TEAM
019

Carbon Capture & Storage System Integrated with an AC Unit

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EE 3 ME CHE

Overview

• Background

Rising CO_2 emissions are a major driver of climate change, creating urgent demand for scalable carbon capture solutions. This project introduces a Carbon Capture & Storage (CCS) system integrated with an air conditioning unit, using adsorption to reduce CO_2 in indoor environments. Captured CO_2 can be repurposed or sold to industry—promoting a circular carbon economy.

Problem Statement

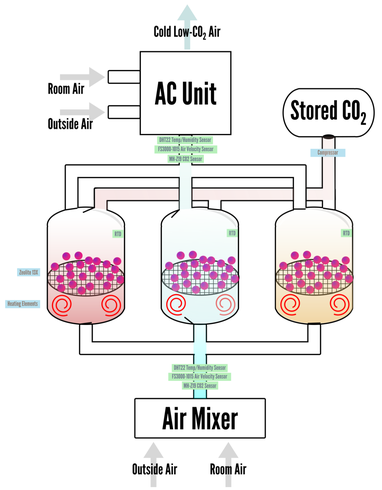
Traditional carbon capture systems are large, expensive, and designed for industrial use. There is a clear need for a cost-effective, scalable solution that passively reduces CO_2 emissions in everyday environments by leveraging existing AC airflow.

- **Constraints**
  - Fused 220 VAC single phase as input.
  - Nominal Power Consumption < 6 kW.
  - Cost < 7000 SAR.
  - operate efficiently between 20-50 Celsius.

Prototype Design

- **All Specifications**
  - System autonomy > 90%.
  - Real-time sensor data display.
  - ≥100 g/day CO_2 captured.
  - 60% adsorption capacity retention.
  - Minimum 400 CFM airflow.
  - Maximum pressure under 50 PSI.
  - Clear acrylic, 240°C resistant
  - Insulation: max 2°C deviation.
  - Doesn't exceed 1.0 m^3.
  - Work 24/7.
  - Maintenance under 1 hour weekly.

• Conceptual Design

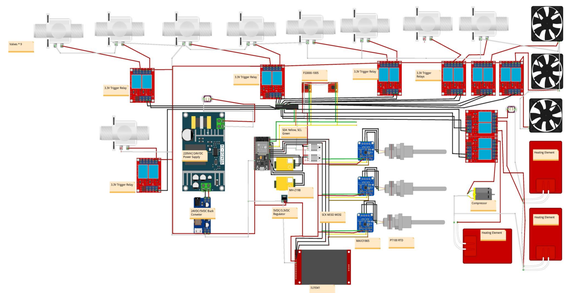


Conceptual Design of the System

Prototype Design

• Mechanical Components and Chemical Process: Three iron-steel chambers wrapped in fiberglass tape connected with PVC fittings and housed in a thermally insulated wooden box. Heaters raise temperatures to 220°C to release CO_2 from Zeolite 13X, which retains over 80% capacity after each cycle. CO_2 is stored in a pressurized tank via reinforced hoses, with support from a compressor, valves, regulator, and hose clamps. Each cycle takes 9 minutes for continuous operation.

• Control & Automation System: **ESP32** manages sensors (**CO_2**, **airflow**, **temperature**) and actuators (**fans**, **valves**, **heaters**, **compressor**). Data is shown on TFT and controlled via serial. Automation handles stage transitions.



Electrical Schematic of the Sensor & Actuator Integration

Validation & Conclusions

- **Autonomy: >90%:** fully automated CO_2 capture stages.
- **Monitoring:** 100% real-time data display and session logging.

Scan for Demonstration

- **Captured CO_2:** ≥100 g/day confirmed by Zeolite 13X calculations.
- **Adsorber Stability:** ≥60% capacity retained after each regeneration.
- **Air Flow:** the integration with the ac unit allows it to breathe naturally to ensure that the inlet air flow is up to spec
- **Chambers:** Iron-steel is able to withstand temperatures well over 220°C
- **Conclusions:**

The system achieved sensor integration and automation, meeting key specs like >90% autonomy, real-time monitoring, and ≥100 g/day CO_2 capture. It offers a scalable foundation for passive CO_2 reduction via AC units.