CO_2NTROL: Carbon Emission Control Web Application

Ankoor Ashtekar, Aditya Tandulkar, Anish Chavan, Himanshu Devgadkar, Vedant Deshmukh, A. H. Raheja
Dept. of First Year Engg. AISSMS IOIT Pune, India

***Abstract*—Rising carbon footprints have become a critical global concern, leading to rapid environmental degradation and climate change. Traditional carbon tracking methods often lack real-time data and user-friendly interfaces, making it difficult for the general public to monitor their environmental impact effectively. This paper presents CO_2NTROL, a web-based carbon emission control application that provides real-time tracking, visualization, and actionable insights for individual carbon footprints. The system employs a Jamstack architecture (JavaScript, APIs, and Markup) with React.js frontend and Node.js backend to deliver a responsive, intuitive dashboard. Users input daily activity data related to transportation, energy consumption, and food habits; the system calculates emissions using standardized IPCC emission factors and displays results with reduction suggestions. Experimental evaluation demonstrates high calculation accuracy, near-native loading speeds via edge hosting, and reliable data persistence. The proposed system addresses key limitations of existing tools—data latency, lack of automation, and interface complexity—making carbon awareness accessible to everyday users.**

***Keywords*—carbon emission, carbon footprint, web application, real-time tracking, sustainability, climate action, SDG 13, React.js, Node.js**

I. INTRODUCTION

Global greenhouse gas emissions have reached a record 60.63 billion tons of CO_2 equivalent in recent years, reflecting an alarming trend of environmental degradation driven by modern consumption patterns. Almost every aspect of contemporary life—commuting, food production, digital device manufacturing—requires energy, and when that energy is derived from fossil fuels, it releases heat-trapping gases into the atmosphere. Engineering solutions are increasingly being developed to address climate change, yet individual awareness and behavioral change remain essential components of any comprehensive strategy.

The Hindi proverb "Boond boond se sagar banta hai" ("a sea is formed drop by drop") encapsulates the philosophy behind CO_2NTROL: even small personal efforts, when aggregated across millions of users, can produce significant environmental impact. This project focuses on developing a digital tool that provides quick, easy access to emission data using modern web technologies, empowering individuals to understand and reduce their carbon footprint.

A. Problem Statement

Despite the availability of environmental apps, existing solutions suffer from: (i) data latency—reliance on historical rather than real-time data; (ii) lack of automation—high user interaction required for manual data entry; and (iii) interface complexity—professional tools too complex for everyday consumers. Energy production and heavy industrial processes additionally pose structural barriers to full decarbonization, reinforcing the need for individual-level awareness and action.

B. Motivation and Objectives

The primary motivation is to lower individual carbon emissions by making tracking simple, immediate, and rewarding. The specific objectives of CO_2NTROL are:

- Real-time tracking of CO_2 emissions from transportation, energy use, and food consumption.
- Daily average emission computation with alerts for excessive or rapidly increasing emissions.
- AI-driven suggestions for precautionary actions to lower personal carbon footprint.
- A gamified reward system to incentivize exceptional emission reduction.
- Continuous learning: tracking avoidable emission instances and suggesting improvements over time.

- Partnership with research organizations for more accurate emission factors and elimination strategies.

II. LITERATURE REVIEW

A survey of existing carbon management solutions reveals three primary categories of tools, each with distinct strengths and limitations.

A. Carbon Footprint Calculation Algorithms

Many digital solutions use standardized emission factors—such as those published by the Intergovernmental Panel on Climate Change (IPCC)—to convert user activity data into CO_2 equivalents. These calculators are mathematically sound and scientifically validated. However, they are highly dependent on manual user input, introducing potential errors and reducing adoption among less technically inclined users [1].

B. Mobile Application-Based Solutions

Existing mobile applications focus on gamifying eco-friendly habits to improve user engagement and retention. While effective at promoting behavioral change at a surface level, these apps often lack the technical depth to provide precise emission tracking for industrial or complex household scenarios. Their outputs are frequently "estimates" rather than rigorously calculated values, limiting scientific utility [2].

C. Comparative Analysis

Table I presents a structured comparison of existing system types against the proposed CO_2NTROL solution.

TABLE I. Comparison of Existing Systems vs. CO_2NTROL

System Type	Advantage	Limitation
Static Calculators	Easy to access, validated	Not real-time; manual entry
Mobile Apps	High retention; gamified	Estimates only; lacks precision
CO_2NTROL (Proposed)	Real-time; user-friendly dashboard	Dependent on data APIs

D. Summary

Existing solutions suffer from high latency or overly complex interfaces. There is a clear need for a standalone, web-based system offering real-time visualization with minimal user effort. CO_2NTROL addresses these gaps by employing a modern tech stack to deliver an intuitive dashboard for immediate carbon footprint analysis.

III. METHODOLOGY

A. System Architecture

CO_2NTROL adopts a Jamstack architecture—JavaScript, APIs, and Markup—to ensure speed, scalability, and maintainability. The frontend is built with React.js for a responsive, component-driven UI. The backend logic runs on Node.js with serverless functions, and user activity data is persisted in a relational database (SQLite or equivalent).

B. Development Workflow

The project followed a structured development lifecycle:

- Requirement analysis and emission factor selection (IPCC standards).
- Tech stack selection and environment configuration.
- Database schema and UI/UX design.
- Frontend and backend programming with API integration.
- Testing, validation, and performance benchmarking.

C. Working Process

The user interaction flow is straightforward: (1) open the web application; (2) input daily emission-related data (transport mode, distance, energy consumption, food choices); (3) the system fetches emission factors and computes the carbon equivalent; (4) the daily CO_2 output is displayed on the dashboard along with personalized reduction tips.

D. Tools and Technologies

The implementation stack comprises:

- Frontend: React.js with a material-themed, responsive UI.
- Backend: Node.js / Python serverless functions for data processing.
- Database: SQLite for structured storage of activity logs and emission history.
- Hosting: Netlify edge deployment for low-latency content delivery.

IV. SYSTEM DESIGN

A. Algorithm

The core emission calculation algorithm follows these steps:

- Accept user inputs: activity type, magnitude (distance, kWh, kg, etc.).
- Map activity to IPCC-standardized emission factors (kg CO_2e per unit).
- Compute daily emission: $E = \Sigma$ ($activity_i \times factor_i$).
- Aggregate emissions by category (transport, energy, food).
- Display totals and generate AI-based reduction suggestions.

B. Software Design

The application is structured into three logical tiers: (i) Presentation Layer—React.js components rendering the dashboard, input forms, and emission charts; (ii) Business Logic Layer—Node.js functions applying emission factors and computing totals; (iii) Data Layer—SQLite schema storing user sessions, activity logs, and historical emission records.

The Jamstack approach ensures the frontend is pre-rendered at build time and served from a CDN, while dynamic data fetching occurs via lightweight API calls. This decoupling improves security, performance, and developer maintainability.

V. EXPERIMENTAL RESULTS AND ANALYSIS

A. Experimental Setup

The CO_2NTROL application was tested by logging varied daily activities—transportation (car, bus, bicycle), energy usage (appliance runtime, kWh), and food consumption (meat-based vs. plant-based meals)—to evaluate the accuracy of the calculation engine. System performance was monitored across multiple browsers (Chrome, Firefox, Safari) and network conditions (broadband, 4G, 3G).

B. Calculation Accuracy

The system successfully automated CO_2 calculations based on user input, with results matching theoretical values derived from standard IPCC emission factor tables. The emission computation engine demonstrated consistent accuracy across all tested activity categories, validating the correctness of the factor mappings and summation logic.

C. System Performance

Due to Netlify edge hosting, the application demonstrated near-native response times regardless of user location. User records were successfully stored and retrieved from the database without data loss across all test sessions. The React.js component architecture ensured smooth UI rendering with no observable lag during dashboard updates.

D. User Analytics

The application generated visual analytics enabling users to identify their highest emission sources. In test scenarios, transportation accounted for the largest share of individual daily emissions, followed by energy consumption and food choices. The dashboard's categorical breakdown proved effective in directing user attention toward the most impactful reduction opportunities.

VI. CONCLUSION AND FUTURE SCOPE

A. Conclusion

CO_2NTROL successfully achieves its objective of developing a reliable, user-friendly carbon emission tracking application aligned with UN Sustainable Development Goal 13 (Climate Action). By providing real-time emission monitoring, visual analytics, and AI-driven reduction suggestions through a modern web interface, the system demonstrates a practical application of environmental informatics for real-world climate action. The transition from manual estimation to automated digital tracking significantly lowers the barrier for individuals to engage meaningfully with their environmental impact.

B. Future Scope

Several enhancements are planned for subsequent development phases:

- AI-Based Prediction: Machine learning models to forecast future emission trends based on historical user behavior.
- IoT Integration: Direct connectivity with smart home devices (smart meters, connected vehicles) for automated activity logging.
- Gamification and Social Features: Leaderboards, challenges, and community comparisons to sustain long-term user engagement.
- Industrial Module: Extension of tracking capabilities to small business and light industrial use cases.
- Research Partnerships: Collaboration with environmental scientists for enhanced emission factor accuracy.

ACKNOWLEDGMENT

The authors express sincere gratitude to their project guide Mr. A. H. Raheja and the Head of the Department Dr. M. P. Gajare of the First Year Engineering Science Department, AISSMS Institute of Information Technology, Pune, for their valuable guidance and constant support. The authors also acknowledge the inspiration provided by Principal Dr. P. B. Mane and all staff members who contributed directly or indirectly to this work.

REFERENCES

[1] D. Bodansky, “The United Nations framework convention on climate change: A commentary,” Yale Journal of International Law, vol. 18, p. 451, 1993.

[2] Y.-M. Chou, A. M. Polansky, and R. L. Mason, “Transforming non-normal data to normality in statistical process control,” Journal of Quality Technology, vol. 30, no. 2, pp. 133–141, 1998.

[3] J. Parikh, M. Panda, and N. S. Murthy, “Consumption patterns by income classes and carbon-dioxide implications for India: 1990–2010,” International Journal of Global Energy Issues, vol. 9, no. 4–5, 1997.

[4] S. Qu, “The decomposition analysis of carbon emissions: Theoretical basis, methods and their evaluations,” Chinese Journal of Urban and Environmental Studies, vol. 8, no. 4, 2020.

[5] C. Wang and F. Wang, “Structural decomposition analysis of carbon emissions and policy recommendations for energy sustainability in Xinjiang,” Sustainability, vol. 7, no. 6, pp. 7548–7567, 2015.

[6] S. K. Sahu and K. Narayanan, “Determinants of energy intensity in Indian manufacturing industries: A firm level analysis,” Eurasian Journal of Business Economics, vol. 4, no. 8, pp. 13–30, 2011.

[7] A. O. Acheampong and E. B. Boateng, “Modelling carbon emission intensity: Application of artificial neural network,” Journal of Cleaner Production, vol. 225, pp. 833–856, 2019.