Peer-to-Peer Energy Swap with IoT, Solana, AI, and M-Pesa

Access to affordable and reliable electricity remains a major challenge in many communities, especially in rural and peri-urban areas. While households with solar panels often generate surplus electricity, others nearby may struggle with energy deficits or expensive grid power. The lack of a transparent, efficient, and trusted system for sharing this surplus energy leads to wasted potential and continued inequality in energy access.

This project proposes a peer-to-peer (P2P) energy trading platform that enables households to buy and sell surplus renewable energy directly, with payments settled in Kenyan Shillings (KES) via M-Pesa, and transactions recorded on the Solana blockchain for trust and transparency.

System Components:

1. IoT Layer (Smart Meters & Gateways)

- Each household is equipped with a smart meter (simulated using Wokwi and ESP32).

- The device measures solar generation and consumption, reporting real-time surplus or deficit.

- Data is sent to an Oracle gateway, which feeds it into the blockchain layer.

2. Blockchain Layer (Solana Smart Contracts)

- Energy production is tokenized as EnergyTokens (eKWh), where 1 token = 1 kWh.

- Smart contracts mint tokens when surplus energy is detected and burn them upon consumption.

- Tokens are exchanged in a trustless manner between households, ensuring fair energy accounting.

3. Payment Layer (M-Pesa Daraja API)

- Buyers pay for energy in Kenyan Shillings using the M-Pesa STK Push mechanism.

- The payment is confirmed by the Daraja API, after which the smart contract finalizes the energy token transfer.

- Sellers can directly withdraw earned KES into their M-Pesa wallet, making the system accessible to all.

4. AI Forecasting Layer

- Historical IoT data, combined with weather APIs, is used to forecast energy production and consumption.

- The AI system provides trading recommendations, such as the optimal time to sell or expected deficits.

- This enhances efficiency and helps households maximize both savings and income.

5. User Interface (Dashboard)

- A web-based dashboard built in React connects all layers.

- Users can monitor real-time energy balance, token balances, fiat balances (KES), AI predictions, and transaction history.

Energy and Money Flow:

- Physical Energy: Surplus power from House A flows into the local mini-grid, which House B can draw from. Energy is not sent directly but shared through existing grid infrastructure.

- Digital Tokens: Smart contracts record that House A contributed energy and House B consumed it, using eKWh tokens.

- Fiat Settlement: M-Pesa ensures House B pays House A in KES. Token swaps and payment confirmations happen simultaneously for trust.

Impact:

- For households with solar panels: Generates extra income from selling surplus electricity.

- For energy-deficit households: Provides cheaper, cleaner, and more reliable energy access.

- For the community: Promotes renewable energy adoption, reduces waste, and creates a sustainable local energy market.

- For scalability: The integration of Solana smart contracts ensures transparency and accountability, while M-Pesa guarantees accessibility in Kenya.

In summary, this project combines IoT for measurement, Solana for trustless accounting, M-Pesa for fiat payments, and AI for intelligent optimization into a single system. It creates a transparent, affordable, and community-driven solution to tackle the challenge of energy access, starting with local microgrids and scaling to sustainable smart cities.