Use of Blockchain Technology in a Local Electricity Network with a Modular Solar-Wind Power Plant

Modular power plants and boiler houses mounted on household trailers or containers have long been known. Compared to conventional power plants and CHPs, they offer ease of deployment and significantly lower manufacturing costs.

Such power plants serve as primary or backup electricity sources in hard-to-reach areas, partially or fully covering the electrical loads of industrial, residential, and social facilities. Until recently, internal combustion engines or gas turbines were the main power sources in these block power plants.

The development of mobile modular power plants has shifted towards utilizing alternative energy sources. An example is a mobile solar-wind power plant, MASWES™, developed by PATRIOT-NRG. It is designed to provide electricity to small farms or communities and it can operate both connected to the central power grid and autonomously.

MASWES™ includes two wind turbines, a set of solar panels, corresponding inverters, batteries with charge controllers, and electric vehicle charging stations. The modular solar-wind charging and generating plants have capacities of 59, 32, and 20.5 kW. The first stage of practical testing of a 20.5 kW prototype has been completed in the mountainous region of Transcarpathia, where it successfully powered a hotel facility.

Deploying such modular power plants with varying capacities enables the creation of local electricity networks by integrating individual electricity consumers. These networks can connect mobile power plants directly to individual consumers or to the low-voltage buses of a transformer substation, reducing dependence on centralized networks. Such a network may also include private household solar and wind power plants as well as private virtual power facilities.

To integrate MASWES™ into a local electricity network, an effective management method must be chosen to ensure reliability, optimal resource use, economic benefits, and resilience to outages. Local networks incorporating multiple renewable energy sources, virtual power plants, and other energy assets can be managed through one of three approaches:

1. Blockchain based on energy trading platforms.
2. Centralized platforms without blockchain.
3. Peer-to-peer (P2P) energy trading platforms.

Blockchain-based Energy Trading Platforms

- WePower (WPR): Tokenizes energy, allowing it to be bought, sold, and invested in renewable projects via smart contracts.
- Electron: A UK-based company that manages decentralized energy markets, focusing on efficient grid balancing and interactive microgrids.
- Power Ledger: A blockchain platform for decentralized energy trading.

Centralized Platforms Without Blockchain

- AutoGrid: Analyzes energy consumption and production to optimize microgrids.
- Schneider Electric (EcoStruxure Microgrid Advisor): An intelligent microgrid management system that selects energy sources to minimize costs.

- Peer-to-Peer (P2P) Energy Trading Platforms.
- Grid Singularity: A decentralized energy trading exchange.
- SunContract: A P2P platform that enables direct energy sales without intermediaries.

After evaluating these platforms, Power Ledger emerges as one the choices for integrating the MASWES™ mobile solar-wind power plant into a residential community. Power Ledger facilitates peer-to-peer energy transactions by recording real-time energy generation and consumption for all platform participants.

Power Ledger’s Hybrid Blockchain Architecture

Power Ledger operates on two blockchain layers:

- Ethereum (Public Blockchain): Handles asset tokenization and financial settlements.
- EcoChain (Private Blockchain): Records energy microtransactions.

Energy production and consumption occur at pre-set rates. Power Ledger employs two tokens:

- POWR: Grants access to the Power Ledger network.
- Sparkz: An internal token pegged to local currency for electricity metering.

These tokens facilitate peer-to-peer electricity transactions and automate payments through smart contracts. When a consumer purchases energy, the system executes the transaction via a smart contract, verifying balance and availability before recording the exchange:

- The buyer receives electricity (physically delivered through the grid).
- The seller receives Sparkz tokens, which can be converted into fiat currency or POWR tokens.

Power Ledger integrates with smart meters and IoT sensors to record in real-time:

- electricity generation (solar panels, wind turbines),
- battery charge levels,
- consumption by each network participant,
- electricity prices in the centralized system.

Meter data is stored on the blockchain, ensuring transaction transparency. The system supports dynamic pricing, allowing users to trade energy based on supply and demand.

Smart Contracts for Energy Optimization

Power Ledger's smart contracts enable the selection of the most cost-effective electricity source:

- If sufficient solar energy is generated → Use solar energy.
- If sufficient wind energy is generated → Use wind energy.
- If neither source is sufficient, but battery storage is available → Use batteries.
- If alternative sources are inadequate → Connect to the centralized grid.

By integrating machine learning into smart contracts, Power Ledger can enhance energy source selection through predictive analytics, considering historical consumption data, weather-dependent generation, and electricity tariff fluctuations.

Real-World Applications of Power Ledger

Power Ledger is actively used for P2P energy trading, virtual power plants (VPPs), and grid balancing. Some notable projects include:

- Fremantle, Australia: Enables households to trade solar electricity at better rates than those offered by traditional operators.
- Bangkok, Thailand: Microgrid participants buy and sell electricity via blockchain-based smart contracts.
- Virtual Power Plant (VPP), USA: Power Ledger enables virtual power plants in several cities, using solar panels and battery storage to trade energy at dynamic tariffs.
- Japan: Blockchain-based automatic price optimization based on real-time supply and demand.

Integrating MASWES™ into a Local Microgrid with Power Ledger

For MASWES™ to function effectively in a community microgrid, Power Ledger must enable:

1. P2P Trading: Consumers connected to the microgrid can trade energy among themselves.
2. Dynamic Pricing: The most cost-effective energy source can be selected automatically in the future.
3. Microgrid Balancing: Excess energy can be sold, and shortages can be covered by purchasing from the grid.

Technical Integration of Power Ledger with MASWES™

Successfully integrating Power Ledger into a MASWES™-powered microgrid requires the interaction of:

- Energy assets (solar panels, wind turbines, batteries).
- Machine learning algorithms (for demand forecasting and optimization).
- Smart contracts (for automated transactions and dynamic pricing).
- Blockchain infrastructure (to ensure security, transparency, and automation).

Power Ledger's smart contracts automate transactions between buyers and sellers, verify user eligibility, determine optimal pricing, and record transactions on the blockchain. The system ensures seamless energy trading by automatically debiting/crediting tokens (POWR or Sparkz) based on completed transactions.

By leveraging blockchain technology, MASWES™ can integrate seamlessly into a local electricity network, enhancing energy efficiency, transparency, and sustainability while reducing reliance on centralized grids.

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