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"An overview of the incorporation of blockchain technology in energy trading"

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Abstract-"Block chain technology has become increasingly popular in both academic and business circles for energy trading. This research offers a comprehensive literature analysis of block chain-based energy trading, covering its background, development process, and a thorough review and analysis of block chain applications in this domain. The study concludes with a summary of key findings and identifies significant future opportunities in the field."

Keywords— Ethereum, Energy trading, Blockchain, Incentivization, Smart contract

INTRODUCTION

Interconnected microgrids (IMGs) have recently garnered attention for their energy management and trading [1]. These IMGs aim to establish a market integration among various microgrids, catering to local players such as residential, commercial, and industrial clients with sustainable, clean, and affordable energy [2]. With increasing government incentives and heightened environmental awareness, energy infrastructure is progressively embracing renewable sources, particularly solar energy [3]. Prosumers, who generate part of their energy needs on-site, are key players in this ecosystem [4]. When multiple prosumers reside in close proximity, they can form prosumer communities or microgrids [5]. Prosumers have the option to either utilize the solar energy they produce for personal consumption or sell surplus energy to the grid or other consumers, facilitating energy trading as a practical means of energy sharing in daily life [6].

However, in traditional peer-to-peer (P2P) energy trading systems, ensuring participant trust, establishing energy trading prices, and enforcing agreement fulfillment without a reliable third party can be challenging or even impossible [7]. Moreover, due to the intermittent nature of renewable energy sources (RESs), some individuals may struggle to meet their energy demands while others may have excess energy [8]. Thanks to distributed generation (DG) systems, small-scale energy providers can now exchange and store energy in a decentralized manner efficiently. To address the limitations of conventional energy trading methods, such as security, privacy, trust, and pricing determination, blockchain technology is being implemented. Blockchain, renowned for its advantages across various industries, is leveraged to overcome these challenges [9].

Considerable research has been conducted on this topic [10], but the integration of blockchain technology into the energy trading industry stands out as particularly intriguing and promising. Through a blockchain-based scheme for energy trading, customers can select suppliers based on their own preferences, such as proximity or preference for clean energy, aiming to reduce electricity costs and improve returns on distributed renewable energy investments. Prior to formally integrating blockchain with the energy trading paradigm, experts explored the feasibility of leveraging distributed technology in the energy market [11]. Supported by data, the peer-to-peer (P2P) framework facilitates the involvement of "prosumers" and enables energy trading markets to operate in a user-centric manner, significantly enhancing the flexibility of traditional energy market models [12–14]. Effective and efficient solutions are essential to address user privacy, security, resource management, and price determination issues in smart grids, crucial for sustainable cities and communities.

Literature survey

BEST, a secure platform for trading of energy for EV application using Blockchain, was created by Rajat et al. [15] for their study (EV). In particular, BEST leverages distributed blockchain to validate EV requests, ensuring robustness against single point of concern. The nodes chosen by miner are nominated to authenticate the requests in accordance with the energy requirements, length of stay, dynamic pricing, connectivity history, and additional factors that are significant at the time of operation. Additionally, s/w-defined interaction is used as the backbone of the system to allocate requests from EVs to a worldwide software-based network controller in order to give real-time services. Finally, BEST is evaluated based on the expenses associated with various communications and computation costs between EVs and the smart grid. In order to boost network throughput, it will be necessary to look at the SDN's flow management method in the future.

Esmat et al. introduced a pioneering decentralized peer-to-peer (P2P) energy trading platform built on Blockchain technology [16]. This platform incorporates a groundbreaking market structure, featuring a simultaneous pool-structured auction for a short duration and a distributed Ant-Colony Optimization clearance mechanism at its core. This design ensures close-to-ideal market outcomes, preserves players' anonymity, and facilitates trade of market goods over time. Leveraging smart contracts, the blockchain layer automates processes, enhances security, and enables efficient real-time settlements. The platform's functionalities for energy trading, market clearing, smart contract execution, and blockchain-based settlements were then tested through simulations using real data. However, a limitation of this approach is its failure to account for prosumers' varying commitments and the intermittent nature of renewable energy sources.

SURVIVOR: In their study, Jindal et al. [17] introduced a Blockchain-based Edge-as-a-Service framework for ensuring secure energy trading within a Vehicle-to-Grid (V2G) environment, utilizing Software Defined Networking (SDN). The proposed system utilizes edge nodes to facilitate energy trading decisions in close proximity to Electric Vehicles (EVs). Furthermore, a selection process involving all active nodes is employed to designate approver nodes, based on a utility function, responsible for validating transactions. Blockchain technology is then utilized to ensure the security of energy trading. Once these nodes are designated, a consent-based blockchain technique is employed to enable secure energy trading within an SDN-enabled V2G environment. The authors suggest that future evaluations of this framework's performance can be conducted using a consortium blockchain system.

Zhou et al[18] .'s improvements to the decision-making trial and evaluation laboratory (DEMATEL) method include the construction of an obstacle analysis model for the relevant scenario and the use of a hesitant fuzzy linguistic word set and K-mediods clustering algorithm. In comparison to the conventional DEMATEL method, the assessment data collection is more precise and adaptable. Additionally, there may be more than two categories for the severity of aneffect, and the classification of obstruction factors is more precise. Prior to providing an overview and analysis of six specific application cases, thirteen barriers to its implementation in power trading are first mentioned. Following that, each possibility is thoroughly examined, including the causal process, impact degree classification, and quantification of influence among obstacles. In the upcoming work, the design and architecture of the block chain trading platform in each application scenario will be more thoroughly investigated Xu et al. introduced a novel approach for the autonomous utilization of Micro Grids employing Power Electronic Jointing (PEJ) based on a Master-Slave (M-S) configuration within the Industrial Internet of Things (IIoT) environment.

This setup involves a superior array performing the overarching control while an inferior array calculates the necessary control procedures for the Power Electronic Jointing. Additionally, the authors presented a new load-sharing method for renewable Micro Grids (MGs) and a secure energy policy. Intelligent control at a superior layer is achieved through a Decentralized Multi-Agent System (DMAS) based on communication. The DMAS employs two distinct control techniques, MAS balance of power control and economic load dispatch. There is significant interest among professionals in the energy sector regarding block chain technology (B.CT). This technology enables the creation of a shared and distributed database, ensuring secure, transparent, automatic, and reasonably priced operations within power distribution networks. In their future work, the authors plan to review and discuss recent proposals for addressing blockchain scalability issues, such as decentralized storage and plasma solutions. Skowronski et al. [20] demonstrated a cryptographic system concept for application in Smart Grid scenarios. This system not only handles and facilitates necessary data transmission and storage but also aims to promote the expansion of green energy fields. The value of both the cryptocurrency and the energy itself is entirely determined by supply and demand dynamics. The design emphasizes the significance of system structures being secure, dispersed, and indeed decentralized, with an enhanced level of safety provided by end-to-end encryption and anonymity provided by unspecified identities. However, due to the platform's openness, there are various methods to ensure legal compliance in each jurisdiction.

Problem addressing using Optimization technique

A micro grid within the traditional energy trading system will assist buyers and users in trading small expanses of energy during each short-term trading time period. On the basis of this supposition, Prosumers and consumers would find it challenging to inquire or bid in each trade for each period. It is vital to set a single price for each period based on the overall supply and demand offered in order to reduce this difficulty. Since energy is exchanged online, it is critical to prevent the sale of the same energy more than once. As a result, it's required to construct an energy possession structure inside of a smart contract. Unless expensive firewalls are installed, systems based on server are similarly susceptible to hackers and manipulation. The rate and maintenance expenses brought on by the secure implementation may be too expensive for micro grid-based P2P trade on a small scale.

I. **Methodology**

In order to create a dynamic rating function to set equilibrium in supply and demand among buyers and users and carry out secure trading within a microgrid, this proposal suggests a novel Smart contract-based block chain framework-based peer-to-peer(P2P) secure trading of energy system. The suggested system is based on a dynamic rating function that balances supply and demand within a micro grid and is based on block chain technology. The ratio of total supply to total demand determines whether prices go up or down each time. Prosumer (consumer) supply and demand will be encouraged or discouraged by the higher or lower price during the necessary trading period. In order to resolve any disagreements and carry out energy trade processes automatically, a smart contract built on the blockchain is used.

The proposed structure for the private blockchain linked to the microgrid begins with the registration of each prosumer or consumer intending to trade energy. Each transaction involving an externally held account includes a digital signature (DG) from the account owner to ensure validation and non-repudiation. The framework utilizes a Proof-of-Closeness (PoC) consensus process for miner selection and block creation. Transactions are the responsibility of the owner and are mined into blocks once confirmed as genuine.

Participating nodes transmit transactions containing information on executable functions, required parameters, compiled bytecode of smart contracts, and relevant smart contract addresses. Upon injection of energy transactions into a block, all nodes execute smart contract functionalities based on defined parameters. When a prosumer injects surplus energy, a notification message creates an element with updated status indicating "Injected Energy."

Energy transmission among participants is managed by the Distribution System Operator (DSO), which operates the blockchain network, develops or updates smart contracts for energy exchange, and facilitates direct communication between nodes to bypass lengthy consensus processes. Only qualified nodes' private keys can update states, ensuring security against unauthorized alterations. Energy possession variations during transactions are securely maintained within the smart contract to prevent double-sale issues.

This peer-to-peer (P2P) secure energy trading system, built on a blockchain framework, plays a vital role in fostering sustainable cities and societies.

I. Architecture Diagram

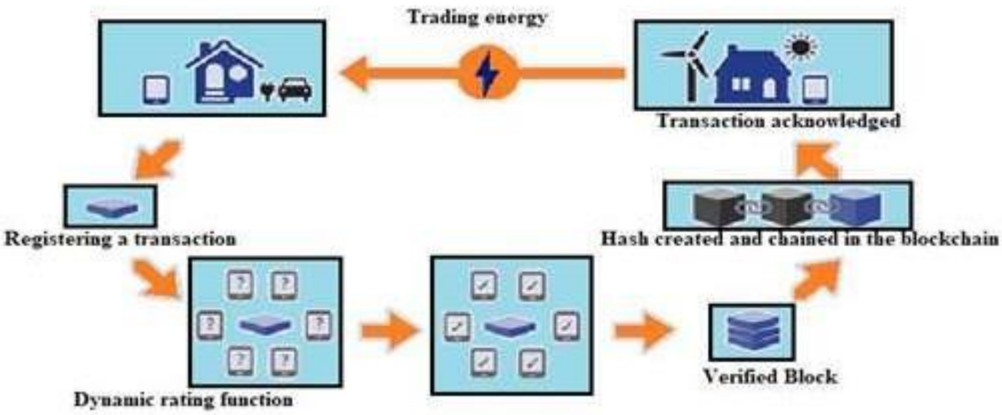

Fig1: Architecture of Authentication by Smart Contract

Conclusion

Following a review of the literature, many scholars are showing keen interest in block chain based energy trading as an evolving and potent technology. This essay outlines the primary challenges across four key areas: (1) establishing the trading platform, (2) addressing operational mechanism considerations, (3) ensuring the trading platform's robustness in terms of redundancy, economics, privacy, security, and scalability, and (4) harnessing the innovative potential of the platform technology for trading. While much of the research remains in its infancy, the development of a functional platform for energy trading and the implementation of efficient algorithms are poised to be significant focal points in future research endeavors.

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