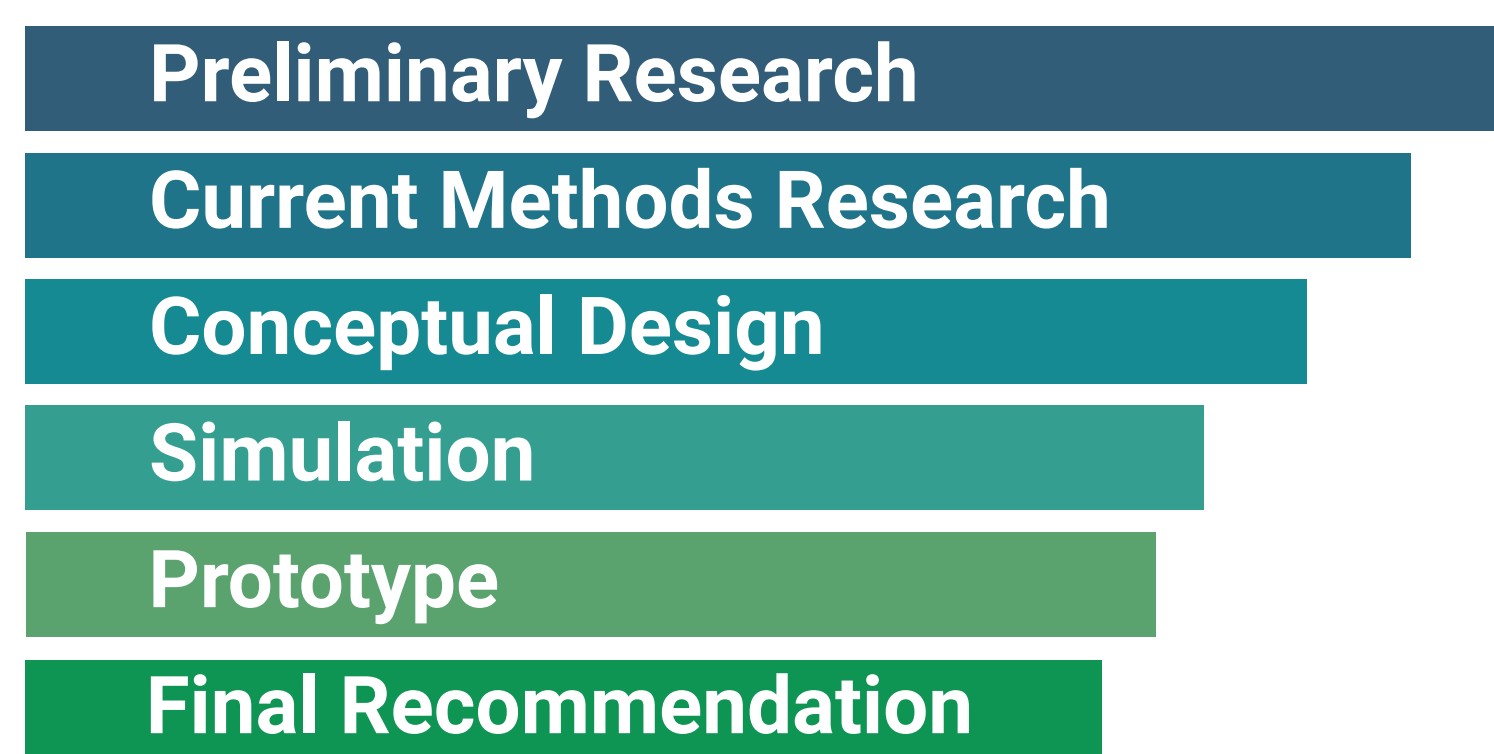
Provide insight for how to integrate and scale up prototype

Prototype and test the separation of CO₂ from exhaust gas

Prototype Design Requirements:

- ✓ Separates 70% of CO₂ from gas mix
- ✓ Functions at CCT's flow rate
- ✓ Separated CO₂ is 80% pure
- ✓ No gas leaks in prototype
- ✓ Modular design
- ✓ Doesn't affect the temperature of the gas
- ✓ Doesn't affect the temperature of the ambient air

Design Process:



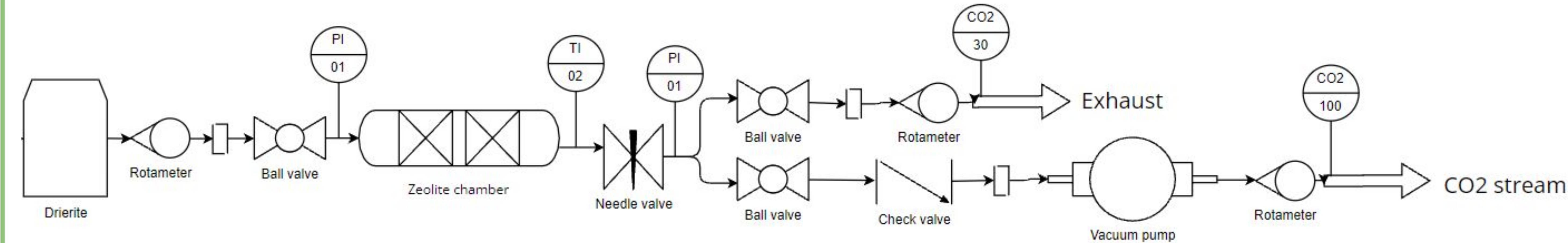
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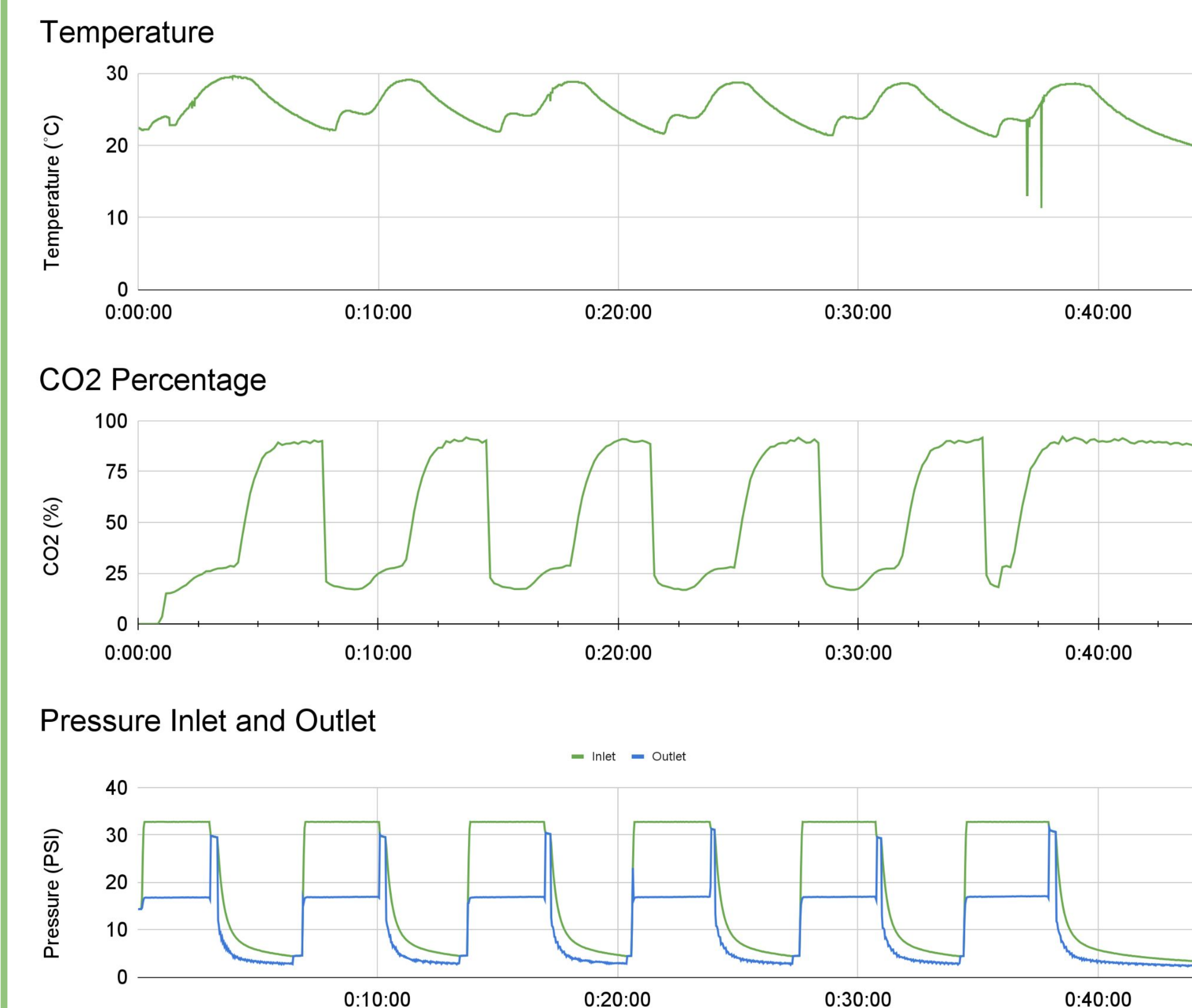
Flow diagram of prototype:



Testing Set Up:

Testing was done with one foot and two foot zeolite chambers to test residence time. There were three phases of testing, one to test sorption, one to test desorption, and one to test sorb-desorb cycles of varying lengths.

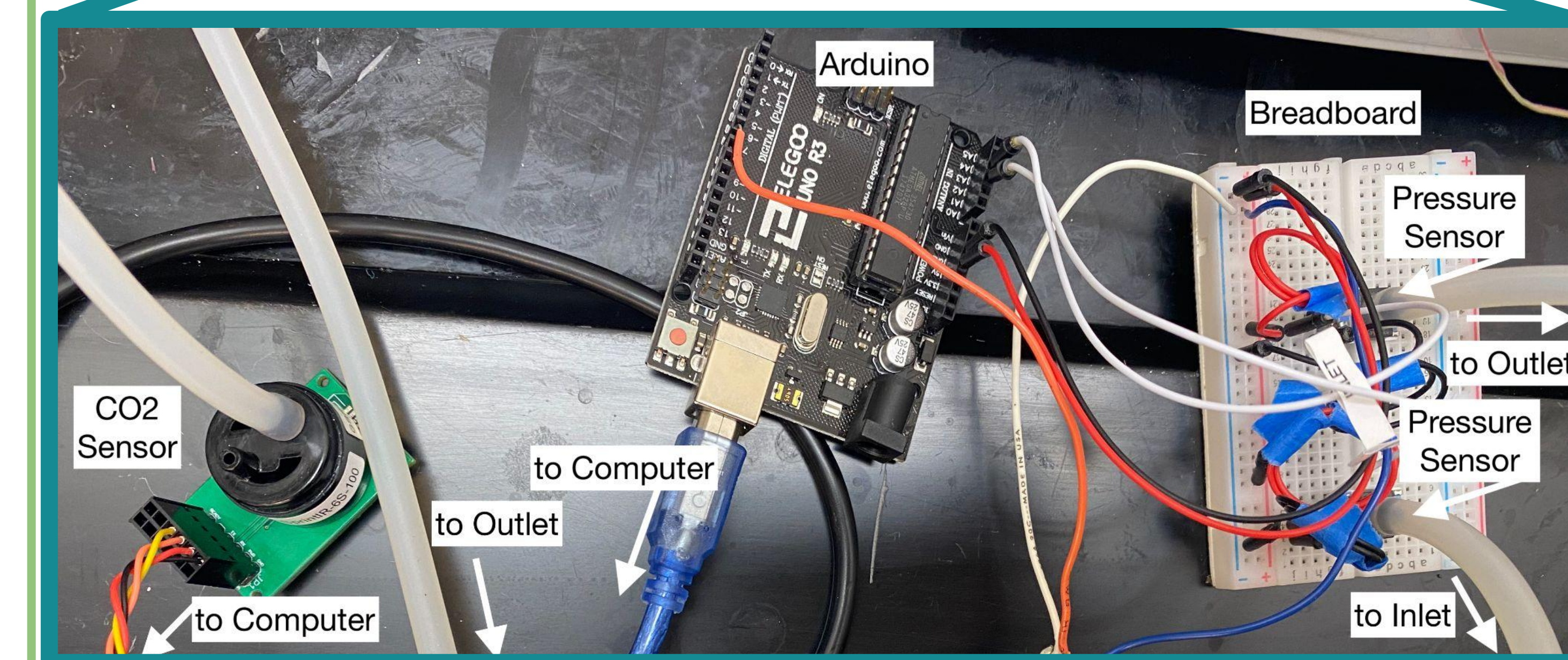
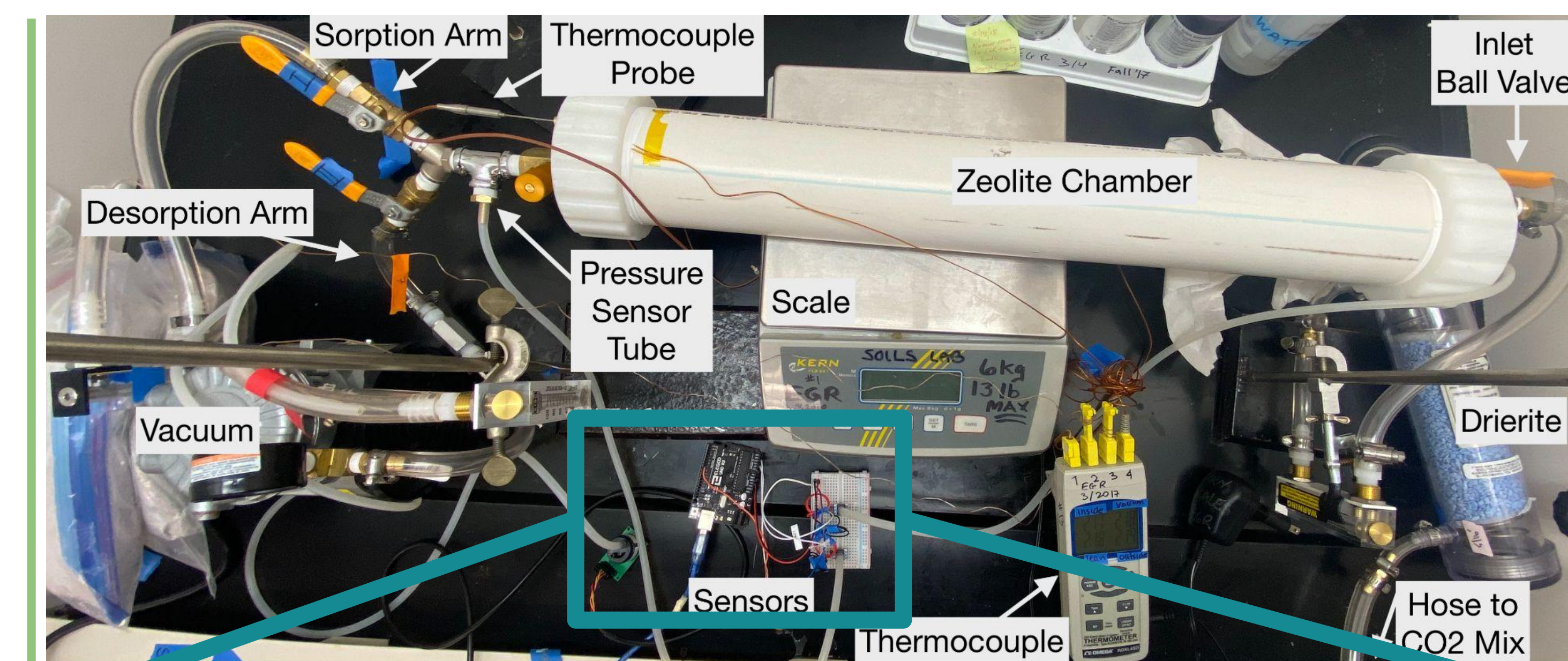
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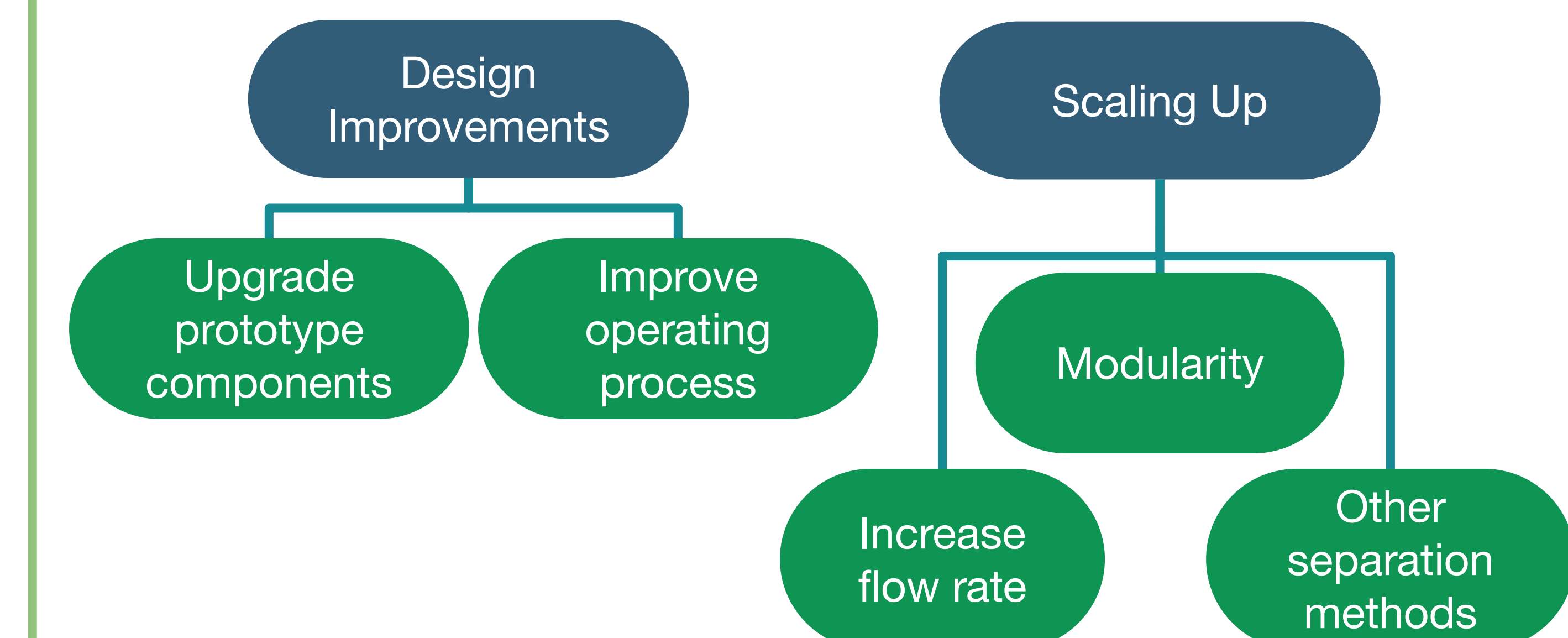
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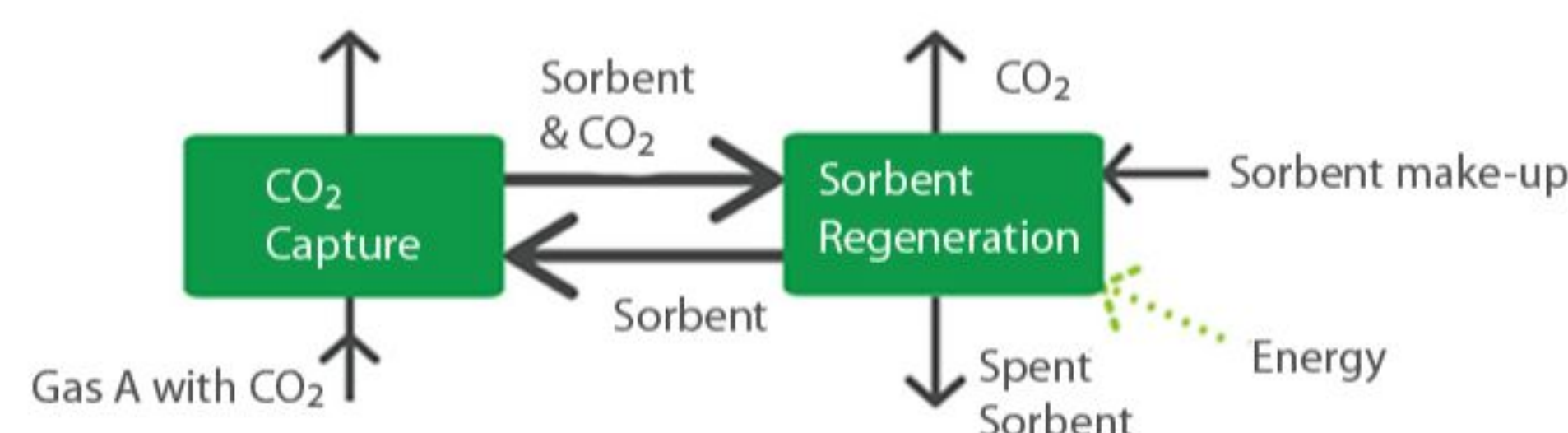
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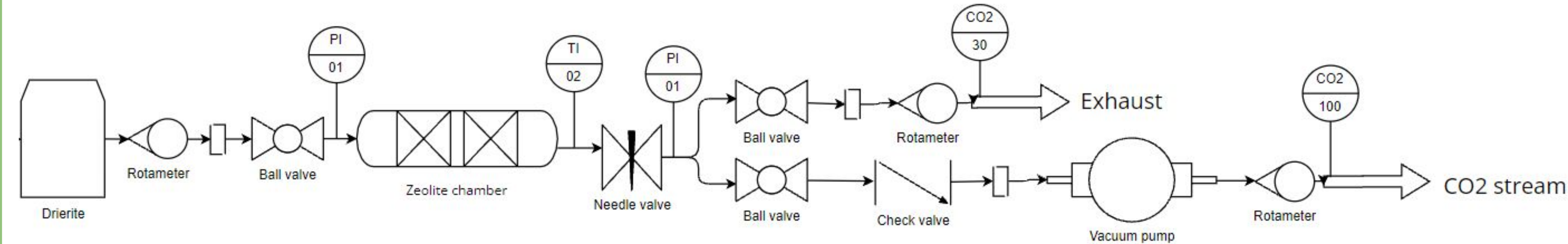
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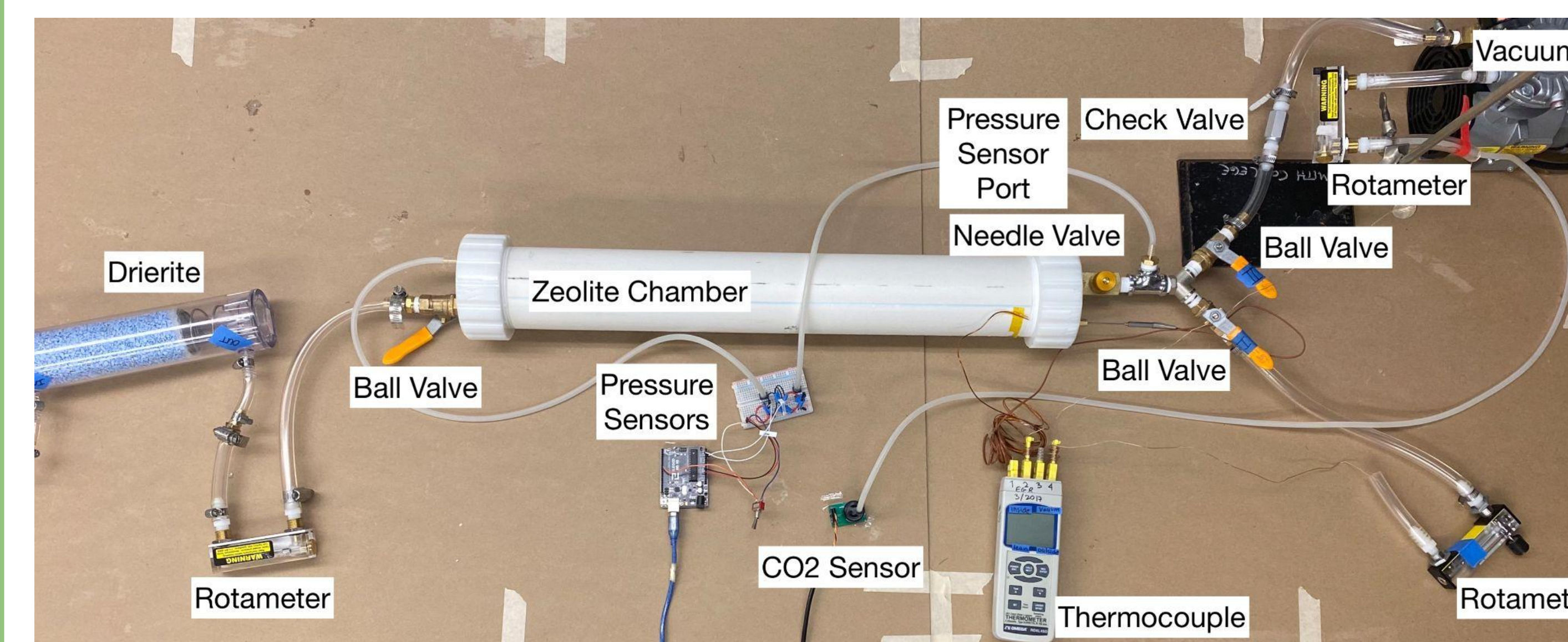
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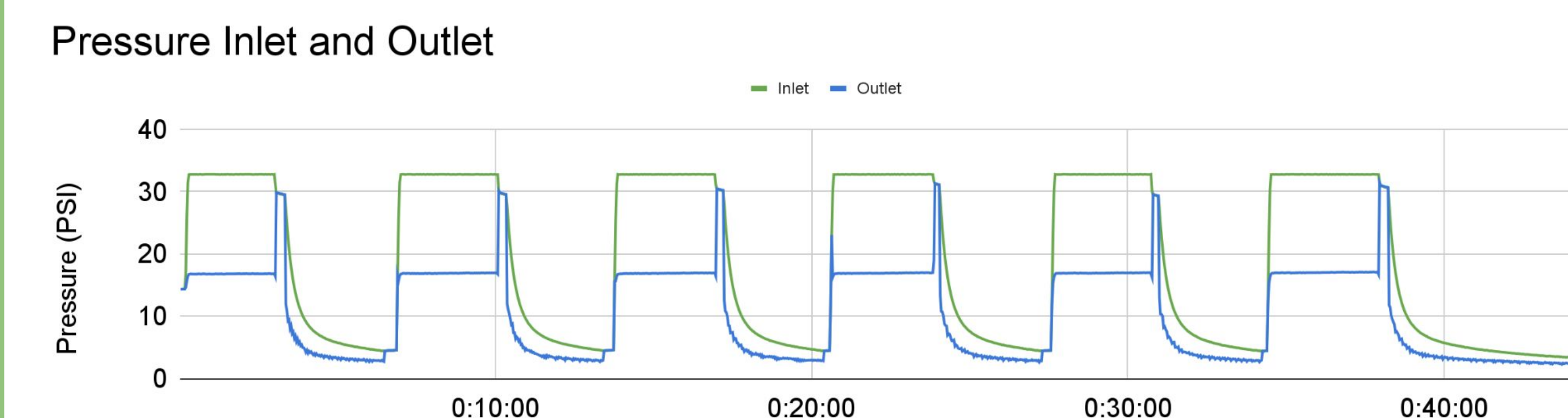
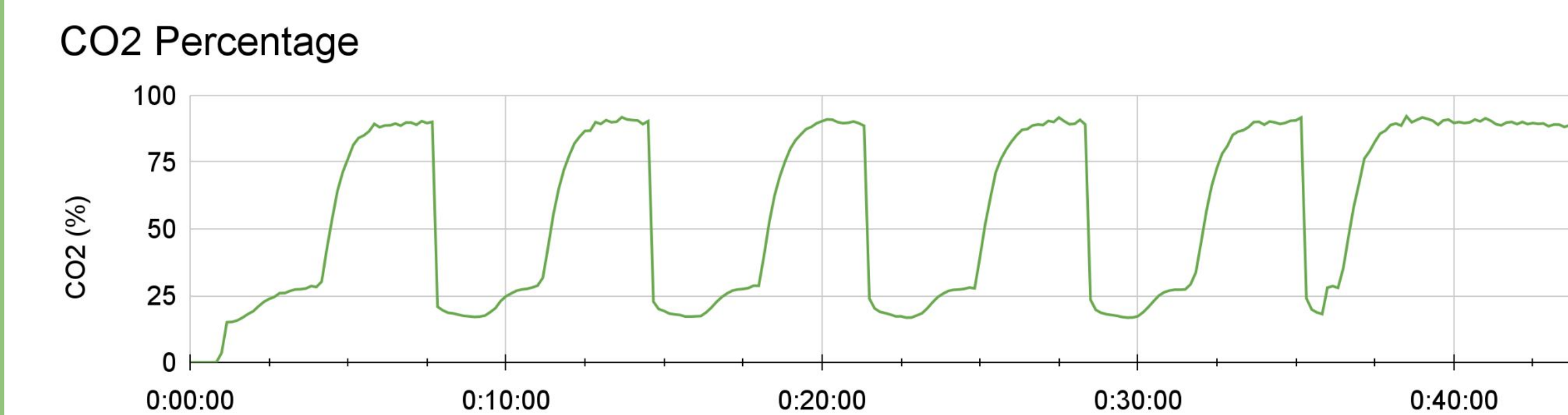
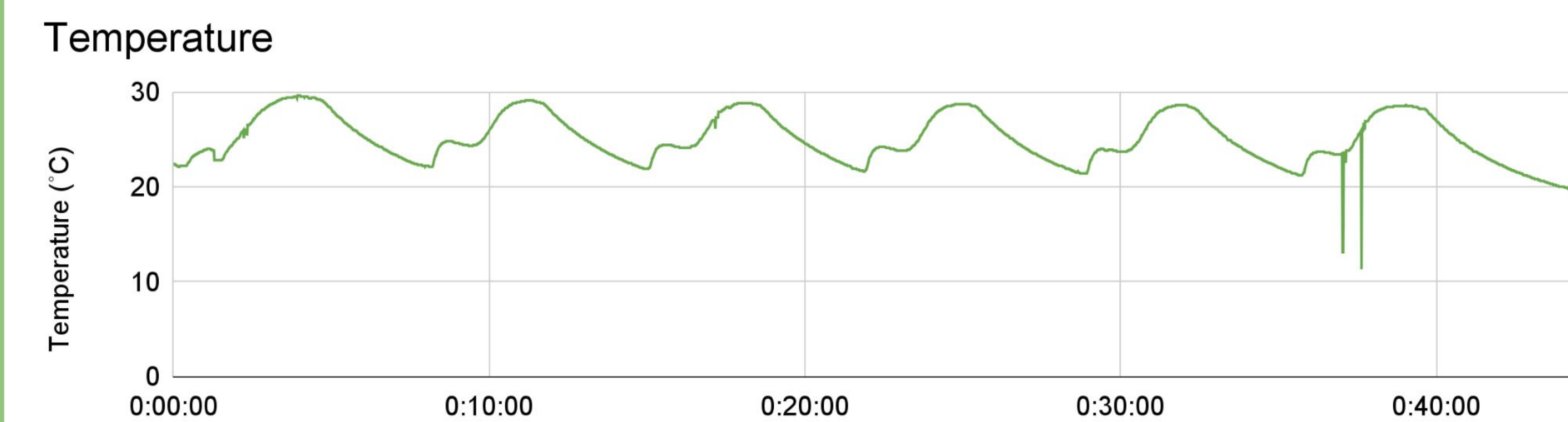
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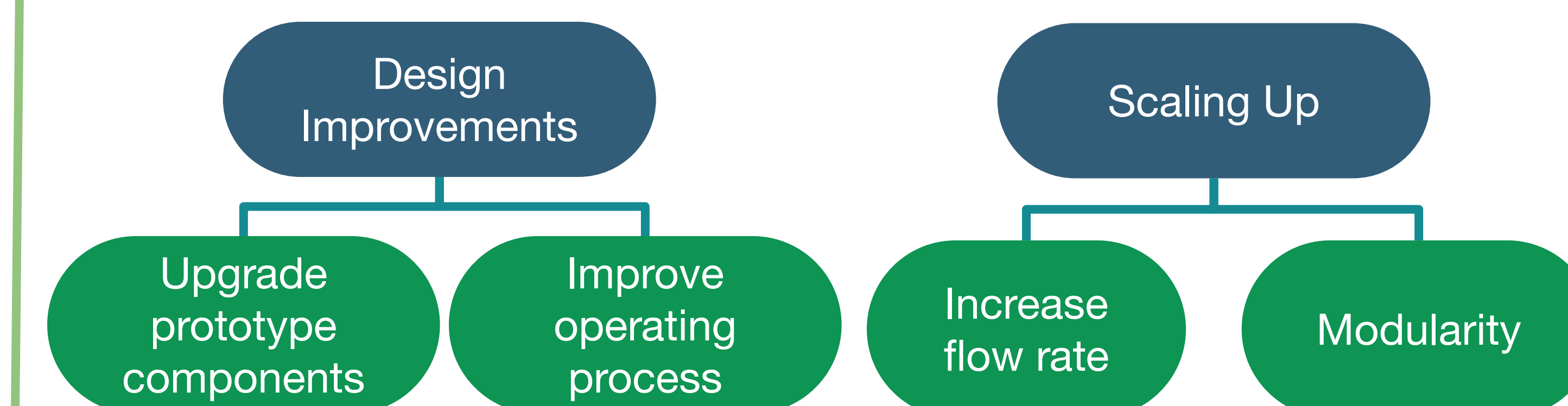


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