A Project Report

On

BLOCKCHAIN-BASED CARBON CREDIT ECOSYSTEM

Submitted to the

Savitribai Phule Pune University

In partial fulfillment for the award of the Degree

of

BE in Information Technology

By

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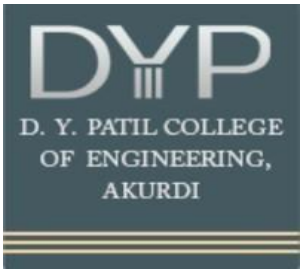

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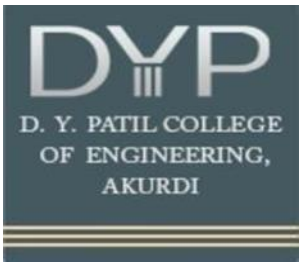
2024-25



CERTIFICATE

This is to certify that the Project Stage 1 **'BLOCKCHAIN-BASED CARBON CREDIT ECOSYSTEM'** being submitted by

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Date:

Place: Akurdi, Pune.

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ACKNOWLEDGEMENT

With immense pleasure, we present the Project report as part of the curriculum of the **B.E. Information Technology Engineering**. We wish to thank all the people who gave us an unending support right from when the idea was conceived. We express sincere and profound thanks to Project Guide **Mrs. Parvati Bhadre,** and **Dr. Preeti Patil, Head, Department of Information Technology** who is ready to help with the most diverse problems that they have encountered along the way. We express sincere thanks to all staff and colleagues who have helped directly or indirectly in completing this seminar successful.

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Abstract

Climate change and global warming are critical issues of our time. One way to address these challenges is by reducing greenhouse gas emissions through a global carbon trading system. A carbon credit is a permit that allows the holder to emit a specific amount of carbon dioxide or other greenhouse gases, with one credit typically representing one ton of carbon dioxide. These credits can be bought, sold, or traded, creating a financial incentive for companies to reduce their emissions. However, current carbon credit systems face problems like fragmentation, lack of transparency, and high transaction costs that benefit intermediaries rather than the environment. Our project proposes a blockchain-based CarbonCredit Ecosystem to solve these issues. By using smart contracts and blockchain technology, we aim to make carbon markets more transparent, accessible, and efficient. The ecosystem will include a tokenization mechanism for securely digitizing carbon credits, clear protocols for creating and retiring these credits, and a transparent system for their distribution and trading. Additionally, we will engage allrelevant stakeholders, such as the energy industry, project verifiers, liquidity providers, NGOs, citizens, and governments, ensuring that the system benefits everyone involved. This model could also be applied to other credit and trading systems.

1. Introduction

1.1. Aim

The aim of this project is to develop a secure, transparent, and decentralized Blockchain-Based Carbon Credit Ecosystem that addresses the inefficiencies of traditional carbon credit systems. By leveraging blockchain technology, the project aims to ensure the integrity and authenticity of carbon credits through immutable records and decentralized verification processes. The system will facilitate the automated issuance, trading, and retirement of carbon credits using smart contracts, reducing the risk of fraud, double-counting, and mismanagement. Ultimately, this project seeks to enhance the globalcarbon credit market by promoting trust, efficiency, and accessibility for all stakeholders, thereby encouraging broader participation in efforts to mitigate climate change.[1]

1.2. Objective

1. **Enhance Transparency:**

- Develop a blockchain-based platform that ensures full transparency in everystep of the carbon credit lifecycle, from issuance to trading and retirement, thereby reducing risks such as over-crediting and double-spending.
- Utilize smart contracts to automate and publicly record all transactions,making them easily auditable by any participant in the ecosystem.

2. **Standardize Carbon Credit Systems:**

- Establish clear and consistent protocols for the tokenization, minting, and burning of carbon credits to ensure uniformity and reliability across globalmarkets.
- Create a universally accepted digital standard for carbon credits that can beintegrated across different regulatory environments and industries.

3. **Reduce Transaction Costs:**

- Implement a decentralized platform that minimizes reliance on intermediaries, thereby reducing transaction costs and streamlining the process of carbon credit trading.
- Develop automated processes for trading and verifying carbon credits, cutting down

administrative overhead and time delays.

4. **Increase Accessibility:**

- Design an intuitive user interface that allows diverse stakeholders—including large corporations, small businesses, NGOs, and individual citizens—to easilyaccess and participate in carbon credit markets.[3]
- Enable global participation by offering multi-language support andcompliance with various regional regulations.

5. **Promote Liquidity:**

- Introduce an automated market maker (AMM) mechanism to maintain a highly liquid market for carbon credits, allowing participants to buy and sellcredits at any time without significant price slippage.
- Encourage the participation of liquidity providers by offering incentives andrewards for maintaining market liquidity.

6. **Support Global Sustainability Goals:**

- Align the platform with international sustainability goals, ensuring that it contributes effectively to the reduction of global greenhouse gas emissions.
- Collaborate with global organizations and initiatives to integrate the platforminto broader climate action strategies.

2. Literature Survey

Sr.No.	Paper Name	Author(s)	Summary
1	A Blockchain-based Carbon Credit Ecosystem	Dr. Soheil Saraji, Dr. Mike Borowczak	**Overview**: This paper addresses the need for transparency and efficiency in carbon credit trading. Using blockchain and smart contracts, the paper proposes an ecosystem that digitizes carbon credits, standardizes trading, and reduces transaction costs. **Advancements**: Blockchain can reduce over-crediting and double-spending, while tokenizing carbon credits for seamless trading. **Scope for Improvements**: The system faces challenges in scaling globally and integrating with existing markets and stakeholders
2	Leveraging Blockchain in Energy Transition and Decarbonization	Dr. Surekha Deshmukh	**Overview**: This paper explores how blockchain can drive energy transition and decarbonization. It highlights its application in peer-to-peer trading, smart contracts, and grid optimization. **Advancements**: Focuses on enhancing transparency and accountability in decarbonization efforts and utility ecosystem management using digital tools like AI and blockchain. **Scope for Improvements**: Better data governance and integration across stakeholders, along with enhanced AI models, are necessary to optimize market and operational efficiencies (3_Dr_Surekha_Deshmukh).

3	A Digital Carbon Credits Ecosystem, Powered by Blockchain	Infosys Limited	**Overview**: The paper proposes using blockchain to address the fragmented nature of carbon markets by creating a unified, transparent platform for carbon credit issuance, trading, and lifecycle tracking. **Advancements**: Blockchain can standardize carbon credit pricing, enhance transparency, and reduce transaction costs by eliminating intermediaries. **Scope for Improvements**: Further integration with IoT and AI is needed to improve data accuracy and reduce auditing complexities(digital-carbon-credits-…).
4	Blockchain of Carbon Trading for UN Sustainable Development Goals	Seong-Kyu Kim, Jun-Ho Huh	**Overview**: This paper focuses on applying blockchain to measure and verify carbon credits aligned with the UN Sustainable Development Goals (SDGs). It suggests using AI and big data for anomaly detection and trading verification. **Advancements**: The blockchain-based verification system can enhance transparency and reduce fraud in carbon trading. **Scope for Improvements**: Additional research is needed on blockchain security and scalability for wider global adoption (Blockchain_of_Carbon_Tr…).

Fig 2.1 Literature Survey

3. Problem Statement with Description

Problem Statement

To develop a decentralized blockchain-based carbon credit system that ensures transparent, secure, and efficient tracking and trading of carbon credits, reducing fraud and costs while promoting trust and sustainability through automated processes.

Description

The existing carbon credit systems face several critical issues that undermine their ability to effectively mitigate climate change. These systems suffer from fragmentation, with different regions and platforms implementing inconsistent standards and practices, leading to difficulties in verifying and comparing carbon credits. This inconsistency erodes trust in the system and hampers global efforts to standardize carbon trading.[1]

Moreover, the lack of transparency in the issuance and trading of carbon credits results in problems such as over-crediting and double-spending, which further diminish the credibility of these systems. Without clear and transparent processes, stakeholders cannot easily audit or verify the authenticity of carbon credits, leading to skepticism and reduced participation.

High transaction costs are another significant barrier, as the involvement of multiple intermediaries increases expenses, reducing the financial incentives for companies and individuals to engage in carbon credit trading. These costs disproportionately benefit intermediaries rather than contributing to actual environmental sustainability.

To address these challenges, the proposed Blockchain-Based Carbon Credit Ecosystem aims to leverage blockchain technology to create a standardized, transparent, and efficient platform. By utilizing smart contracts and decentralized ledgers, this ecosystem will enhance the integrity and authenticity of carbon credits through immutable records and decentralized verification processes. The system will facilitate the automated issuance, trading, and retirement of carbon credits, reducing the risk of fraud, double-counting, and mismanagement. This approach will lower transaction costs, increase accessibility, and promote broader participation, ultimately making carbon markets more effective in achieving global greenhouse gas reduction goals.[2]

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4. Software Requirements Specification

The purpose of this Software Requirements Specification (SRS) document is to provide a comprehensive and detailed description of the features, functionalities, and behaviors of the **Blockchain-Based Carbon Credit Ecosystem**. This document serves as a foundational blueprint for the development and implementation of the platform, ensuring that all stakeholders, including developers, project managers, regulators, and users, have a clear understanding of the system's goals and operational requirements.

The platform is designed to revolutionize the carbon credit market by leveraging blockchain technology to create a secure, transparent, and efficient environment for the issuance, trading, and retirement of carbon credits.

. 4.1. Functional Requirements

4.1.1. User Registration & Authentication

- Users must create accounts or log in using existing credentials.
- KYC procedures will be implemented to verify the identity of users.
- Authentication support for email, phone, and social media (Google, Facebook).

4.1.2. Carbon Credit Issuance

- Environmental projects can submit documentation for certification.
- Upon successful verification, smart contracts will tokenize and issue carbon credits automatically.

4.1.3. Trading Platform

- Users can buy, sell, and trade carbon credits in real-time through the marketplace.
- Automated Market Maker (AMM) protocols ensure liquidity and reduce price slippage during transactions.

4.1.4. Smart Contracts

- All transactions (buying, selling, retiring) are managed via automated smart contracts to ensure security and transparency.

4.2. Non-Functional Requirements

4.2.1. Performance Requirements

- The system must support at least **10,000 concurrent users** with minimal latency.
- Transaction confirmation times should be under **5 seconds**.

4.2.2. Security Requirements

- All user data must be **encrypted** to ensure privacy and security.
- Compliance with **GDPR** and **COPPA** regulations for data protection.
- Implement **multi-factor authentication (MFA)** for user accounts.

4.2.3. Usability Requirements

- The platform should feature a **user-friendly** and intuitive interface.
- Provide a **comprehensive onboarding process** to educate users about carbon credits and blockchain technology.

4.2.4. Compatibility Requirements

- The platform will support cross-platform usage, including **desktop**, **web**, and **mobile** applications.
- Ensure compatibility with major operating systems: **Windows**, **macOS**, **Android**, and **iOS**.

4.2.5. Scalability

- The backend architecture should scale **horizontally** to accommodate an increasing user base.
- The blockchain infrastructure must support an increasing volume of transactions over time

5. Project Requirements Specification

5.1. Software Requirements

a. Blockchain Platform:

- Ethereum (or any other suitable blockchain platform like Hyperledger orPolkadot)

b. Smart Contract Development:

- Solidity (for Ethereum-based smart contracts)
- Remix IDE (for writing, testing, and deploying smart contracts)
- Truffle Suite (for development, testing, and deployment of smart contracts)

c. Decentralized Application (dApp) Development:

- Web3.js or Ethers.js (for integrating smart contracts with the front-end)
- React.js or Angular (for building the front-end interface of the dApp)
- Node.js (for back-end development)
- IPFS (InterPlanetary File System) for decentralized storage

d. Database:

- MongoDB or PostgreSQL (for off-chain data storage and management)
- Redis (for caching and real-time data processing)

e. Security and Compliance:

- OpenZeppelin (for security audits and using secure smart contract libraries)
- Gnosis Safe (for secure multi-signature wallets)

f. Monitoring and Analytics:

- The Graph (for indexing blockchain data)
- Grafana or Kibana (for real-time monitoring and data visualization)

g. Development Environment:

- Git (for version control)
- Docker (for containerization and managing microservices)
- Jenkins or GitHub Actions (for CI/CD)

5.2. Hardware Requirements

- Processor: Intel i5 or AMD Ryzen 5
- RAM: 8 GB minimum
- Storage: 512 GB SSD
- Cloud-based servers: AWS, Azure, or Google Cloud
- High-speed internet connection for development and deployment tasks.

6. Proposed System Architecture

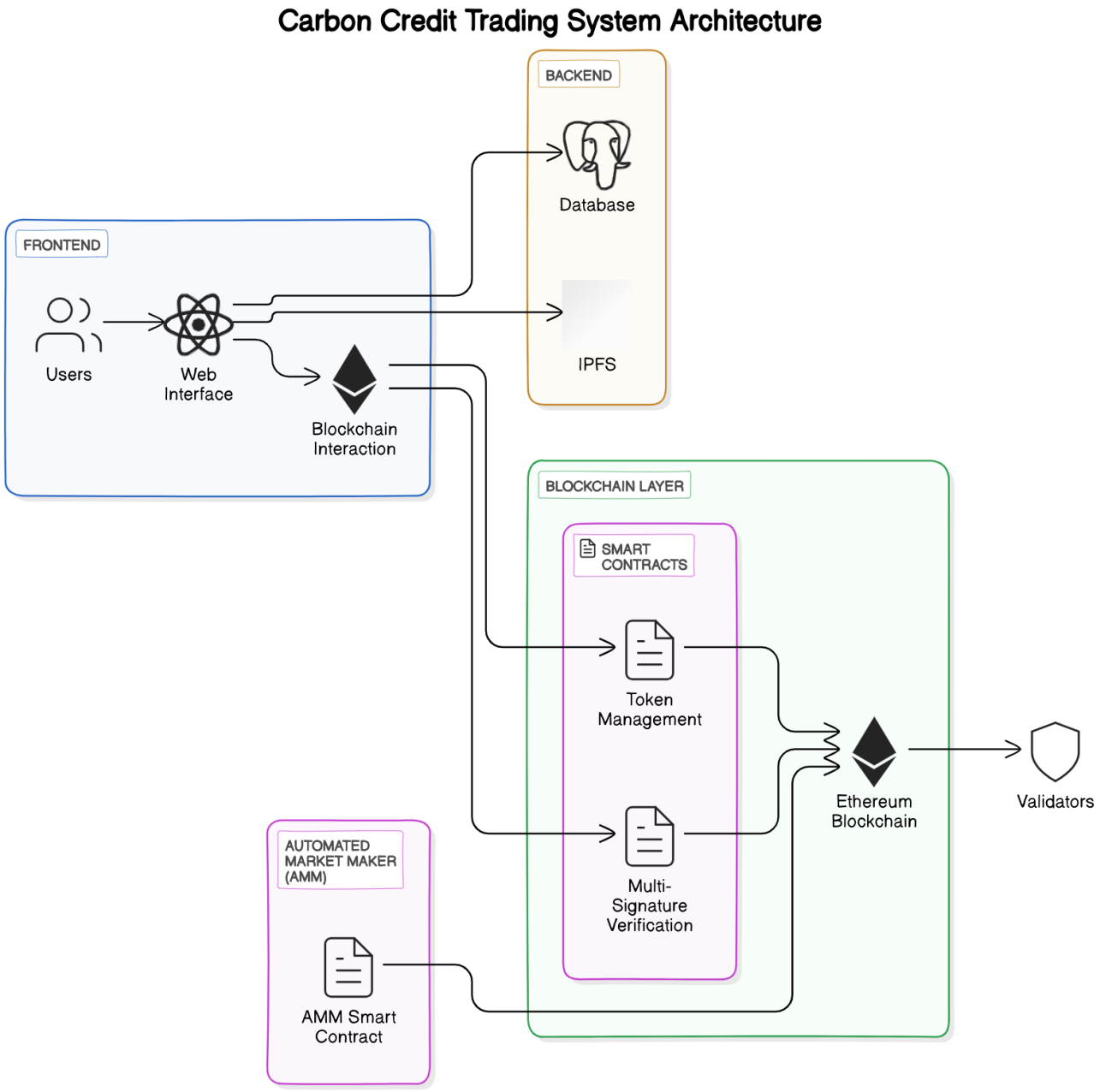

Fig 6.1 System Architecture

We aim to create a Blockchain-based Carbon Credit Ecosystem that enhances liquidity, transparency, accessibility, and standardization in carbon markets. Thisecosystem will integrate all stakeholders, including carbon credit generators and consumers, into a unified platform. Key features include:

- **Tokenization Mechanism:** Clear protocols for minting and burning carbon tokens.
- **Transparent Distribution:** A system for equitable token distribution.

- **Automated Market Maker (AMM):** Facilitates trading of carbon tokens, driven by supply and demand dynamics.[7]

The ecosystem involves several key stakeholders:

- **Generators:** Entities like wind farms, reforestation projects, and CO2 sequestration initiatives that generate carbon credits.
- **Consumers:** Carbon emitters or polluters, such as those in the energy sector, who purchase carbon credits.
- **Validators:** Accredited and globally distributed experts who validate carbon credits and onboard projects to the platform. They help ensure that the carbon credits are genuine and properly represented.

The process includes:

- **Tokenization:** Carbon credits are converted into digital tokens on the blockchain. Validated projects receive these tokens.
- **Trading Platform:** A decentralized exchange allows buyers and sellers to trade carbon tokens. Prices are determined by market forces.
- **Burning Mechanism:** Carbon tokens are retired using a "buy and burn" model, where tokens are sent to a smart contract or blockchain address with restricted access. Successful token burns are rewarded with non-fungible tokens (NFTs) representing carbon removal certificates.

6.1. Smart Contracts

The system will utilize four key smart contracts, each serving a specific function and interacting with stakeholders and liquidity providers. The design includes:

a. Smart Contract 1: Registry System

To record essential information for stakeholders, including:

- **Verifiers:** Validate carbon credits and ensure the burnt tokens correspond to actual emissions reductions.
- **Credit-holders:** Organizations that possess carbon credits within the trading ecosystem.
- **Customers:** Individuals and companies buying and retiring carbon credits.

b. Smart Contract 2: Token Management

- Approve carbon credits entered by credit-holders, as certified by verifiers.
- Mint carbon tokens based on approved credits.
- Enable transfer and burning of carbon tokens.
- Issue NFTs as certificates for successfully retired carbon tokens.

c. Smart Contract 3: Multi-Signature Verification

- **To** facilitate verification of carbon token minting and burning.
- **R**equires approval from at least 70% of verifiers before execution.[7]

d. Smart Contract 4: Automated Market Maker (AMM)

- Automate trading of carbon tokens against digital currencies (e.g., stablecoins orfuture central bank digital currencies).
- Incentivize liquidity providers through transaction fees (e.g., 0.3%) shared amongthem.
- Provide dynamic pricing for carbon tokens based on market activity

6.2. Frontend

The frontend of the Blockchain-based Carbon Credit Ecosystem provides a user-friendly interface for interacting with the system. Key features include:

a. User Dashboard:

- Centralized view of user activities, including carbon credits, tokens, and transactions.
- Notifications for important updates and events.

b. Carbon Credit Management:

- Interfaces for carbon credit generators to submit projects and for buyers andsellers to trade tokens.
- Tools for tracking market trends and transaction history.

c. Verification and Validation:

- Dashboards for validators to review and approve credits.
- Audit trail for verification activities to ensure transparency.

d. Marketplace Interaction:

- Integration with the Automated Market Maker (AMM) for trading carbon tokens and viewing liquidity pools.

e. Security Features:

- Secure login with multi-factor authentication (MFA) and data encryption toprotect user information.

6.3. Technology Stack:

- **Frontend Framework:** React.js
- **Web3 Integration:** Web3.js or Ethers.js
- **Styling:** CSS or frameworks like Bootstrap or Material-U

7. High Level Design

7.1. Flowchart

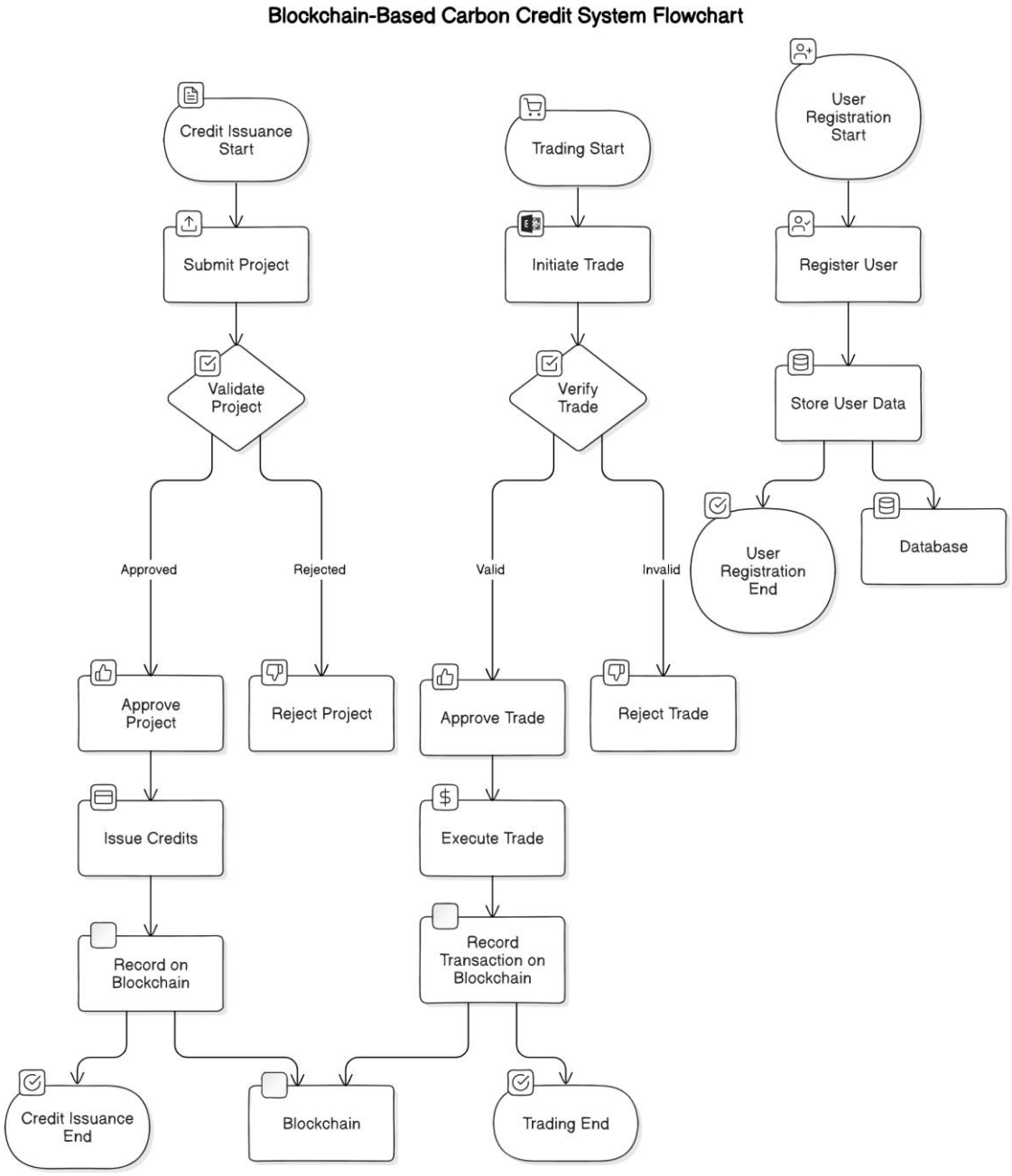

Fig 7.1 Flowchart

7.2 Sequence Diagram

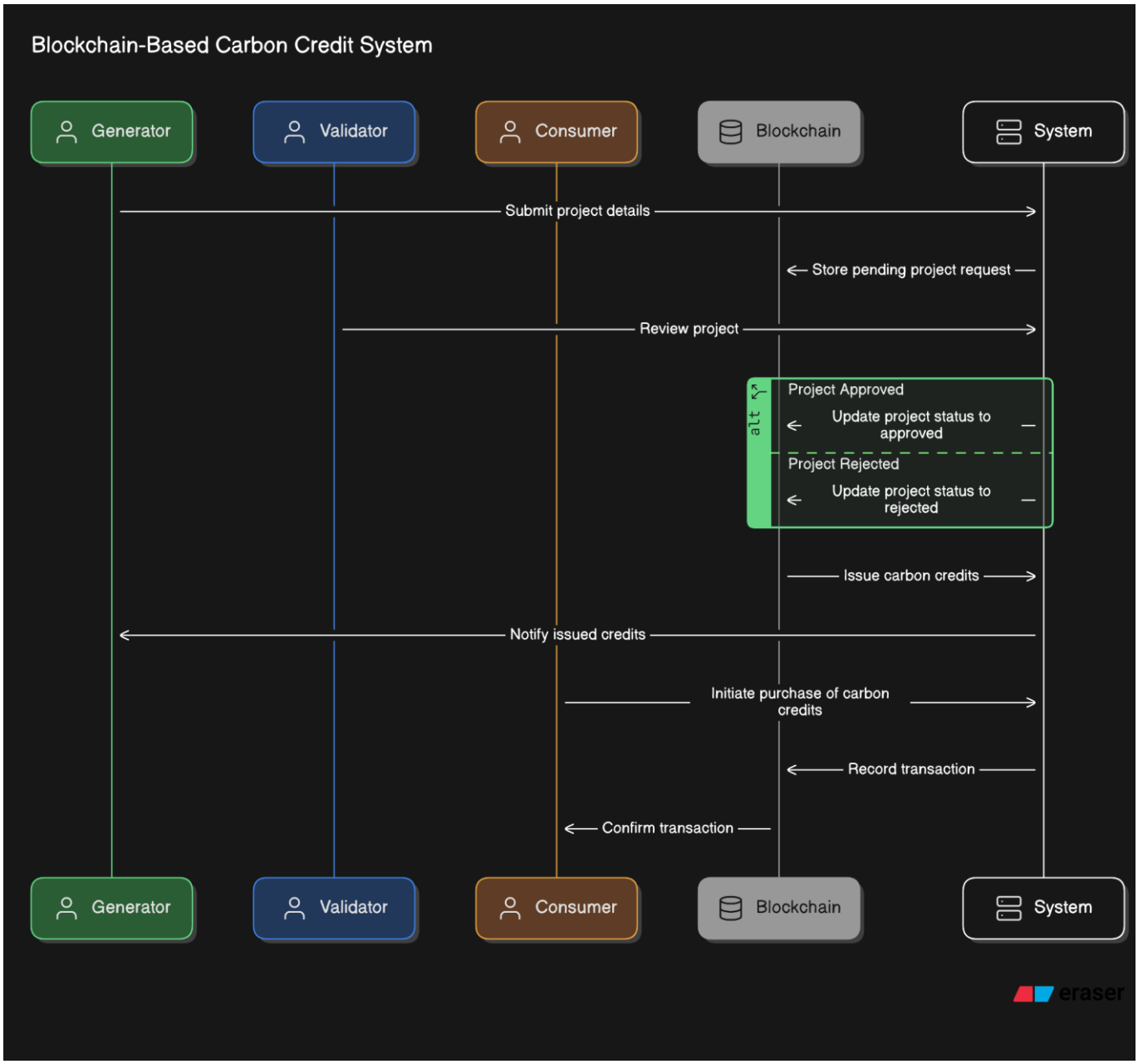

Fig 7.2 Sequence Diagram

7.2. UML Diagram

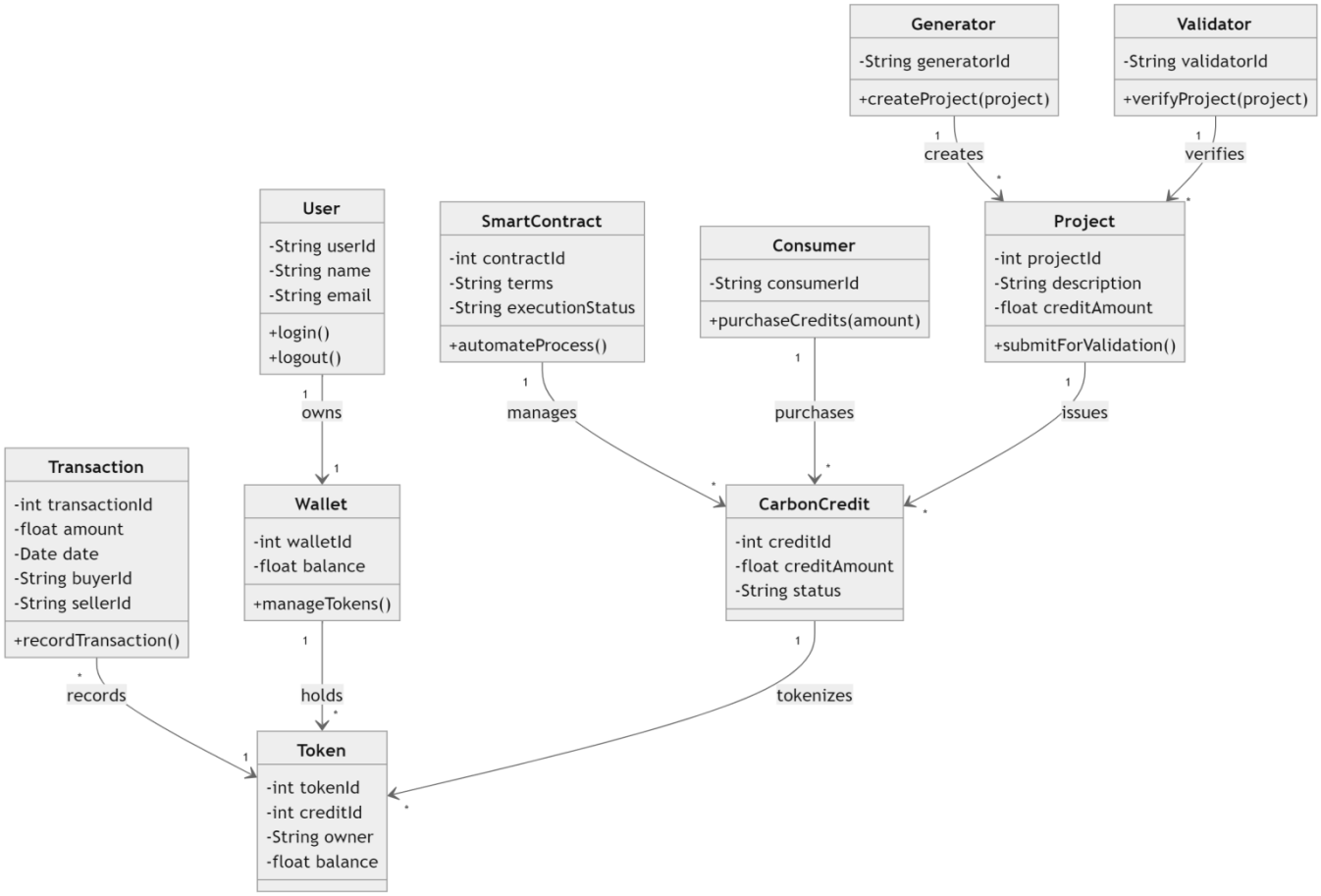

Fig 7.3 UML Diagram (Object Diagram)

8. System Implementation

The implementation of the Blockchain-Based Carbon Credit Ecosystem provides a robust solution to the challenges faced in the current carbon credit market.[5] By leveraging blockchain technology, smart contracts, and user-friendly applications, the system enhances the integrity, transparency, and efficiency of carbon credit transactions, thereby contributing to global sustainability efforts.

Implementation Steps

1. **Setting Up the Blockchain Environment**:
   - Install the Ethereum development framework (e.g., Truffle or Hardhat).
   - Configure the smart contracts and deploy them to the Ethereum test network.
2. **Developing the Web and Mobile Applications**:
   - Set up the React.js application for the web interface.
   - Use React Native to create the mobile app for Android and iOS.
3. **Integrating Smart Contracts**:
   - Use web3.js to interact with the deployed smart contracts from the web and mobile applications.
   - Implement necessary functions for issuing, trading, and retiring carbon credits.
4. **Testing**:
   - Conduct unit testing for smart contracts using tools like Mocha and Chai.
   - Perform end-to-end testing for the web and mobile applications.
5. **Deployment**:
   - Deploy the web application on a cloud platform (e.g., AWS, Heroku).
   - Publish the mobile application on app stores (Google Play Store and Apple App Store).

9. Proposed GUI/ Working modules/ Experimental Results

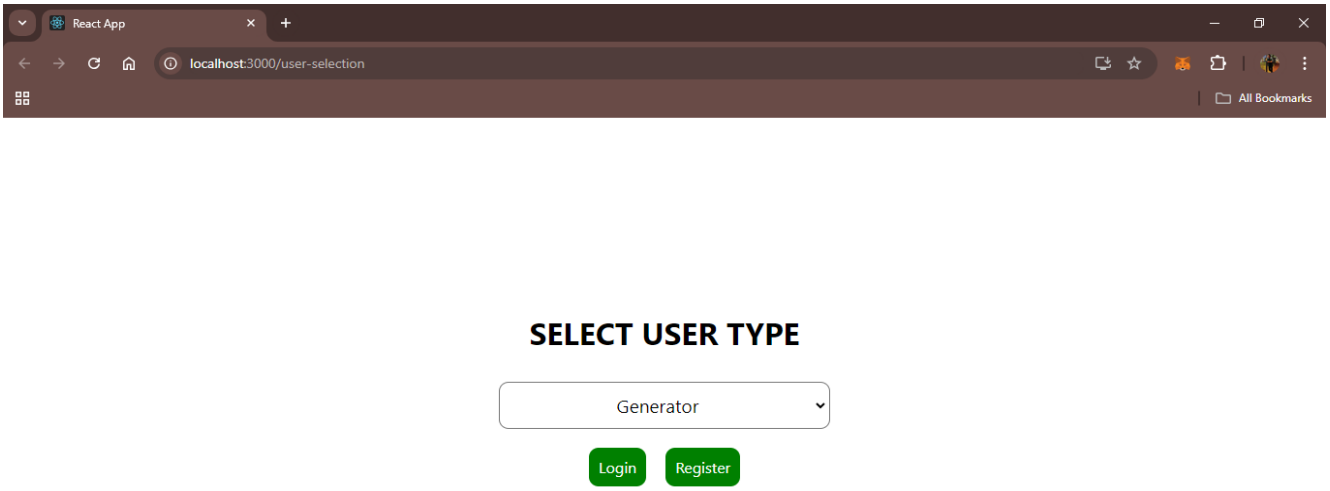

Fig 9.1 Landing Page

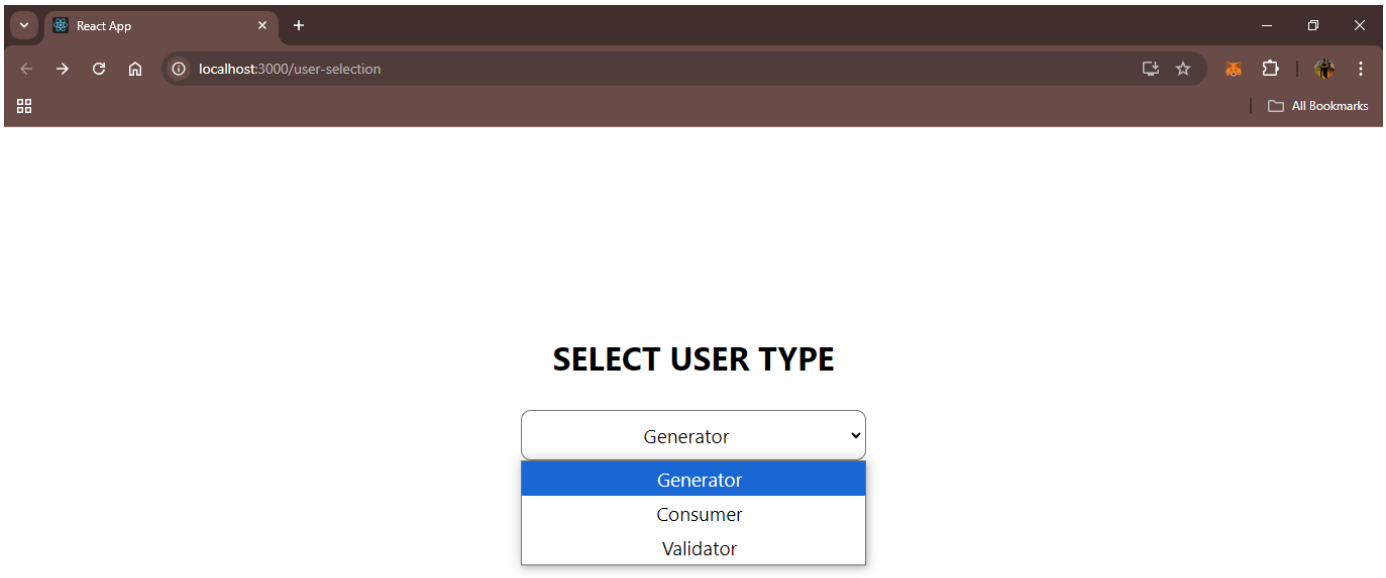

Fig 9.2 Select User Type Page

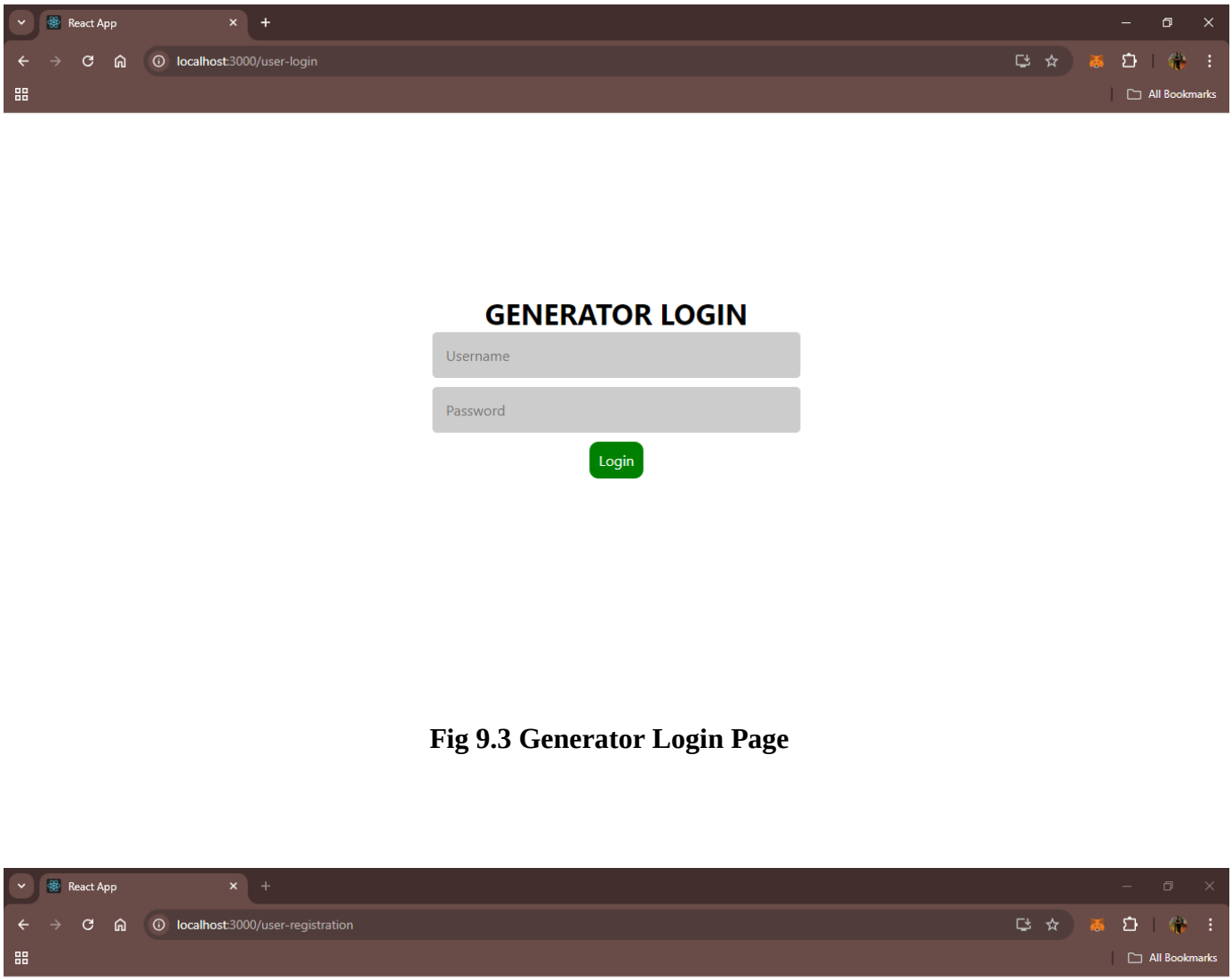

Fig 9.3 Generator Login Page

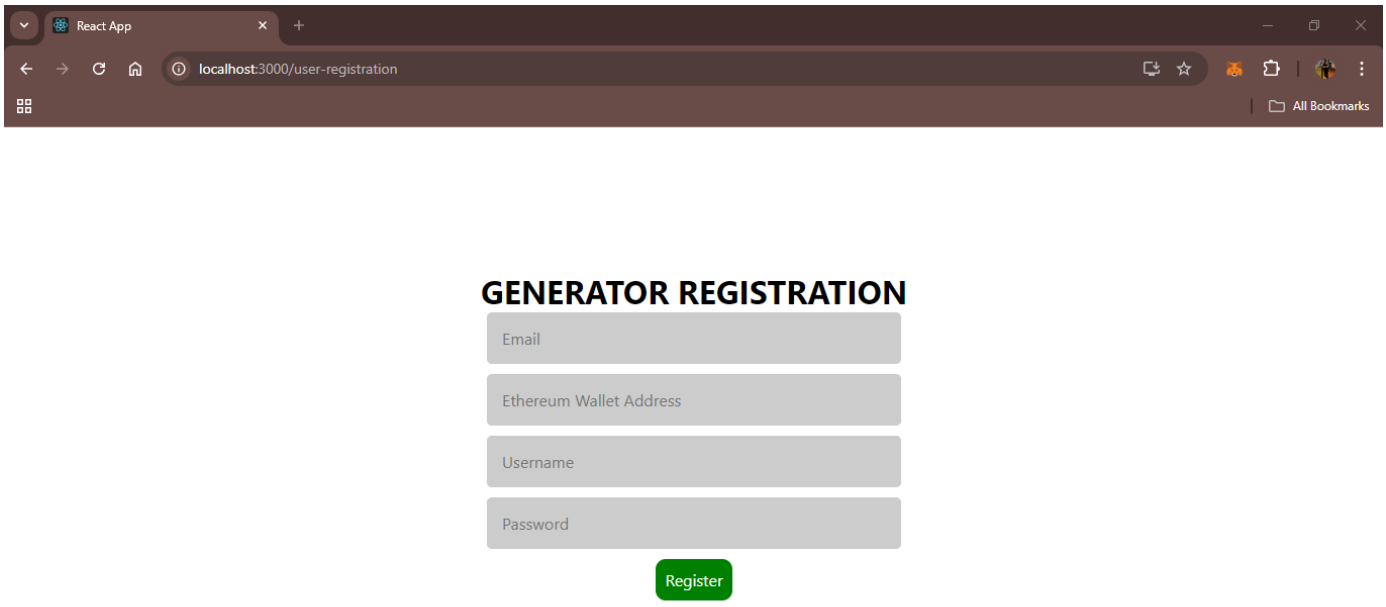

Fig 9.4 Generator Registration Page

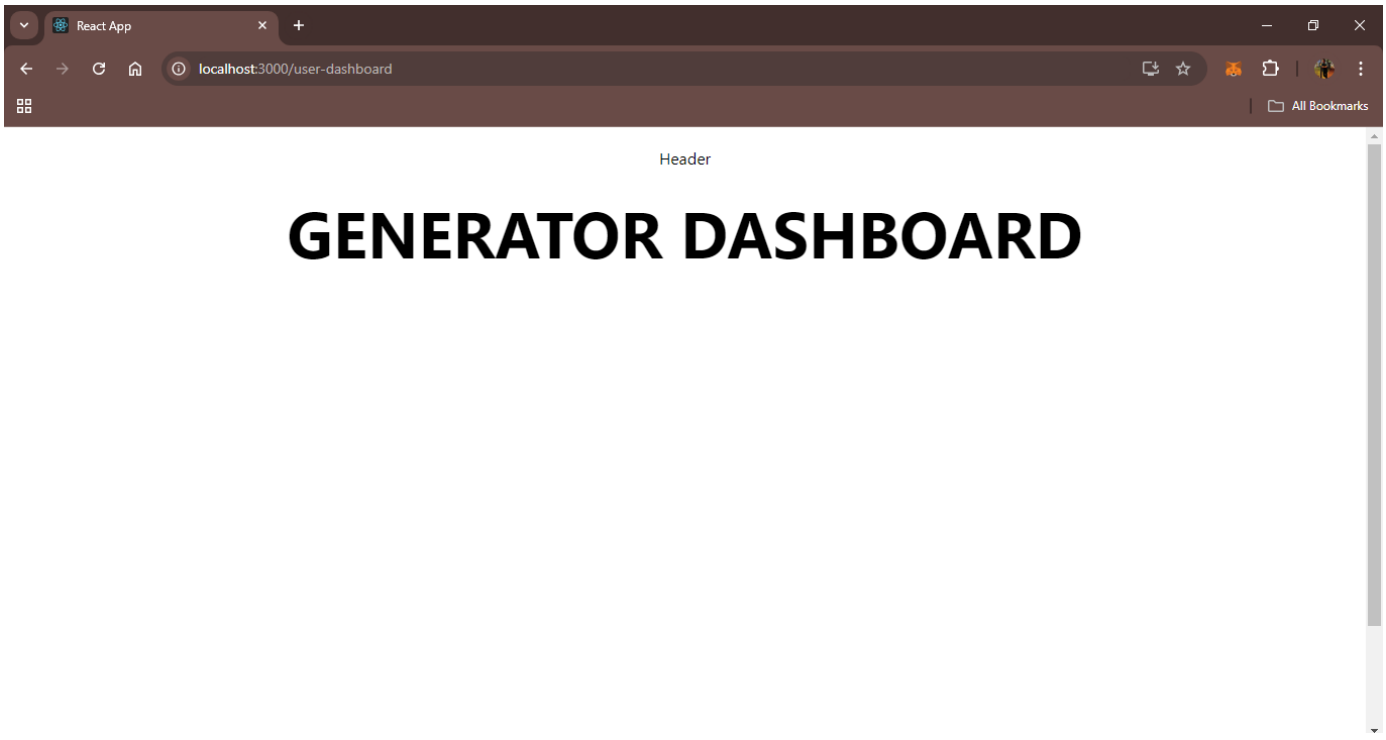

Fig 9.5 Generator Dashboard Page

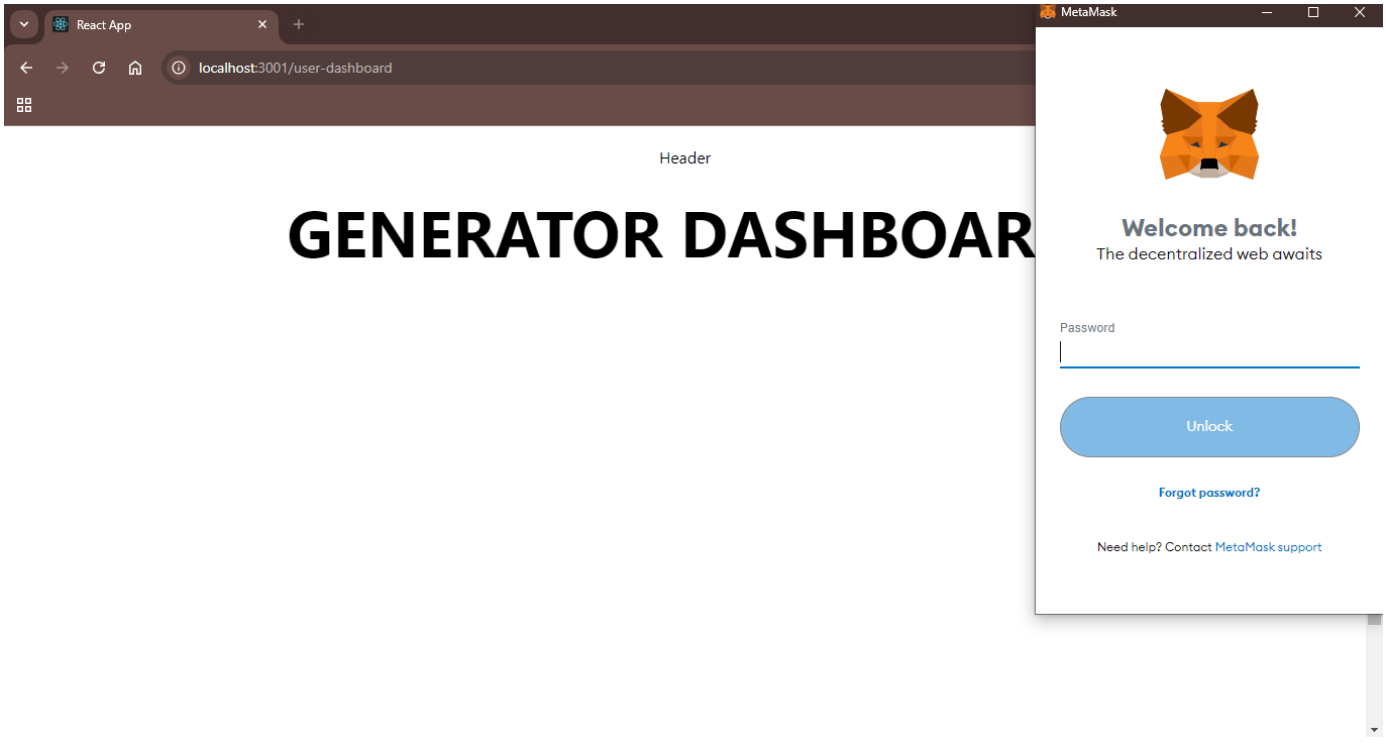

Fig 9.6 Dashboard Login Page

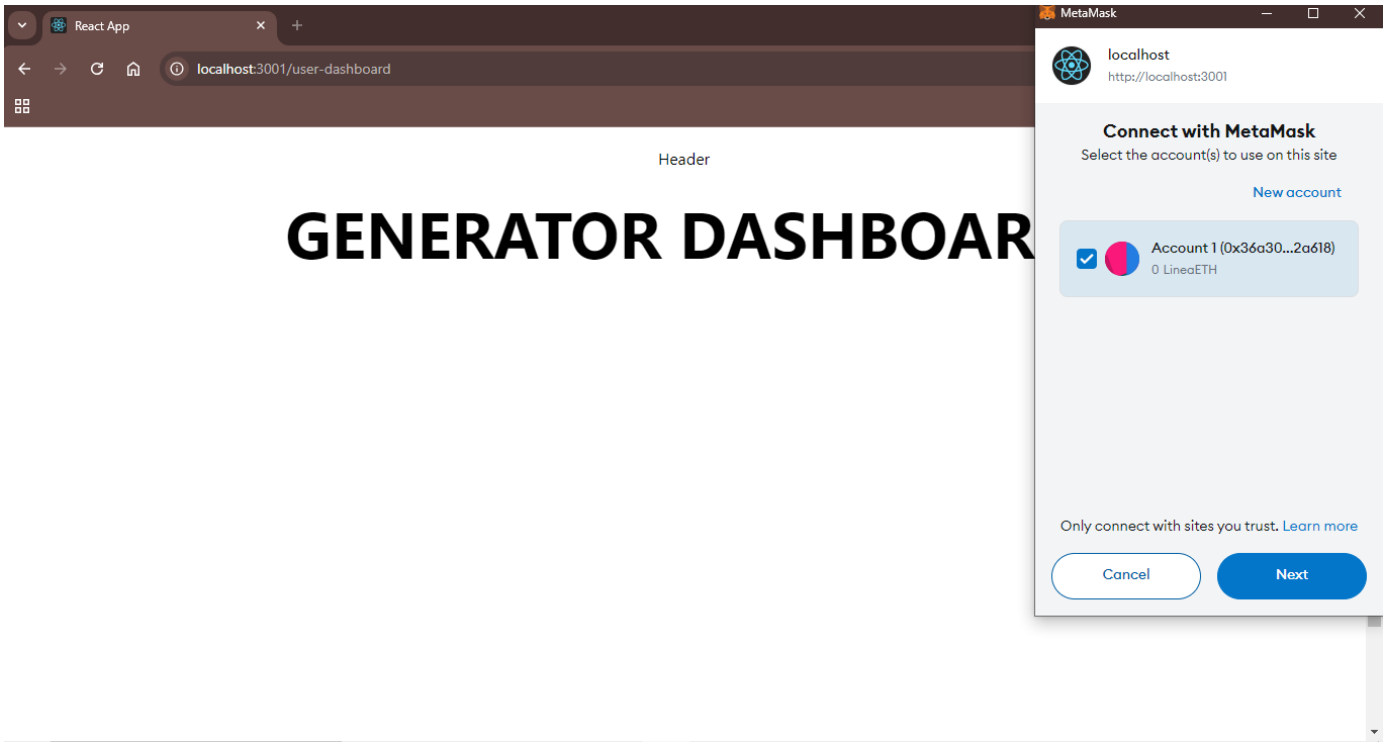

Fig 9.7 User Account Selection Page

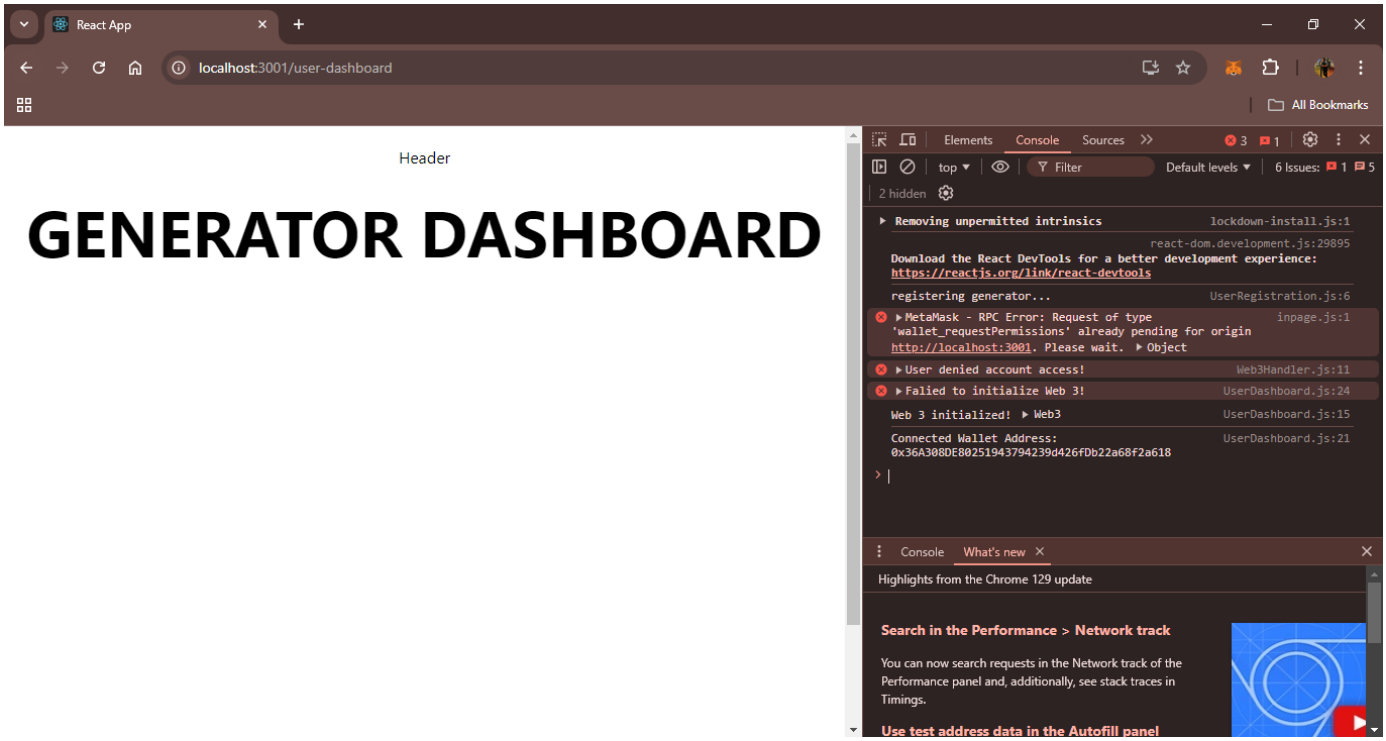

Fig 9.8 Generator Credit Wallet Page

10. Project Plan

Month	Schedule	Project Task
July	1st Week	Idea about Project Selection / Project Topic Selection
	2nd and 3rd Week	Submission of the Project Synopsis / Abstract
	4th and 5th Week	Defining Project Scope & Objectives
August	1st Week	Discussion with Guide
	2nd Week	Project Review-1
	3rd & 4th Week	Researching for More Relevant Papers
September	1st and 2nd Week	Refining Scope and Features
	3rd Week	Project Review-2
	4th Week	Follow Up and Discussion
October	1st Week	Requirements Gathering and Analysis: - Identify key requirements for the carbon credit ecosystem. - Conduct stakeholder interviews and surveys. - Define system requirements and user stories. - Analyze existing carbon credit systems and identify gaps.
	2nd and 3rd Week	System Architecture Design: - Develop a comprehensive system architecture for the platform. - Design blockchain network (node structure, consensus mechanisms, smart contract framework). - Define data flow diagrams, ER models, and user interaction flows.
	4th Week	Development of Blockchain Platform: - Implement the core blockchain platform. - Set up the blockchain infrastructure (Ethereum or Hyperledger Fabric). - Develop and deploy smart contracts. - Implement the decentralized marketplace.

November	1st to 2nd Week	Integration of IoT and Data Oracles: - Ensure real-time data integration for accurate monitoring. - Integrate IoT devices for data collection. - Connect data oracles to feed external data. - Test data integration for accuracy and reliability.
	3rd Week	User Interface and Experience Design: - Develop an intuitive and accessible user interface. - Design UI wireframes and prototypes. - Develop front-end application. - Ensure responsiveness and accessibility across devices.
	4th Week	Testing and Quality Assurance: - Validate functionality, security, and performance of the platform. - Conduct unit, integration, and system testing. - Perform security audits and penetration testing. - Gather user feedback through beta testing.
December	1st Week	Deployment and Launch: - Deploy the platform to a live environment and begin operations. - Conduct final testing and quality checks. - Launch with initial users and projects.
	2nd Week	Post-Launch Support and Maintenance: - Ensure smooth operation and continuous improvement. - Provide ongoing technical support. - Monitor system performance and implement updates. - Gather feedback for future enhancements.
Ongoing	Ongoing	Ongoing Support and Maintenance

Fig 10.1 : Project Plan

11. Conclusion

The Blockchain-Based Carbon Credit Ecosystem represents a significant advancement in the way carbon credits are managed and traded. By leveraging blockchain technology, the project aims to create a more transparent, efficient, and trustworthy system for carbon offsetting. The ecosystem addresses key challenges in the current market, such as the lack of transparency, inefficiencies in verification processes, and the potential for fraud.Through this project, stakeholders will benefit from a decentralized and secure platform that automates the lifecycle of carbon credits, from issuance to retirement. The integration of IoT devicesand data oracles ensures real-time and accurate monitoring of environmental impact, enhancing the credibility of carbon credits. Moreover, the decentralized marketplace will foster greater market liquidity and allow for peer-to-peer trading, reducing transaction costs and barriers to entry.

References

1. Andoni, M., Robu, V., Flynn, D., Abram, S., Geach, D., Jenkins, D., & Peacock, A. (2019). Blockchain technology in the energy sector: A systematic review of challenges and opportunities. *Renewable and Sustainable Energy Reviews*, 100, 143-174.
2. Kim, S., & Huh, J. (2020). Blockchain of Carbon Trading for UN Sustainable Development Goals. *Sustainability*, 12(10), 4021.
3. Luo, F., & Gai, K. (2020). A Distributed Electricity Trading System in Active Distribution Networks Based on Multi-Agent Coalition and Blockchain. *IEEE Transactions on Industrial Informatics*, 16(8), 5046-5054..
4. Wang, S., & Yu, J. (2021). Energy Crowdsourcing and Peer-to-Peer Energy Trading in Blockchain-Enabled Smart Grids. *IEEE Transactions on Industrial Informatics*, 17(6), 3564-3572..
5. Zubair, S., & Khan, F. (2020). Exploring the potential of blockchain technology for carbon emissions reduction: A review. *Journal of Cleaner Production*, 263, 121365.
6. Zhang, Y., & Li, J. (2022). Blockchain-based carbon trading platform: A new approach for sustainable energy transition. *Energies*, 15(4), 1312.
7. Pahl, S., & Grefen, P. (2020). Blockchain technology for sustainable carbon markets: A review of challenges and opportunities. *Sustainability*, 12(11), 4622.
8. Sutherland, A., & Zhou, Z. (2021). The role of blockchain in enhancing the transparency of carbon credit markets. *Environmental Science & Policy*, 121, 64-73.
9. Rojas, J., & Jha, P. (2023). The impact of blockchain on carbon credit trading systems: An analysis of market efficiency. *Energy Economics*, 112, 105894.
10. Yadav, A., & Yadav, R. (2020). Leveraging blockchain technology for carbon credits: Opportunities and challenges. *Journal of Environmental Management*, 267, 110624.
11. Rejeb, A., & Rejeb, K. (2022). Blockchain technology for carbon footprint tracking: A systematic review. *Journal of Cleaner Production*, 333, 130107.
12. Dimitrov, S. (2022). Blockchain for carbon management: A decentralized approach to carbon trading. *Computers & Chemical Engineering*, 156, 107401.
13. Farahani, R. Z., & Khosravi, A. (2021). A blockchain-enabled framework for carbon trading: Challenges and prospects. *Sustainable Cities and Society*, 74, 103201.
14. Bhatia, M., & Malik, V. (2022). Blockchain as a tool for achieving sustainability in carbon credit trading: An analytical framework. *Environmental Science and Pollution Research*, 29(6), 8438-8454.

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