

C02-FUEL CIRCULAR SYSTEM

Overview

EcoLoop is an interactive climate-technology simulation built to visualize how atmospheric CO₂ can be captured, converted into synthetic e-fuel, and recycled in a closed-loop system.

Although purely front-end and simulation-based, the platform is designed to resemble a real operational control center used in next-generation carbon removal facilities.

EcoLoop integrates four major layers:

- Live environmental monitoring
- Engineering workflow visualization
- AI-powered climate modeling & strategy generation
- Immersive narrative storytelling

The experience aims to educate, inspire, and demonstrate future sustainable technologies.

Features

Dashboard — Global CO₂ Intelligence Hub

- A real-time simulation that displays the planet's carbon condition and fuel synthesis performance.

CO₂ Captured (Geospatial Simulation)

- Values increase dynamically based on global CO₂ density, inspired by CO-Earth-style datasets.
- Simulated fluctuations mimic environmental variability.
- User input does not affect capture rate — the system behaves autonomously.

Fuel Generated (Proportional Yield Estimator)

- Fuel output is directly proportional to CO₂ captured.
- Predictive modeling gives rough fuel estimates.
- Demonstrates dependency between carbon intake and fuel synthesis.

System Efficiency (Dynamic Behavior)

- Efficiency fluctuates realistically based on simulated system conditions.
- Behavior approximates:

Atmospheric CO₂ PPM (Stability Threshold)

- Updates every minute.
- Critical Alert Mode activates when levels exceed ~420 PPM.
- System generates automated operational recommendations.

Planetary Globe Visualization

- Background shifts between blue → stable and red → critical states.
- Includes animated rotating globe.
- Stabilization nodes appear as pulsing dots.

Extraction vs Production Graph

Real-time animated graph visualizing:

- CO₂ extraction rate
- Fuel production rate

Live Operations Feed

Displays actionable system messages and diagnostics.

Process Map — Engineering the Carbon-to-Fuel Pathway

Direct Air Capture

“Huge fans draw in ambient air. Chemical sorbents selectively bind with CO₂, separating it from other gases.”

Green Hydrogen Production

“Renewable energy powers electrolyzers that split water into Hydrogen and Oxygen.”

Reaction Chamber

“Captured CO₂ and H₂ undergo a Reverse Water-Gas Shift reaction to form methanol precursors.”

Fuel Synthesis

“Crude methanol is refined into drop-in e-fuels compatible with existing engines.”

Zero-Net Use

“Vehicles burn the synthetic fuel, releasing CO₂ that is captured again, forming a perpetual carbon loop.”

Includes voice narration and clickable nodes for engineering details.

Gemini AI — Planetary Modeling, Optimization & Strategy Engine

Global Analysis

- CO₂ rise vs temperature anomaly (2000–2025)
- Climate risk correlations
- Predictive visual insights

Tech Simulator (10 MW → 1000 MW)

Adjust parameters such as:

- Capture capacity
- Energy assumptions
- Technology type

Outputs estimated carbon removal, energy demand, and fuel potential.

AI Chatbot Assistant

- Answers climate, engineering, and CO₂ questions
- References live simulation data
- Provides analytical and educational support

Strategy Planning

- Country-specific strategy generation
- AI-created 20-year environmental impact modeling
- Recommendations for DAC scaling and infrastructure planning

Story Mode — Immersive Climate Narrative

Chapter 1 — The Invisible Threat

Industrial emissions have thickened the atmosphere, pushing the planet toward a tipping point.

Chapter 2 — AI-Driven Capture

Gemini AI optimizes DAC arrays by predicting airflow and saturation patterns.

Chapter 3 — Sustainable Mobility

Captured carbon becomes e-fuel, enabling carbon-neutral aviation, shipping, and transport.

Chapter 4 — The Circular Future

A fully closed-loop carbon system where humanity thrives sustainably.

Category	Technology
Framework	React
Language	TypeScript(.ts, .tsx), html
Data	JSON simulations
AI Logic	Custom Gemini Service
Rendering	ReactDOM

Folder Structure

```
/components
  AInsights.tsx
  Dashboard.tsx
  Navigation.tsx
  ProcessMap.tsx
  StoryMode.tsx

/services
  geminiService.ts

App.tsx
  index.html
  index.tsx
  metadata.json
  types.ts
```

EcoLoop — User Guide & Instructions

A step-by-step walkthrough of every feature, component, and interactive element.

Welcome to EcoLoop, an interactive simulation that helps you understand how CO₂ is captured from the atmosphere and transformed into synthetic fuel — all supported by advanced AI insights.

This guide will help you navigate each section of the app and understand what the data, visuals, and tools represent.

1. Dashboard — Your Real-Time Carbon Monitoring Hub

The Dashboard is the first screen you see.

It acts like a global control room displaying the planet's carbon condition and the performance of the Carbon-to-Fuel system.

✅ What You Can See Here

• CO₂ Captured

Shows how much atmospheric CO₂ is being removed.

It increases over time based on simulated geographic CO₂ data.

• Fuel Generated

Displays the amount of synthetic fuel produced using the captured CO₂.

Fuel output rises proportionally as more CO₂ is processed.

• System Efficiency

Shows how efficiently the system is converting CO₂ into fuel.

This value fluctuates dynamically to simulate real-world plant behavior.

• Atmospheric CO₂ PPM

Represents the planet's CO₂ concentration.

If this value crosses a threshold (~420 PPM), the system goes into Critical Mode.

• Planetary Globe

A rotating globe visualization where:

- Blue = stable planet
- Red = critical condition
- Pulsing dots = stabilization zones

• Extraction vs Production Graph

Shows a live comparison of:

- Carbon extraction rate
- Fuel production rate

• Live Operations Feed

The panel generates real-time warnings, alerts, and system recommendations based on global conditions.

2. Process Map — Understanding the CO₂-to-Fuel Journey

The Process Map explains how carbon captured from the air becomes usable synthetic fuel.

👉 Tap any of the five stages to view its full explanation:

1. Direct Air Capture (DAC)

Shows how giant fans pull in air and specialized chemicals extract CO₂ from it.

2. Green Hydrogen Production

Explains how renewable energy splits water to create hydrogen — a key ingredient for fuel synthesis.

3. Reaction Chamber

Describes how CO₂ and hydrogen react under heat and pressure to form methanol precursors.

4. Fuel Synthesis

Shows how methanol is refined into clean e-fuels that can power vehicles and machinery.

5. Zero-Net Use

Demonstrates the full loop:

Fuel is burned → CO₂ is released → CO₂ is captured again.

Voice Narration

You can enable voice narration from the top right corner and walkthrough to the entire process.

3. Gemini AI Suite — Analytical Tools & Smart Insights

The Gemini AI section includes advanced tools to help you explore climate impact, evaluate technologies, and generate strategies.

◆ A. Global Analysis

Visual graphs that explain:

- CO₂ increase over time
- Temperature rise correlation
- Major sources for carbon emissions is also listed out

These visuals help you understand why carbon capture matters.

◆ B. Tech Simulator

Experiment with different carbon capture technologies. There are four technologies listed namely

-Direct Air Capture(Solid Sorbent)

-Direct Air Capture(Liquid Sorbent)

-Post Combustion Amine Scrubbing

-Enhanced Weathering (Mineralization)

Any of the technologies can be chosen and then there is an adjustable slider included used to adjust the capture capacity in 'MW' unit

- Capture Capacity (10 MW → 1000 MW)

What You Receive:

- Estimated CO₂ captured
- Cost
- Fuel output potential
- Efficiency
- Along with an AI technical summary.

An AI Chatbot is introduced for any follow-up doubts regarding the generated simulation for the respective capture capacity.

Ask anything — from climate science to fuel generation.

Example questions already present are

- Cost analysis
- Efficiency Check
- Risk assessment

The chatbot can refer to real simulation data to give context-aware answers.

◆ C. Strategy Planning

Select a country → the AI generates:

- A 20-year climate impact projection
- Suggested deployment plans
- Recommended technology mix
- Energy optimization strategies

This simulates how future governments or organizations may plan climate policies.

4. Story Mode — Learn Climate Science Through Storytelling

EcoLoop includes a four-chapter interactive story that makes climate change easy to understand.

Chapter 1 — The Invisible Threat

Explains how hidden emissions have heated our planet.

Chapter 2 — AI-Driven Capture

Shows how future AI systems optimize CO₂ capture.

Chapter 3 — Sustainable Mobility

Demonstrates how e-fuels can power cleaner transportation.

Chapter 4 — The Circular Future

Imagines a world where humanity and the planet coexist sustainably through closed carbon loops.

Each chapter includes visuals, descriptions, and immersive narration.

5. Navigation Guide — How to Move Around the App

- Use the top navigation bar to move between Dashboard, Process Map, AI Tools, and Story Mode.
- Each section loads instantly without needing refresh, some process may require time to analyze and generate the accurate data.

6. Recommended User Flow (Step-by-Step)

If you want the best experience, follow this order:

① Start at Dashboard

Understand the current simulated planet condition. The carbon captured is the current carbon present in a region.

② Move to Process Map

Learn how CO₂ becomes fuel step by step.

③ Visit Gemini AI → Global Analysis

See real-world climate trends.

④ Try Tech Simulator

Experiment with different technologies.

⑤ Use AI Chatbot

Ask question to get clarification.

⑥ Explore Strategy Planning

See long-term national impact.

⑦ End with Story Mode

Enjoy a cinematic overview of the entire journey.

7. Tips for First-Time Users

- All values are simulate.
- Click everywhere as panels include hidden details to be explored
- Use the AI Chatbot when confused
- The Dashboard updates automatically, user may not need to refresh.

Running the Project

Install dependencies:

```
--npm install
```

Start dev server:

```
--npm run dev
```

Build production files:

```
--npm run build
```

Purpose

EcoLoop serves as:

- A climate-tech demonstration tool
 - A CO₂-to-fuel educational simulator
 - A prototype for future sustainability platforms
 - A storytelling + analytics experience
 - A conceptual model for closed-loop ecosystems
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