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# Decentralized Energy Trading

Kajal Jewani[1], Ria Dharmani[2], Archana Bhatia[3], Mohini Bhave[4], Aishwarya Sahoo[5]
Department of Computer Engineering
Vivekanand Education Society's Institute of Technology
Chembur, Mumbai, India

**Abstract:- This paper describes how blockchain technology can be incorporated in the energy trading process. A decentralized approach can give more power to the prosumers and hence promote renewable energy production and consumption.**

***Keywords:-*** *Renewable Energy, Blockchain, Prosumers, Peer-to-peer energy trading, daily consumption tracking.*

## I. INTRODUCTION

Renewable energy sector has shown appreciable growth in the Indian power network, from 65.78 billion units in 2016 to 126.76 billion units in 2019 [1]. This cleaner, greener alternative has proven extremely useful in reducing emissions. As a part of the Paris agreement commitment the Indian government has a target of producing 175 GW of renewable energy by 2022. But, renewable energy tends to pose several problems such as- variation in supply, expensive storage and selective availability. The fluctuations in supply make it imperative to either consume renewable energy as it is generated or opt for the prohibitively expensive option of battery storage to minimize wastage. The 3Ds- decarbonisation, decentralisation and digitalisation summarize future requirements of energy. Hence, we propose an energy trading system empowered by blockchain to effectively trade energy among peers on a grid. The blockchain platform chosen for implementation is geth. Ethereum is inherently public, but using geth the network can be implemented in semi-private form. Additionally, we discuss the future scope of this study using IoT devices.

## II. EXISTING SITUATION

India has now become the third-largest consumer of electricity in the world [1]. The energy demand of the country is growing at a whopping rate of 6% per annum, while the share is set to roughly double to ~11% by 2040 [2]. The primary sources of power are listed in the following table along with their contribution to power generation.

| Sources | Contribution |
|---|---|
| Oil | 29% |
| Gas | 6% |
| Coal | 56% |
| Hydro | 4% |
| Nuclear | 1% |
| Renewables (including biofuels) | 3% |

Table 1:- Sources of Power with Contribution

The above table clearly shows our huge dependency on non-renewable sources for power generation. Hence, it is the need of the hour to make use of other alternative sources of power.

The carbon emissions are increasing at an alarming rate across the globe. Being the third-largest emitter of greenhouse gases, India has vowed a 33-35% reduction in the emissions intensity by 2030 [3]. To achieve this, the current government has a plan of additional renewable capacity installations of 175 GW by 2022, of which 100 GW would be solar. The government is also giving a subsidy of up to 70% to encourage the installation of solar panels.

However, today the generated solar power must be diverted to national grids for distribution. The solar power generated by the solar panels is much more than that actually transferred to the grid. A major portion of this energy is wasted either as conversion losses within the components or as transmission losses through wires. There is no off-grid mechanism to cut down such wastage of power and resulting transmission costs. The existing grids are not well-equipped to efficiently handle renewable energy. The producers and consumers depend on

centralized systems, which in turn, raise infrastructure set-ups and admin costs. What the situation demands is a technology that supports decentralized, distributed, and automated power generating frameworks, which can ensure the peer-to-peer sale of solar energy directly.

The technology that seems to be the most promising for these varied demands is- Blockchain.

## III. BLOCKCHAIN

Blockchain is an immutable digital ledger. There is no centralized authority responsible for the management of the blockchain, it is maintained by a group of concerned individuals.

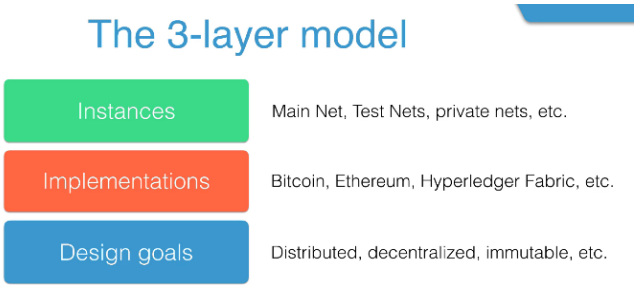


Fig 1:- The 3-layer model of Blockchain[4]

### *A. Types of Blockchain*

➢ *Public*

Permission less/public blockchain is a completely decentralized form of a digital ledger. No central authority is in control, and anyone can mine blocks from the public platform. This freedom entails a reduced sense of security. Hence some kind of consensus mechanism has to be applied. Users have to invest their resources for carrying out transactions or accessing the ledger. As a result of which these networks prove to be expensive, especially for data storage [5].

➢ *Private*

Permissioned/private blockchains are the ones where a central authority/organization controls the mining on the blockchain. Every user first has to be authorized and only then can they read/carry out transactions on the blockchain. Authorities are empowered to impose certain access control mechanisms on the users for reading or transaction issuing. Consensus is used here as well but users do not have to expend their resources in processing transactions. Hence private blockchains are faster and inexpensive as compared to their public counterparts. However, this type of blockchain cannot be classified as decentralized, thereby compromising a major functionality of blockchains.

➢ *Consortium*

A consortium blockchain presents a trade-off of sorts between the completely decentralized public network and the single entity monitored private platform. [6]

Permissioned: Only a pre decided group of individuals are authorized to be a part of the network.

Semi-decentralized: Supervised by members of the group; Multi-party consensus: all operations are verified by specific nodes.

### *B. Consensus*

Since blockchain is a decentralized system with no central authority to monitor the network, a consensus mechanism is required to make decisions. The consensus mechanism is a dynamic way of reaching agreement in such a network. In a permission less setup, consensus mechanisms account for maliciousness; especially Sybil attacks. Generating multiple identities to manipulate consensus processes is allowed by Sybil attacks [7]. Consensus algorithms do not merely agree with majority votes, but also agree to one that benefits all of the users in the network.

A consensus mechanism would satisfy the requirements if it can:

1. handle maximum percentage of malicious participants
2. carry out at low operational costs
3. prevent clustering of dominating parties in the network
4. discredit malicious behaviours.

The consensus rights are assigned to the individual nodes based on their ownership of some kind of scarce resource [8]. Different algorithms use different scarce resources. The two most popular consensus mechanisms are:

➢ *Proof of Work(PoW):*

The main objective behind this technology is to solve complex mathematical problems and to give out easy solutions. Hence, massive computational power is required to validate and store a set of transactions on a blockchain network. However, proof of work does possess some limitations. As the network grows, the amount of energy required is huge. The process increases the overall sensitivity of the system.

➢ *Proof of Stake(PoS):*

PoS addresses the main flaws of PoW. In this algorithm, each block is validated before the network adds another block to the ledger. Any individual can act as a validator and the selection process depends directly on the amount of coins he possesses. The bigger the amount possessed, the higher is the probability of selection.

The PoS principle doesn't require any heavy hardware backup. It simply needs a computer system, a stable internet connection and a decent amount of coins in your wallet. However, the main drawback is that full decentralization is not possible. Eventually the individuals with the maximum amount of coins will dominate the network.

*C. Advantages of Blockchain*

- Immutable: Blocks can only be added in the blockchain, and cannot be removed.
- Sustainable environment: Decentralised and digitised implementation of blockchain provides a trustworthy platform for exchange of renewables.
- Secure: All the participants in the permissioned network have to be authorized by the handful of governing bodies. Therefore, all the transactions and data reads are performed by trusted parties.
- Independent: Keys are auto generated with no control by third parties.

## IV. IMPLEMENTATION

*A. Ethereum*

Ethereum is one of the most widely used public blockchain platforms. It provides a platform for running and testing smart contracts [9]. A state is referred to as an account, each account has a unique 20-byte address. When a transaction takes place, a state transition between accounts is recorded.

An account contains four fields:

- Nonce, (Number Only Used Once) is a counter used to ensure that a single transaction takes place only once.
- Current ether balance
- Contract code, if a contract is linked to the given account
- Account's storage (empty by default)

*B. Smart contracts*

A smart contract is essentially a cryptographic box that is unlocked when certain conditions are met. The application of smart contracts will reduce the cost of management and at the same time, avoid unnecessary disputes because all the transactions are transparent here [9].

*C. Peer to peer network*

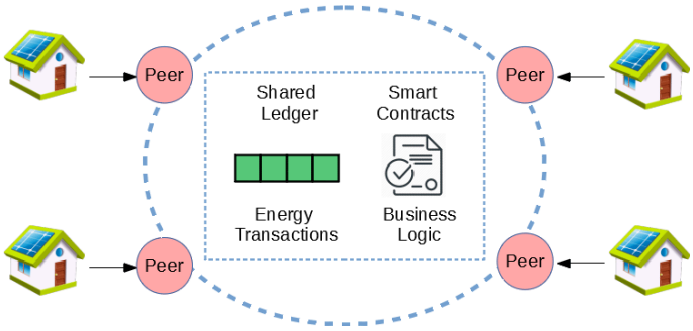


Fig 2:- Peer-to-Peer energy trading [10]

In such a scenario every node is considered as an entity, which can be classified as either a consumer or a prosumer. In a grid where all the entities are interconnected with one another, the prosumers will put forward an offer the node that lies closest to the prosumer will have more preference to the transaction, to avoid any sort of energy losses during transmission.

*D. Working*

The private ethereum network is isolated from the main net. This makes it ideal for organizations where sensitive data may be published on the blockchain. Additionally, all the transactions on the private network will be free of cost and mining difficulty can be set during creation. These advantages make private blockchaining the preferred methodology over public networks [11]. Geth is a command line interface tool that connects our system to the ethereum network. Enabling transactions, mining ether, creating smart contracts and private blockchains [11].

Every user on the microgrid (network) will have two attributes, a public and a private key. A deployer node, or the bootstrap node, will authenticate users on the network and will serve as a medium for transactions. The aggregator node will receive all the demand requests and map these requests to the prosumers. Following which the transaction is verified using proof of stake principle. After the transaction has been successfully verified then the block is added to the blockchain network. The server on the aggregator end will initiate a bank transaction. Wherein, the equivalent amount of units which have been exchanged is transferred from one bank account to another.

When a consumer initiates a transaction, it is broadcasted on a network. All the peers depending on their state can participate in the transaction. The nodes with greater energy demand than supply will become consumers and ones which have more energy supply than demand will become prosumers. The system is buyer initiated. The Deployer node propagates the transaction to a suitable consumer node and the transaction takes place. Ethers are transferred from the deployer to the consumer's wallet. The condition that is kept in mind is the problem of double spending.

## V. DAILY CONSUMPTION TRACKING

Some of the main components of a microgrid system are renewable energy resources, different types of energy storage devices, operation mechanisms, and various real-time monitoring and management/control methods. For real-time monitoring, IoT devices can be used. For a system having a microgrid having aggregate node setup, we can track production and consumption within the grid using live data given by smart meters integrated with IoT devices.

A peer-to-peer distributed energy network is composed of two layers. One layer is a physical energy network and the second layer is a virtual energy trading network. The physical layer includes a distribution grid that is responsible for the physical transfer of energy between the peers. The virtual trading platform includes the technical infrastructure i.e blockchain-based architecture for the local energy market. IoT is included in the physical layer.

Using IoT systems, smart devices are introduced to interact with smart contracts and transmit energy data i.e. consumption and production by users, to be stored in the digital ledgers. Some of the IoT devices are listed below:

- Rotary potentiometers
- Analog to Digital (ADC) converter chips
- Raspberry Pi 3

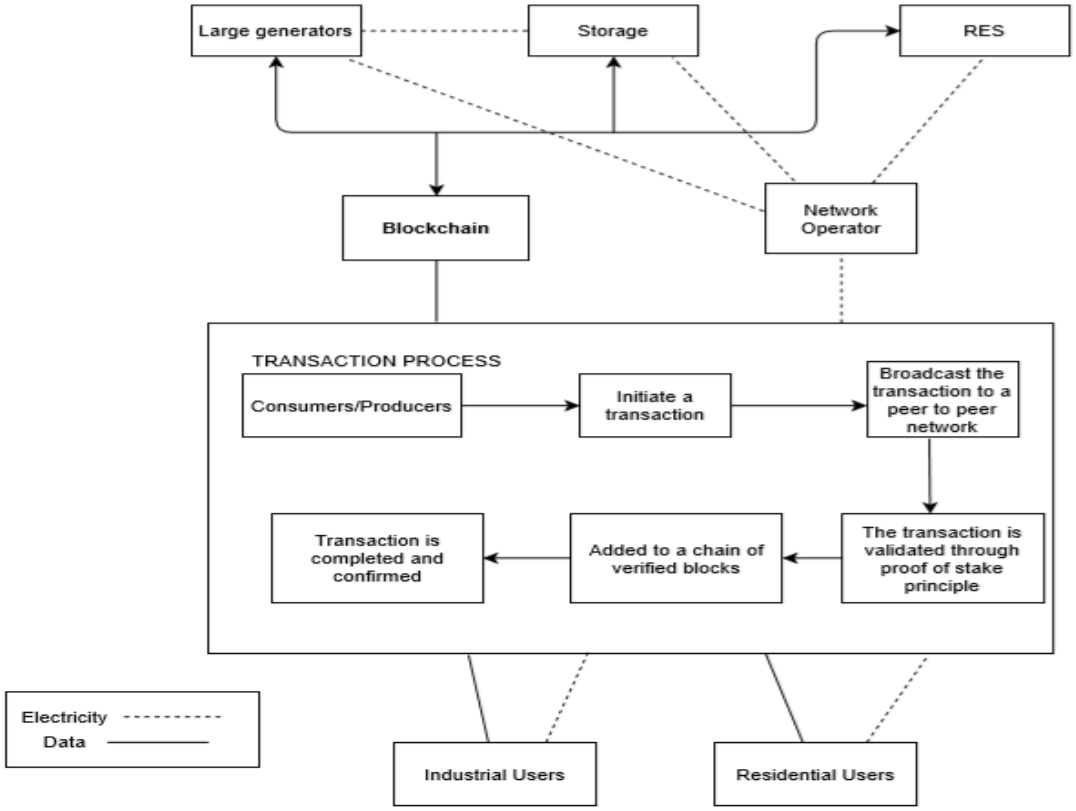


Fig 3:- A P2P network block diagram

The Kwatt production and consumption data gathered using IoT can be used to get electricity usage patterns for all users and predict when there is excess production and allocate it to required consumers as per that user's consumption pattern. Algorithms can be used to allocate consumers to prosumers according to factors like demand-supply and distance. In addition, calculations of electricity bills are based on two electricity rates (utility grid and microgrid), which results in the reduction of electricity bills when electricity users accept the power supply from the community microgrid system.

## VI. CONCLUSION

This method of decentralizing the trade of energy successfully eliminates the need for third parties in the exchange structure. In a P2P network, transactions are free (in private networks) hence reducing power transfer costs. The transition from a hierarchical network to a distributed one results in more power to the prosumer, consequently encouraging homes to generate power and promoting the use of renewable energy. Additionally, the excess power which would have been wasted otherwise can now be easily exchanged with peers across the grid; this method provides for a cheaper alternative to battery storage.

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