P2P Energy Trading and Carbon Credit System Using Blockchain

Secure, Transparent, and Decentralized Solution for Renewable Energy and Emission Trading

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PROJECT OVERVIEW

Our project creates a blockchain-based platform for:

Decentralized P2P Energy Trading

- Prosumers sell excess renewable energy directly to consumers
- Cuts out intermediaries, lowering costs and delays

Carbon Credit Tokenization

- Auto-generates and tracks carbon credits for clean energy
- Credits can be traded securely on the blockchain

Secure & Transparent System

- Smart contracts ensure trustless, automated operations
- Promotes green energy and sustainability

Project Objective

Our goal is to build a blockchain-based system that:

Enables Fair Energy Access

- Allows direct energy trading between users without central control

Rewards Green Energy

- Issues carbon credits for verified renewable energy generation

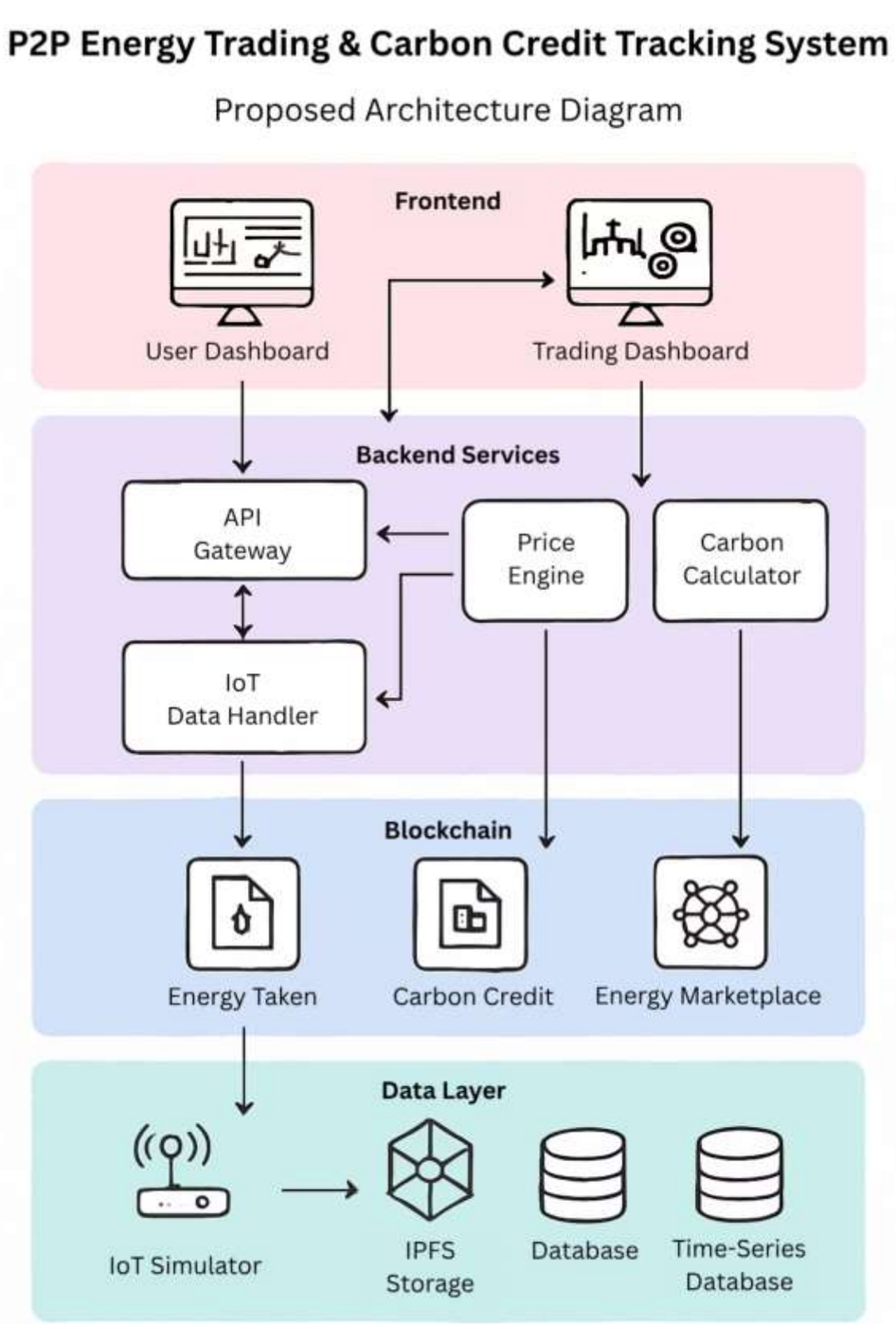
Ensures Trust & Transparency

- Uses smart contracts to automate and secure all transactions

Supports Sustainability

- Encourages local clean energy adoption and carbon offsetting

Architecture Design of the Blockchain-Based P2P Energy Trading and Carbon Credit System



Detailed breakdown of each layer of the architecture:

Frontend

Interface for users to interact with the system.

- **User Dashboard:**Displays energy usage, generation stats, and carbon credits earned. Enables monitoring of personal energy profile.
- **Trading Dashboard:**Allows users to buy/sell energy in the P2P marketplace and view transaction history and credit balances.

Backend Services

Core logic layer connecting frontend with blockchain and data processing.

- **API Gateway:**Central point of contact between frontend and backend services. Routes requests securely.
- **IoT Data Handler:**Ingests energy data from IoT devices and prepares it for processing by other services.
- **Price Engine:**Calculates energy prices dynamically based on supply/demand. Sends rates to API and Blockchain Marketplace.
- **Carbon Calculator:**Analyzes energy usage and calculates carbon credits based on saved emissions. Pushes records to the blockchain.

Blockchain Layer

Ensures secure, transparent, and immutable record-keeping.

- **Energy Taken:**Smart contracts log the amount of energy consumed or contributed by users.
- **Carbon Credit:**Smart contract manages carbon credit issuance, transfers, and balances.
- **Energy Marketplace:**Executes trading logic — match-making between buyers and sellers using smart contracts.

Data Layer

Storage of energy data and other related metrics.

- **IoT Simulator:**Generates mock energy data (generation and consumption) to test the system.
- **IPFS Storage:**Decentralized file system used to store raw energy data securely and verifiably.
- **Database:**Stores user profiles, transaction history, and structured metadata.
- **Time-Series Database:**Stores continuous energy generation/consumption data for monitoring and historical analysis.

Insights from Research Papers

Learnings from P2P Energy Trading Research

Smart Contracts Enable Secure and Automated Trading

Automated execution and settlement reduce the need for intermediaries

Ensures transparency, immutability, and lower transaction costs (Source: Renewable Energy Trading Platform using Blockchain)

Energy Tokenization for Efficient Microgrid Operations

ERC-20 tokens standardize energy units for trade

Demand response contracts balance energy supply and demand in real-time (Source: Decentralized P2P Trading in Microgrids)

Local Trading Enhances Grid Efficiency

P2P energy exchanges reduce transmission losses and enable decentralized control

Encourages local production and consumption of renewable energy (Source: Review of P2P Energy Trading)

Learnings from Carbon Credit System Research

Blockchain Prevents Over-Crediting and Double-Spending

Immutable records and smart contract-based issuance eliminate fraud

Credits can be transparently tracked across their lifecycle (Source: Blockchain-based Carbon Credit Ecosystem)

Standardization and Automation Improve Credit Validity

Emissions can be tokenized based on verified data (IoT, sensors, etc.)

Blockchain ensures fair pricing and regulatory compliance (Source: Digital Carbon Credits Ecosystem – Infosys)

Carbon Credits Can Be Linked to Energy Trades

Credits can be auto-generated based on excess green energy sold

Encourages users to adopt and trade renewable energy ethically (Source: Combined insights from papers)

Challenges Identified

1. **Scalability :** Public blockchains like Ethereum can face high gas fees and slow transaction speeds, making real-time energy and credit trading difficult and potentially expensive.
2. **Interoperability :** Integrating blockchain systems with existing grid infrastructure is complex, as legacy systems lack standard APIs or compatibility with decentralized platforms.
3. **Standardization :** There's no universal framework for measuring emissions or issuing carbon credits, leading to inconsistent verification and credit valuation across regions.
4. **Regulatory Hurdles :** Legal acceptance of decentralized trading platforms varies by country, with unclear or restrictive laws slowing down adoption and innovation.
5. **Infrastructure :** Costs Deploying smart meters, IoT sensors, and secure connectivity at scale is costly, especially for rural or underdeveloped areas with limited energy infrastructure.

How Our Project Solves These

- Use of **layer-2 solutions** for scalability
- **ERC-20 tokens and smart contracts** ensure standard compliance
- **On-chain + off-chain hybrid models** to integrate with grid
- **Permissioned blockchain** to match regulatory compliance
- **Open-source APIs and dashboards** for easy adoption

Conclusion and Future Scope

- Our platform **democratizes energy trading** and incentivizes **carbon offsetting**
- Paves the way for **community-based microgrids**
- Future plans:
  - Integration with **AI-based pricing**
  - Real-time **weather-based energy forecasts**
  - Support for **carbon NFTs**

References

Drive link for all the research papers :

Google Drive

Blockchain Project Research papers - Google Drive