13 - Technique to capture atmospheric CO_2/CO

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Technique to capture atmospheric CO_2/CO

Aim

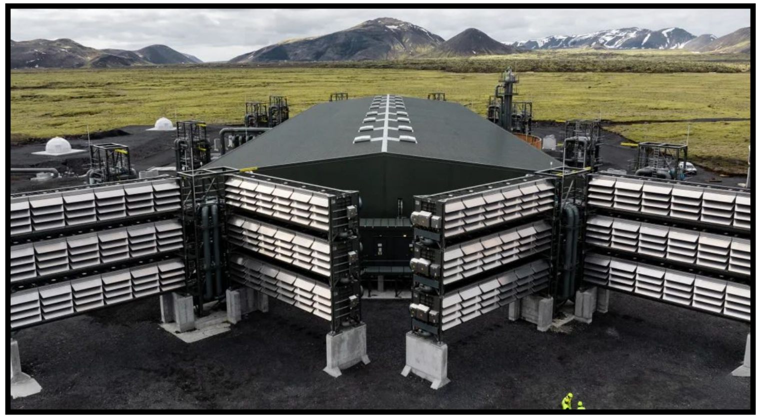
❖ To develop an innovative solution that integrates Direct Air Capture (DAC) technology with wind turbines, harnessing renewable wind energy to efficiently capture and reduce atmospheric CO_2 levels, contributing to climate change mitigation and advancing sustainable energy practices.

Objectives

❖ The primary objectives of the project includes:
  - To create a practical prototype that is not easily confined by geographical boundaries.
  - To create an effective system for taking in ambient air while saving a considerable amount of energy from air contactor fans.
  - To integrate our project with existing technology to minimize substantial downtime and maintenance concerns that new technologies may encounter.

1. Problem Statement

- A technique to capture CO_2/CO from the air, helping mitigate climate change.
- Currently, we rely on Direct Air Capture (DAC) Technologies to achieve negative emissions.
- However, these technologies are generally constrained by:
  - Expense: Spending on some DAC plants currently reaps less return than other alternatives.
  - Concentration: Systems must process huge volumes of air to capture relatively modest levels of CO2 in air [0.04% or 400 ppm in ambient air].
  - Energy: Approximately 5.92 GJ of energy is required to remove on ton of CO2.
  - Location: To achieve net zero emissions, the system must be physically close to renewable sources.

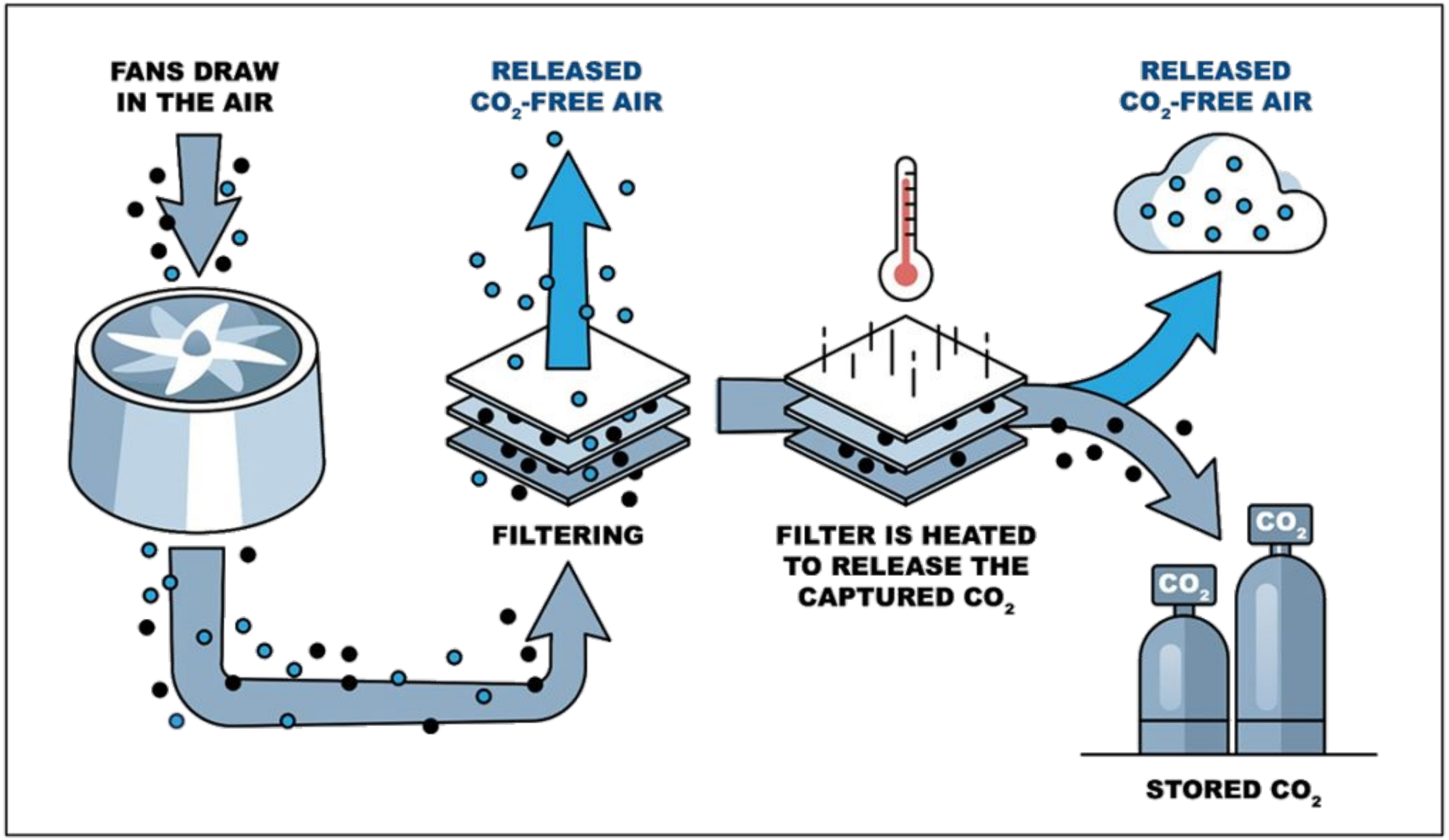


Mammoth: our newest direct air capture and storage facility

Step	Type	Energy Required (GJ/t CO_2)
Air contactor fans	Electrical	0.55-1.12
Vacuum Pump	Electrical	$(110-140) \times 10^{-4}$
Desorption Heat	Thermal	3.4-4.8

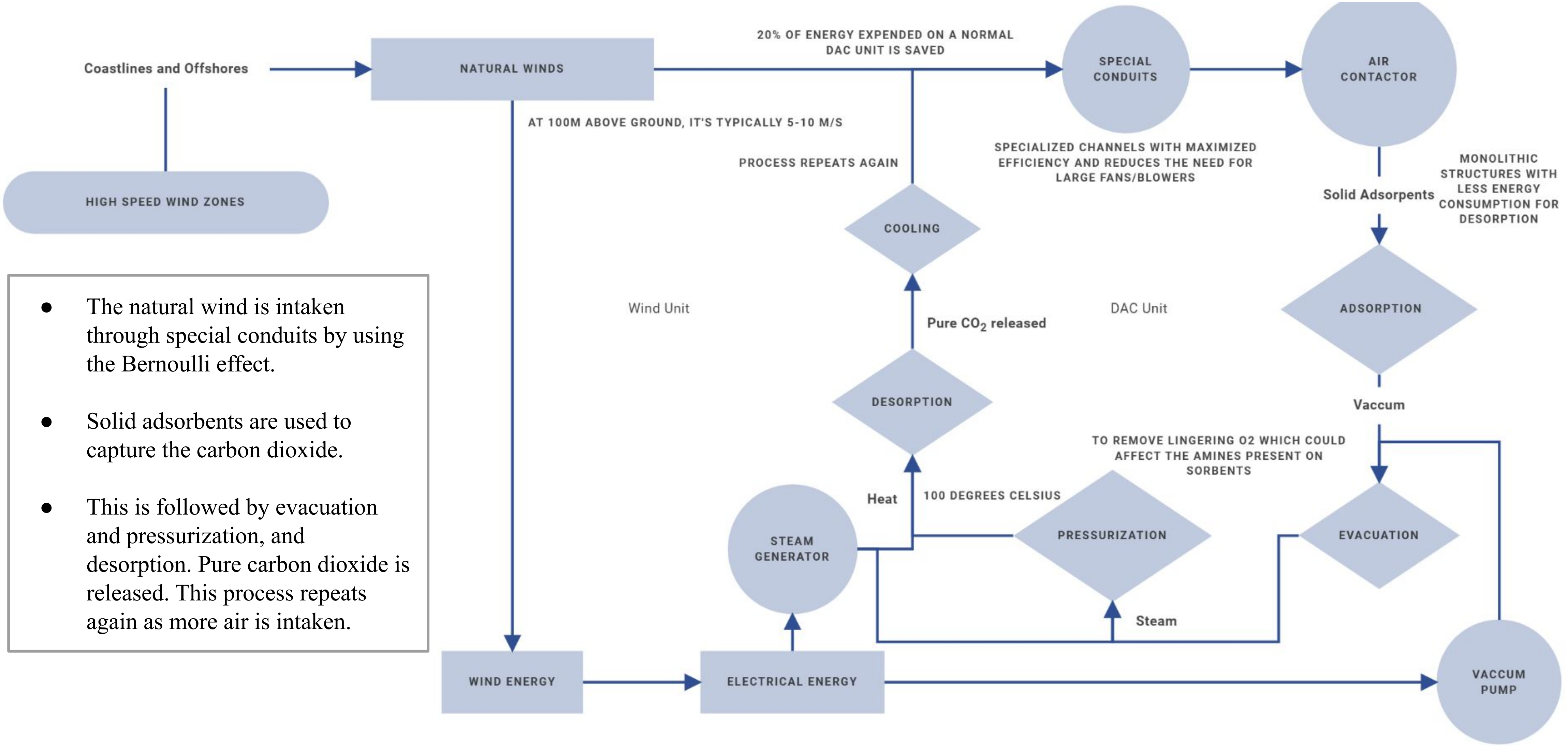
National Academics

2. Existing Technology Overview



Flowchart

3. Innovation - Conceptual Flowchart



- The natural wind is intaken through special conduits by using the Bernoulli effect.
- Solid adsorbents are used to capture the carbon dioxide.
- This is followed by evacuation and pressurization, and desorption. Pure carbon dioxide is released. This process repeats again as more air is intaken.

3. Innovation

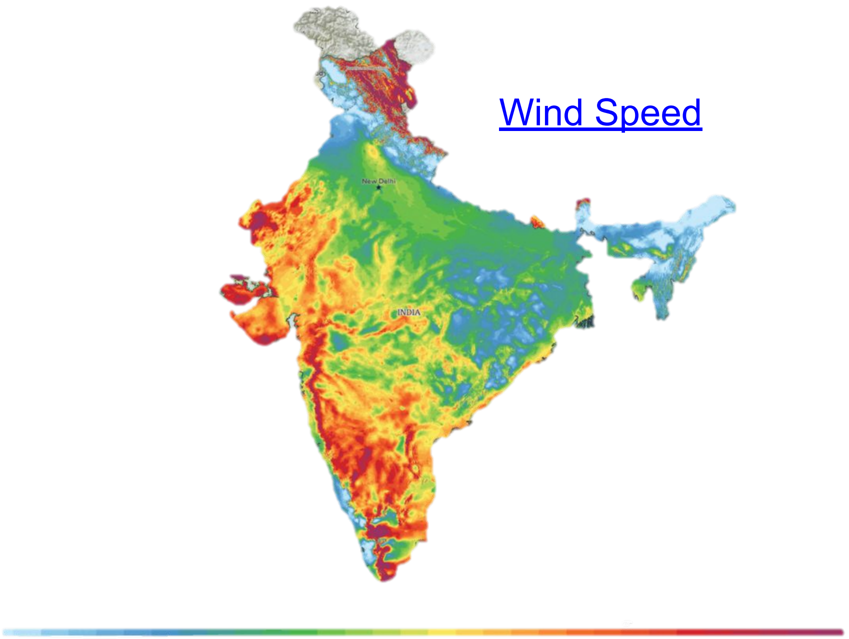
Category	Key Features	Benefits
Land Use	DAC integrated with windmills eliminates the need for additional land.	Optimized land utilization.
Energy Efficiency	Utilizes windmills' electricity and heat energy directly for DAC operations.	Prevents energy wastage by using surplus power for CO_2 removal.
Natural Airflow Advantage	High-speed wind zones enable direct air intake via ducts (Bernoulli effect).	Reduces fan energy requirements, cutting operational costs by ~ 20%.
Solid Sorbents Over Liquids	Requires less thermal energy compared to liquid sorbents.	Enhances energy efficiency and scalability for large-scale deployment.
Economic and Environmental Impact	Wind energy is a carbon-neutral power source.	High CO_2 removal potential with reduced environmental footprint.
Cost Reduction Strategies	Shared infrastructure between DAC and windmills lowers initial costs.	Mass production of small DAC units across wind farms further reduces costs.

4. Technicalities and Scope

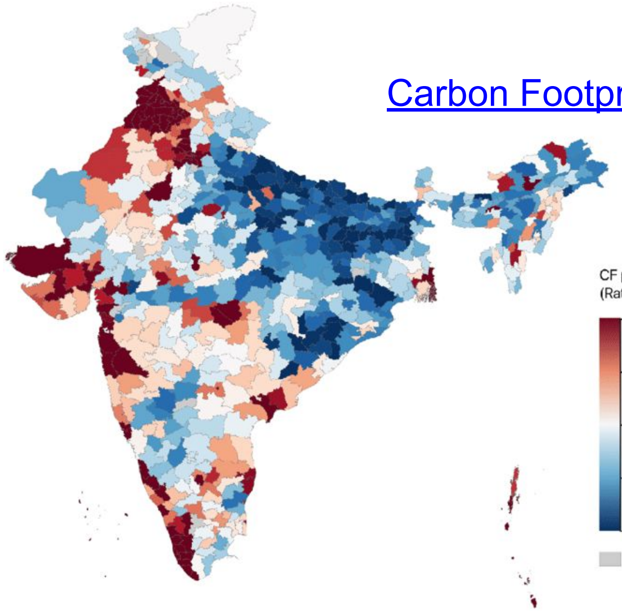
❖ **Technical Feasibility of DAC with Wind Energy in India:**

- Abundant wind energy and advanced wind farm technologies.
- Potential for synergy with wind farms for optimised energy utilization and reduced operational costs.

Wind Speed



Carbon Footprint

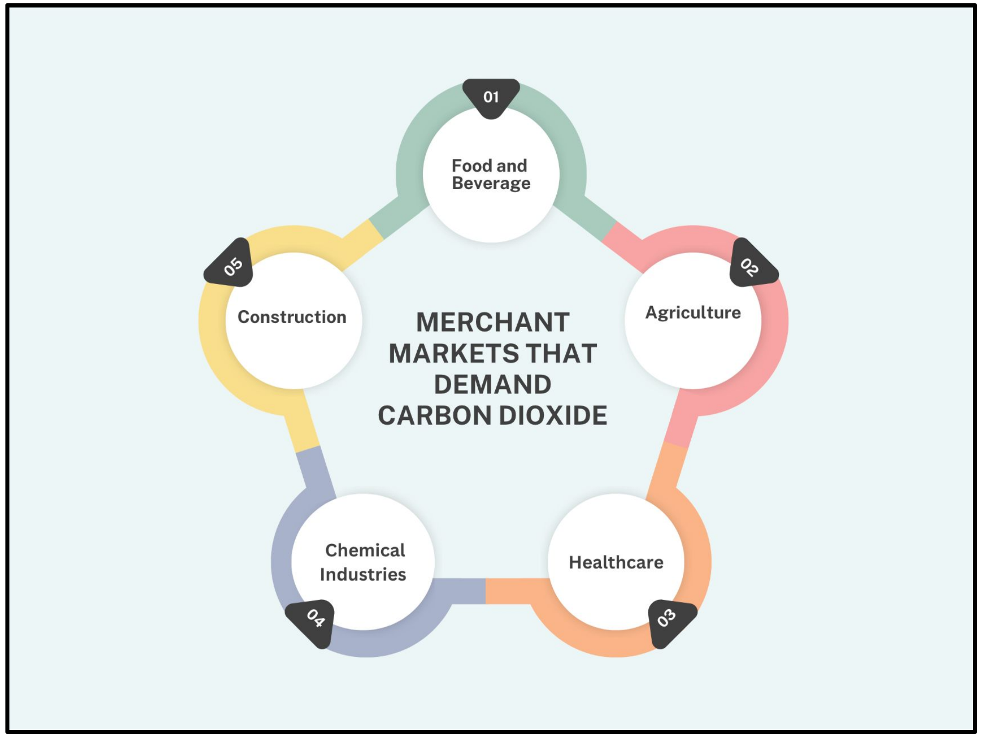


❖ It can be interpreted that the regions with high wind speed also correlate to the areas with higher carbon footprint. Thus, integration of windmills with DAC is the right step in combating climate change.

❖ **Scalability**: Integration with existing infrastructure. Modular design allows gradual scaling.

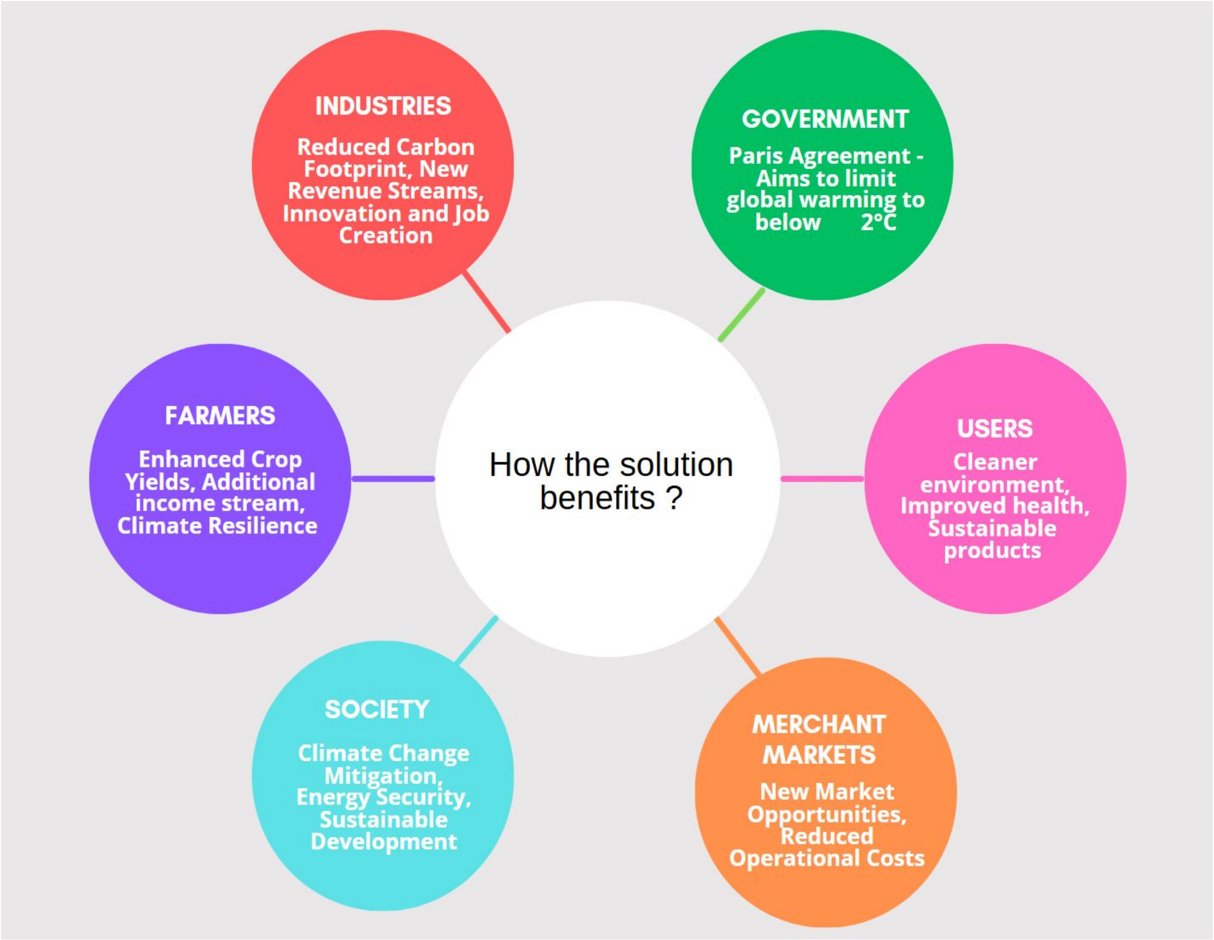
5. Target Audience/Market

- Currently, most of the existing DAC units inject CO_2 back into geological formations. This is an expensive process, and detriments efficiency and capacity of the units.
- As an alternative, we propose to meet the demand for carbon dioxide in several industries, by supplying the captured CO_2 to them.
- Benefits:
  - Supply Reliability
    - Consistent supply of carbon dioxide.
  - Sustainability
    - Scalable source of CO_2 that aligns with net-zero goals.
  - Circular Economy
    - The system involves capture, use and recycling of CO_2.
    - This reduces overall environmental impact.



6. Social/Environmental Impact

- ❖ Carbon capture, utilization, and storage (CCUS) is a powerful tool for a sustainable future.
- ❖ Lower carbon footprint in industries reduces greenhouse gas emissions, improves air quality.
- ❖ By capturing and storing CO_2, CCUS mitigates climate change and fortifies energy security.
- ❖ Industries, farmers, and society as a whole benefit from CCUS.



7. Financials

Components	Cost Ranges	Technical Part Names
Sorbent Material, Support Structure and Mechanical Regeneration System	₹4,500 - ₹10,000	Activated Carbon (AC), Zeolite (ZE), Metal-Organic Frameworks (MOF)
AC Generator	₹5,000 - ₹10,000	Small Permanent Magnet Generator AC Alternator
Sensors	₹2,500 - ₹5,500	CO_2 Sensor (MH-Z19), Pressure Sensor (BMP180)
Control Systems	₹1,000 - ₹2,500	Arduino Uno Microcontroller (ATmega328P) Miscellaneous Electronics (Wirings, Connectors)
Actuators	₹2,500 - ₹5,500	Linear Actuator (LA-14), Rotary Actuator (RA-25)
Pneumatic Cylinders	₹2,000 - ₹4,500	SMC Compact Cylinder (CQ2B Series)
Total	₹17,500 - ₹38,500	-