Where Energy Meets Sustainability

Green Ledger

OVERVIEW

Introduction

Decentralized platform for energy trading and carbon credit verification using blockchain, zero-knowledge proofs (ZK-SNARKs), and smart contracts. It enables fair, transparent, and automated transactions in a sustainable energy market.

Core Components & Technologies

- **Smart Contracts (Ethereum-based)** → Secure and trustless energy & carbon credit transactions.
- **ZK-SNARKs (Poseidon Hash Function)** → Ensures privacy and validity of energy production without revealing sensitive **data.**
- **Chainlink VRF (Verifiable Randomness)** → Fairly selects sellers in trade matching to prevent manipulation.
- **Hybrid Gas Estimator (Blocknative + Web3 + Tatum API)** → Optimizes gas fees while ensuring transaction reliabili**ty.**

Key Challenges in Decentralized Energy & Carbon Trading

Lack of Transparency in Carbon Credit Trading

Fraudulent or double-used credits reduce market credibility.

Slow & Inefficient Order Execution

Buyers face long wait times if no immediate seller is available.

Market Manipulation in Energy Trade Matching

Biased seller selection gives unfair advantage.

Privacy Concerns in Energy Verification

Energy producers may hesitate to disclose sensitive data.

COMPETITOR ANALYSIS

Feature	Green Ledger	Toucan Protocol	KlimaDAO	EnergyWeb
Blockchain Network	Ethereum (Expandable to Polygon, BSC, Solana)	Ethereum & Polygon	Ethereum	Energy Web Chain
Token Standard	ERC-20 (Fungible Carbon Credits)	ERC-20 (TCO2 Tokens)	ERC-20 (KLIMA Token)	ERC-20 (EWT Token)
Privacy Mechanism	ZK-SNARKs for Private Energy & Credit Validation	No Privacy Mechanism	No Privacy Mechanism	No Privacy Mechanism
Gas Fee Optimization	Hybrid Gas Estimator (Blocknative, Tatum, Web3.js)	Standard Ethereum Gas	Standard Ethereum Gas	Energy Web Optimized
Fair Trading	Chainlink VRF for Random Seller Selection	Manual Pool Selection	KLIMA Token Influence	Energy Sellers Decide
IoT Integration	Supports Smart Meter & IoT-Based Energy Tracking	No Direct IoT Support	No IoT Integration	Supports Industrial IoT
Cross-Chain Trading Potential	Planned Cross-Chain Swaps (LayerZero, Wormhole)	Limited to Ethereum & Polygon	Only on Ethereum	No Cross-Chain Support
Carbon Credit Use Case	Minted only when verified renewable energy is produced	Tokenized existing credits	Used as DeFi Collateral	Direct Energy Asset Tokenization

TECH STACK

BLOCKCHAIN & RANDOMNESS API

- Ethereum (Solidity)
- Chainlink VRF

FRONTEND & USER INTERFACE

- React.js
- Tailwind CSS
- React Router

GAS ESTIMATION & COST OPTIMIZATION

- Blocknative API
- Web3.eth.getGasPrice()
- Tatum API

CRYPTOGRAPHIC HASHING & VERIFICATION

- Poseidon v2 Hash (Circomlibjs)
- ZK-SNARKs (Zero-Knowledge Proofs)

DEVELOPMENT & CONFIGURATION

- Web3.js & Ethers.js
- Clerk Authentication API

TOKENOMICS MODEL

MARKETPLACE TRADING FEES

A small percentage fee (0.5% - 2%) is deducted from every carbon credit transaction on the marketplace. This ensures sustainable revenue generation while allowing seamless credit trading. Handled by CarbonMarketplace.sol, where fees are automatically deducted from each trade.

ENERGY TRANSACTION FEES

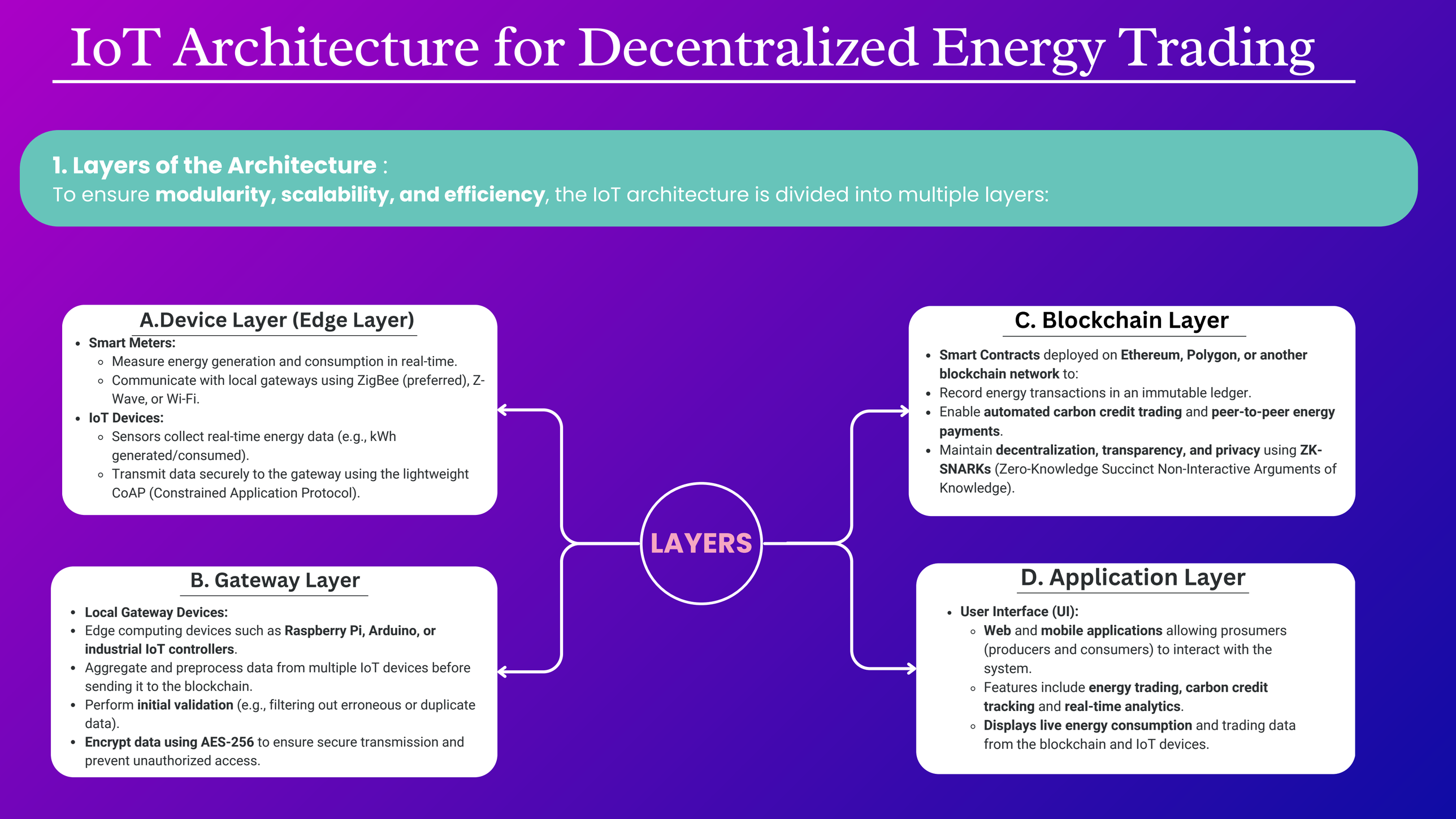
Each matched energy buy/sell order incurs a small transaction fee, ensuring that the platform remains financially viable while supporting efficient energy trading. Implemented in OrderBook.sol, which processes trade execution and fee collection.

CREDIT RETIREMENT FEES

When a carbon credit is retired (burned) for CO_2 offsetting, a minimal processing fee is deducted. This ensures verifiability of carbon offsets while maintaining platform stability. Managed by CarbonCredit.sol, where the _burn() function permanently removes credits from circulation.

IoT Architecture for Decentralized Energy Trading

1. Layers of the Architecture :
To ensure **modularity, scalability, and efficiency**, the IoT architecture is divided into multiple layers:



A.Device Layer (Edge Layer)

- **Smart Meters:**
  - Measure energy generation and consumption in real-time.
  - Communicate with local gateways using ZigBee (preferred), Z-Wave, or Wi-Fi.
- **IoT Devices:**
  - Sensors collect real-time energy data (e.g., kWh generated/consumed).
  - Transmit data securely to the gateway using the lightweight CoAP (Constrained Application Protocol).

B. Gateway Layer

- **Local Gateway Devices:**
- Edge computing devices such as **Raspberry Pi, Arduino, or industrial IoT controllers**.
- Aggregate and preprocess data from multiple IoT devices before sending it to the blockchain.
- Perform **initial validation** (e.g., filtering out erroneous or duplicate data).
- **Encrypt data using AES-256** to ensure secure transmission and prevent unauthorized access.

C. Blockchain Layer

- **Smart Contracts** deployed on **Ethereum, Polygon, or another blockchain network** to:
- Record energy transactions in an immutable ledger.
- Enable **automated carbon credit trading** and **peer-to-peer energy payments**.
- Maintain **decentralization, transparency, and privacy** using **ZK-SNARKs** (Zero-Knowledge Succinct Non-Interactive Arguments of Knowledge).

D. Application Layer

- **User Interface (UI):**
  - **Web** and **mobile applications** allowing prosumers (producers and consumers) to interact with the system.
  - Features include **energy trading, carbon credit tracking** and **real-time analytics**.
  - **Displays live energy consumption** and trading data from the blockchain and IoT devices.

Privacy and Security Measures

01 **Data Encryption**

AES-256 Encryption is used to secure energy data between IoT devices and gateways, preventing unauthorized access or tampering.

02 **Authentication & Access Control**

Secure device identity management using TLS certificates, OAuth, or blockchain-based identity verification.

03 **Privacy-Preserving Transactions**

ZK-SNARKs are implemented to keep sensitive transaction details private while ensuring data validity on the blockchain.

Advantages of CoAP for IoT Integration

01 **Lightweight and Efficient**

CoAP is designed for resource-constrained IoT devices such as smart meters.
It uses a compact binary message format, reducing overhead compared to HTTP.

02 **RESTful Architecture**

Supports a RESTful model similar to HTTP, making it easy to integrate with existing systems.
Supports common operations like GET, POST, PUT, and DELETE for managing energy data.

03 **Low Bandwidth Consumption**

Operates over UDP, which is more efficient than TCP.
Ideal for IoT scenarios where devices send small packets of data frequently.

ROADMAP

1.Ideation & Finalization

- Research existing solution and finalize the takenomics model
- Identify the key blockchain networks, APIs, and cryptographic protocols

2.IoT-Integrated Energy Consumption Monitoring

- Our system uses IoT devices and smart meters to track energy consumption and production.
- Data is verified on-chain for tampe proof renewable energy tracking.

Decentralized Smart Grid

- Unlike centralized grids that restrict energy producers, our system allows **direct participation of prosumers**

Testing, Security Audits & Deployment

- Conduct **end-to-end testing** for order matching, gas efficiency & ZK verification.
- Perform **smart contract security audits**, finalize optimizations, and **deploy on Mainnet**.

Interoperability & Multi-Chain Expansion Potential

- Our architecture supports Ethereum, Polygon, BSC, and L2 for lower fees and scalability.
- This ensures cross-chain carbon credit trading, making the system future-proof.

FUTURE PROSPECTS

Carbon Credit Prediction Markets

Implement **AI-driven analytics** to track **energy consumption and travel habits**, providing **personalized recommendations** on the number of carbon credits needed for offsetting emissions.

Carbon Credit Cross-Chain Swaps

Enable seamless trading of carbon credits across **Ethereum, Solana, BSC, and Avalanche** using **cross-chain bridges (LayerZero, Wormhole)**. This ensures **greater liquidity and accessibility** for users worldwide.

Dynamic Energy Pricing (Supply & Demand Algorithm)

Develop a **real-time pricing algorithm** where **smart contracts adjust energy prices based on supply and demand**, optimizing pricing efficiency for buyers and sellers.

AI-Based Carbon Footprint Tracking & Recommendations

Create a **prediction market** where users **stake tokens on future carbon credit prices**, with **AI-driven insights** helping investors anticipate price movements and make informed trades.

Privacy-Preserving Trade Matching (ZK-Proof Vaults)

Use **ZK-SNARKs to match buy/sell orders privately**, preventing **front-running and manipulation**, ensuring **fair and secure order execution**.

Auto-Execution of Orders (Automated Trading)

Automatically **match pending buy orders with new sell orders**, reducing **order book scanning delays**, increasing **trade efficiency**, and **notifying users of long-pending orders**.

THANK YOU