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ECONOMIC ANALYSIS OF TRANSMISSION SYSTEM USING BLOCKCHAIN TECHNOLOGY

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Keywords:

Blockchain technology; Digitalization; Electrical market; RES.

A B S T R A C T

All the national and international regulatory boards are making different urgent decisions on decarburization of society, it is concomitant with digitalization and decentralization of power sector interconnected with renewable energy sources in the modern era. The Distributed Ledger Technology blockchain can be used in the energy sector in different aspects like generation, transmission, and distribution. The initial application of blockchain technology is to pay electricity bills by using the cryptocurrencies is presented here. The variable RES like wind, solar in the grid integration how the DLTs will contribute to the enhanced management of the power system. Finally, the transmission sector transmission charges based on power production, and losses are ruined optimally and blocks are interconnected to blockchain are presented clearly. Implementing blockchain technology to the transmission system generation, and distribution systems lead to the digitalization of the electrical industry. Using the blockchain technology the end-users to generation cost analysis will be recorded.

1. INTRODUCTION

The utilization of electrical energy is increasing drastically day by day in all countries, to surplus the electrical demand the traditional fossil fuel power plants need more fuel which leads to more emission of carbon in the environment. To satisfy the industrial, commercial, and domestic loads the renewable energy like solar, offshore, and onshore wind, bio thermal, ocean energy, etc., are playing a key role. Smart infrastructure, renewable energy sources (RES), Electric hybrid vehicles (EHV) are widely spread. Load forecasting, Demand response management, Energy management are becoming more common in the energy sector. All the data are stored which leads to the use of the big database.

Utilize indigenous sources of energy and infrastructures for different local uses and promote rural communities, to utilize promptly renewable energy Aldo Iacomelli, PhD. Difficult to forecast the RES, they depend on weather environments. Variable RES increases the new challenges to ensure system stability, reliability, and safe operation of the interconnected system Eid C, Codani P. The total renewable energy power generated from 2010-2019, and the major RES contributed like wind, solar, and bioenergy is shown in figure 1 IRENA (2020). Investment in the wind energy sector increased exponentially from 1982 to 2010, with the height (25 m

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to 150 m), diameter (15 m to 125 m), and power (55kW to 5000 kW). Similarly, solar energyinvestments are increased from standalone plants to central plants from kW to MW. Grid integration, smartinfrastructure, implementing SCADA to control the power system which leads to large assets in different sectors in the generation, Transmission, and Distribution. Improvement of profile parameters of the network by installing the FACTS devices leads to the extra cost of the power system network Sunil Kumar J.

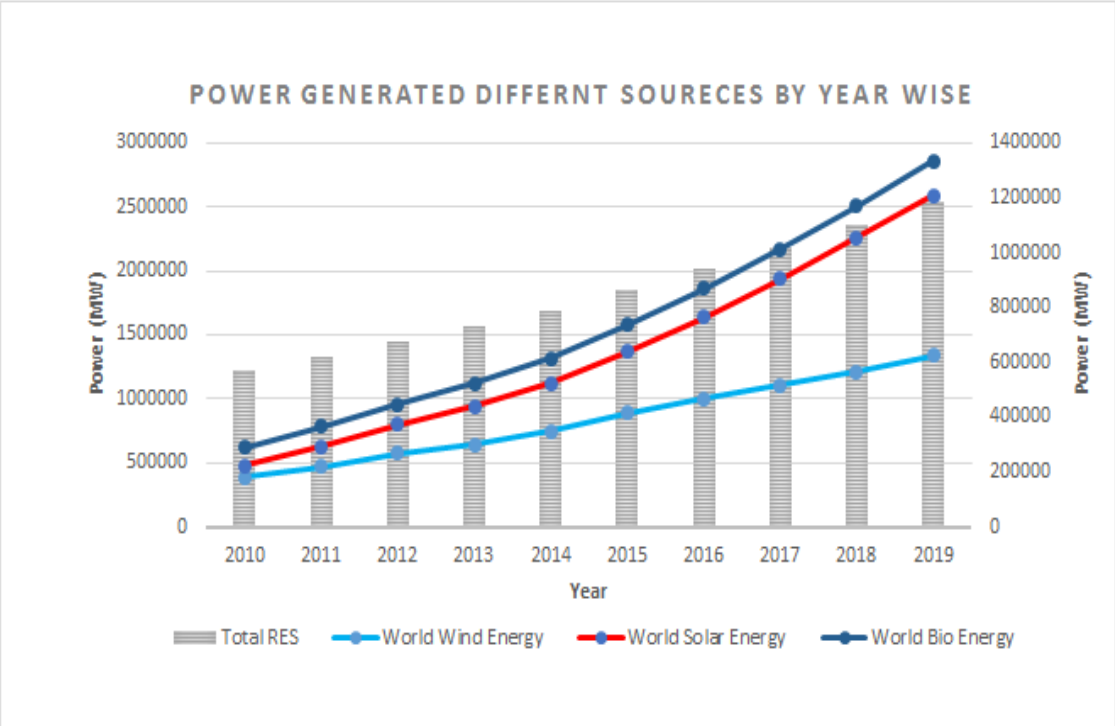


Figure 1. The power generated by total RES from 2010-2019

2. ENERGY SECTOR CHALLENGES

For decades the energy sector has different challenges. First, the traditional plants are centralized power plants, Second, centralized coordination like utilities, local transmission or distribution authorities, managed sprawling electricity grids, inappropriate scheduling, and electricity flowed from centralized units to decentralized users. Finally, operators have nominal information on real-time equipment which is a connected grid. Thanks to RES a drastic change in the energy sector to support the traditional plants. The rise of RES and distributed energy forefront to centralized grid management. Previously, the fluctuating demand is controlled easily by the plant operators, now with the rising share of RES like wind, solar, biomass, Ocean Energy, it is complex to control centralized grid management. Many industrial and domestic consumers are installed their energy management software's to use energy efficiently. Blockchain technologies are implemented for smart infrastructure (SI), energy trading (ET), green initiatives (GI), and energy management (EM) and smart contracts (SC), RES to grid integration, etc.

3. DIGITALIZATION OF ENERGYINDUSTRY

Introducing blockchain technology to the power sector is increasing, the potential applications include smart contracts, RES bids, smart meters, etc. Blockchain is a distributed, digital transaction technology that allows for secure data storage and performing business transactions between the peer to peer networks SWAN. Blockchain is a decentralized (distributed) electronic ledger system that records any transaction of value whether it be money, goods, property, work, or votes Plansky, J.et.al. Banks and financial sectors were the first ones to use the tools via cryptocurrencyBitcoin. Blockchain is not a bitcoin. Bitcoin is a cryptocurrency that uses blockchain as its technological base. The unique advantages of blockchain are decentralization, data storage in a trusted manner, data cannot tamper, fault tolerance, and audibility. Decades before the energy markets stated digitalization, but it faces problems in security associated with the database, documents, etc. The traditional approach is centralized models, these models need the intermediate part to make the transaction, the intermediate party charges extra payment. The main disadvantage of the intermediate party is having the possibility to tamper with the documents. The advantages of blockchain are

high computing capacity can be realized with blockchain at a low cost. Prevent fake transactions and establish an open and transparent credit system. All nodes can work independently towards system equilibrium without central supervision.

A. Unspent Transaction Output (UTXO)

The main element in the blockchain is Transaction. Many transactions form a block. Many blocks from the blockchain through a digital data link. All the data is consensus and verified by different peer nodes called miners T. T. A. Dinh, et.al. Miners are very powerful computers executing software-defined by the protocol. The fundamental item in bitcoin is Unspent Transaction Output (UTXO). UTXO makes the transaction for input and output by each reference number. The functions of Transactions, UTXO's are presented clearly in figure 2.

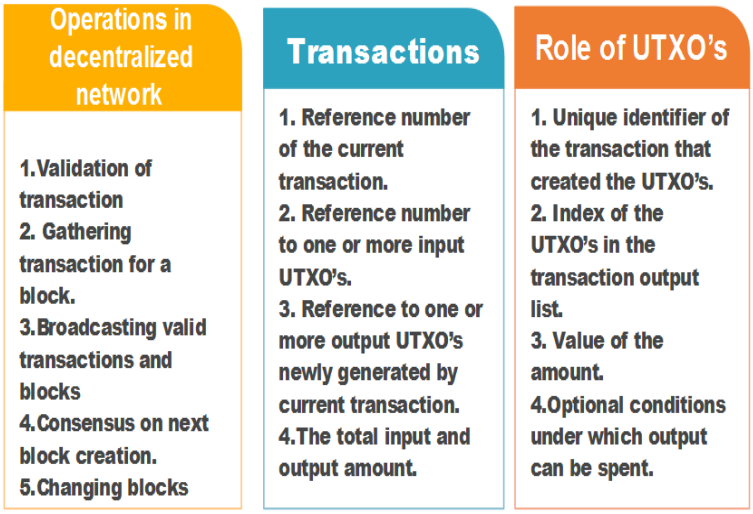


Figure 2. Roles of Transactions, UTXO's, and operations in a decentralized network.

B. Blockchain

The group of blocks makes the blockchain, and each block has its own hash value all the transactions create the reference value which is converted using the SHA 256 algorithm (Guadamuz and Marsden, 2015). Each block has the following data which is shown in figure 3. Different types of blockchain are presented in table.1.

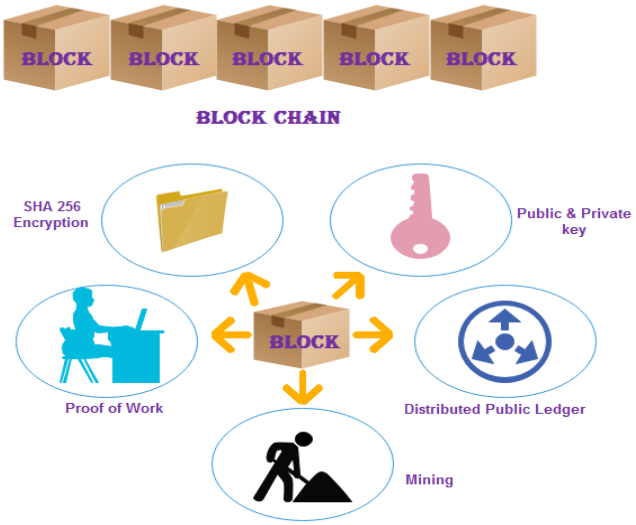


Figure 3. Representation of blockchain and its features.

C. Hashes

Each blockchain has the following summary like the number of transactions, the value of transactions, Hashes. Hashes play a key role in blockchain, the SHA 256 encryption converts the transaction value to an alphanumeric value (Clark, 2017). Then hash values of pervious and next block values are included in each

block. The hash values are created for each transaction. If anyone tries to tamper with the block i.e., tried to modify the block the hash values will change which leads to an invalid block. figure 4 shows the clear has values of each block.

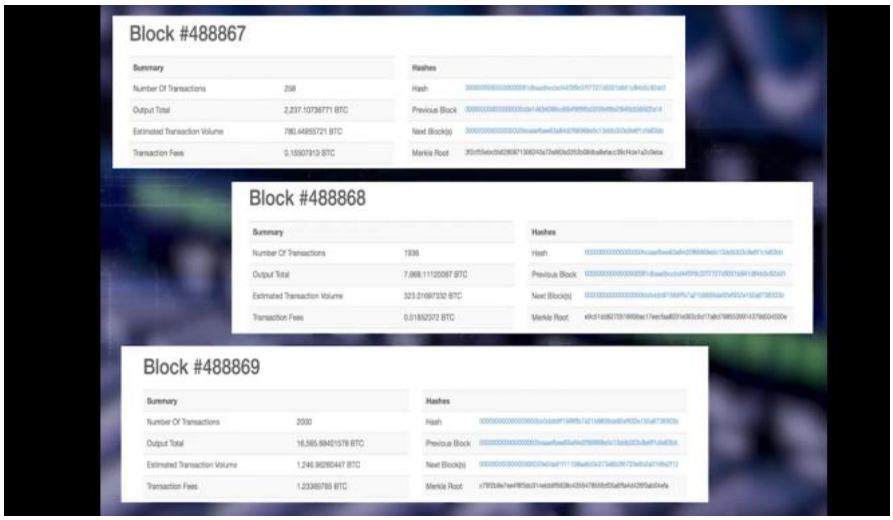


Figure 4. Hash values for each blockchain

There are two major participants in the blockchain, one who initiate the transactions, and miners. Miners will play a key role in initiating and creating the block. Miners will verify the transactions, broadcast the transactions, complete top creates the block, reach consensus by validating the block, broadcast new block, and confirm the transaction. Miners will check the minimum 20 criteria to create each block. Miners will check like UTXO's are valid, Reference UTXO's are valid. Then only the miners will create the block. Figure 5 block diagram shows how to create the block by the miners.

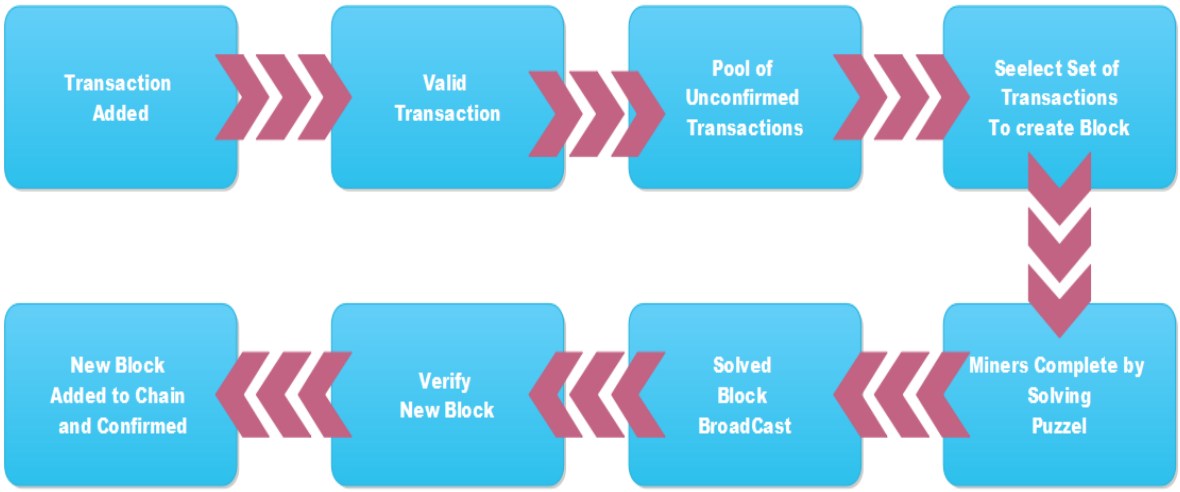


Figure 5. Block diagram to create the block

More than 300 cryptocurrencies are currently using. Three important blockchain technologies have emerged from the bitcoin foundation. Bitcoin is used only for cryptocurrencies, Etherium is used for currency and business transactions, hyper ledger use for only business logic (Guadamuz and Marsden, 2015).

D. Data Management:

There are two types of data management used first is on-chain all the validated transactions are stored on the blockchain. Dimensions of blockchain and the database increases as the chain increases. The second is off-chain, only the hashes of important data are stored on a blockchain. The database is small compared with the on-chain database.

4. OPEN ELECTRICAL MARKETS:

All the financial markets are bilateral, which involves the buyer and seller. The open electrical markets are classified into three categories. Three types of electrical

market trading are presented clearly in table.2. Theory of economic regulations effort to predict which recognized procedure is preferable. Especially there are Government monopoly, Private monopoly without regulation, Private monopoly with regulation under this category national and regional regulations has to follow. Monopoly traditional market: In the monopoly market there is only one seller of power to consumers.

Electrical energy is generated by different utilities and independent power producers (IPP) and regulated by state public utility (SPU) and transmitted to consumers by high tension transmission lines, based on the load utility the voltage will rise or lower by using the transformer. Figure 6 shows the traditional electrical trading here the consumer pays money to banks directly for the consumed power. The generating stations pay money to raw goods supplies.

Table.1 Types of Blockchain technologies

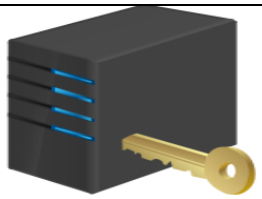
1		**Public**	Mostly used Bitcoin. Transactions are public. Anybody can join or leave. No need for permission. The public is anonymous.
2		**Private**	Access is limited to participants within an organization. Simplifying the operation, blockchain and consensus module
3		**Permission**	Ease of governance. Only specific people are grant permission. Government, health care professionals.

Table.2 Electrical market Trading

S.No	Type	Description
1.	Customized long term contracts	• Usually involves the sale of large power from 100 or 1000 MW. • It is used for longer periods. • These are flexible and can be negotiated privately. • It has a large transaction cost.
2.	Counter trading	• Transactions involve smaller amounts of energy. • A definite amount of energy is transmitted to loads during different periods. Periods may be day and week • Lower transaction cost.
3.	Electronic Trading	• It is the modern trading system which all over the developed countries they are using. • Both the participant's buyer and seller enter into computerized markets to make a bid and to purchase the energy. • In this market the software engineers design the software for the bids, it will select the best bid based on the low cost and best quality. The main drawback in this trading is tampering is possible, and the rules will change according to the favorite person.

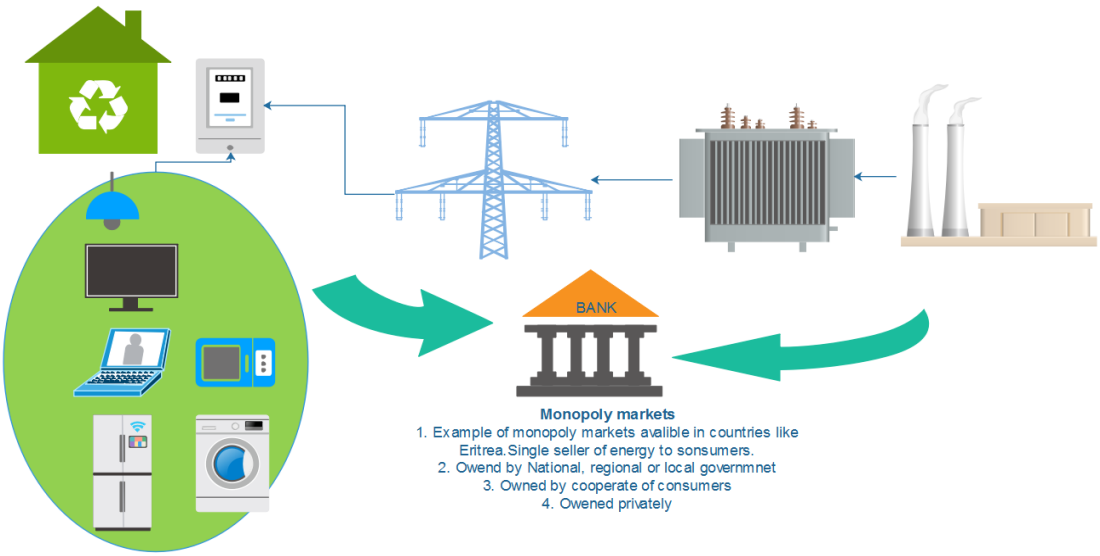


Figure 6. Traditional Monopoly electrical trading

Transmission network and electrical markets: Generally trading in the transmission networks is done in decentralized mode or bilateral trading system. All the transactions will involve buyers and sellers. In trading, two parties will decide on the price or condition that they want to trade. The system operator doesn't involve in the transactions.G1, supplies the load of 500 MW, G2 supplies the load of 300 MW, these transactions are bilateral shown in fig.7. They agree with the prices between the suppliers and receivers. The amount of power to be transmitted must be reported to the system operator because the power flows on the system. The system operator must checks that the system will remain secure while transmitting 800 MW of power from the sender end to the receiver end. While transferring the power the system should be insecure and the contingency of the system should be within the limits. During the min and max conditions, the thermal limits should be considered and it should be kept within prescribed limits. Much modern power system software is there like MATLAB, CYME, NEPLAN, ETAP, etc. to determine the power system operation is safe and contingency analysis. The physical transmission rights are intended to support the actual transmission of a certain amount of power over the transmission line.

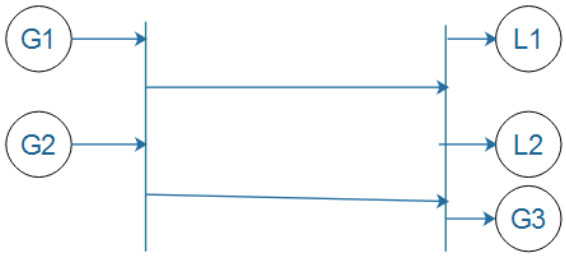


Figure 7. Bilateral trading in a two-bus power system

5. IMPLEMENTING BLOCKCHAIN TO SMART GRIDS INCORPORATING RES:

Incorporating RES into the existing systems leads to a decrease in the usage of fossil fuel power plants. All the consumers are showing interest to install solar roof plants or PV plants on their premises. Mostly those who are using the PV became the prosumers. Many international companies in different countries are developing blockchain pilot projects. The basic blockchain application in the energy sector is for bill payments by using cryptocurrency's most famous application is bitcoin and the extension of blockchain is to implement smart contracts for the different bids in the generation, transmission, and distribution.

After successfully implementing blockchain technology in the financial sector, the next big sector is the energy sector. Initially started with smart contracts, smart metering, and bill payments by cryptography. Implementing technology in the energy sector fetches many advantages. Increasing decentralized and digitally connected systems needs a secure IT solution in many sectors like communication, automation, and documentation. The well established smart energy system is dependent on the data to be shared correctly, quickly, and uniquely across the system appropriately without any tamper. Blockchain promises a more efficient and resilient IT infrastructure in comparison with the existing system. Besides, small-scale companies and households are increasing exponentially the global energy production by installing RES (Peters and Panayi, 2015). The prosumers are increasing their production and selling to the transmission system. The traditional flow of electrical energy, amount, and data are shown in Figure 8.

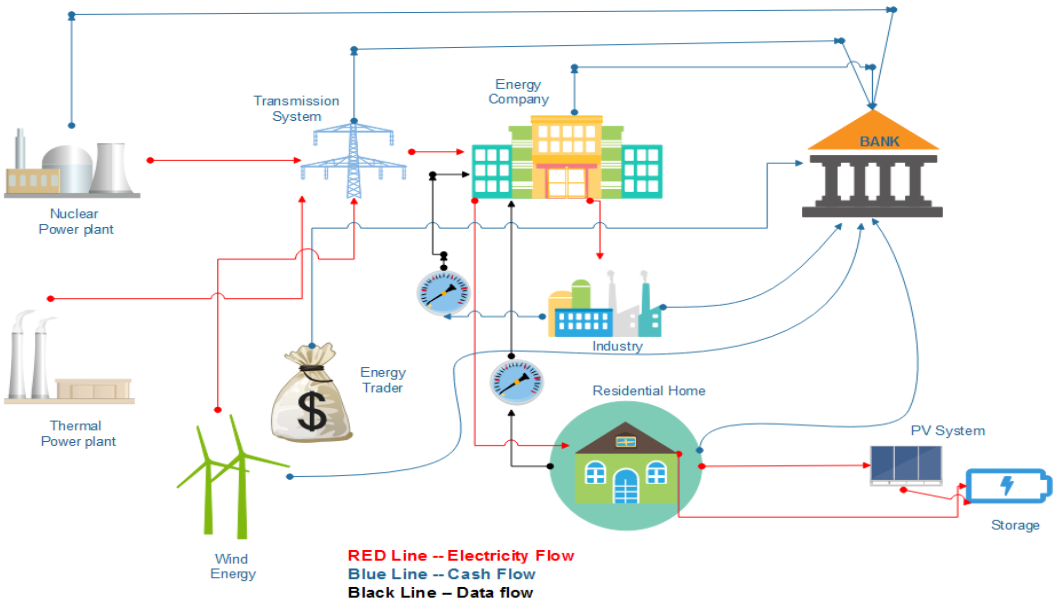


Figure 8. Decentralized electrical energy market transformation structure.

Implementing the blockchain in the energy market for the bill payments by all sectors by using the bitcoin. Especially for the energy markets, Ethereum is used in blockchain technology. By implementing blockchain technology the operating fees are lower. RES overtaking the conventional plants, solar power certificates developed the Linq platform for PV A. Ahl, et.al. Bill payments by using the blockchain technology are shown in below figure 9.

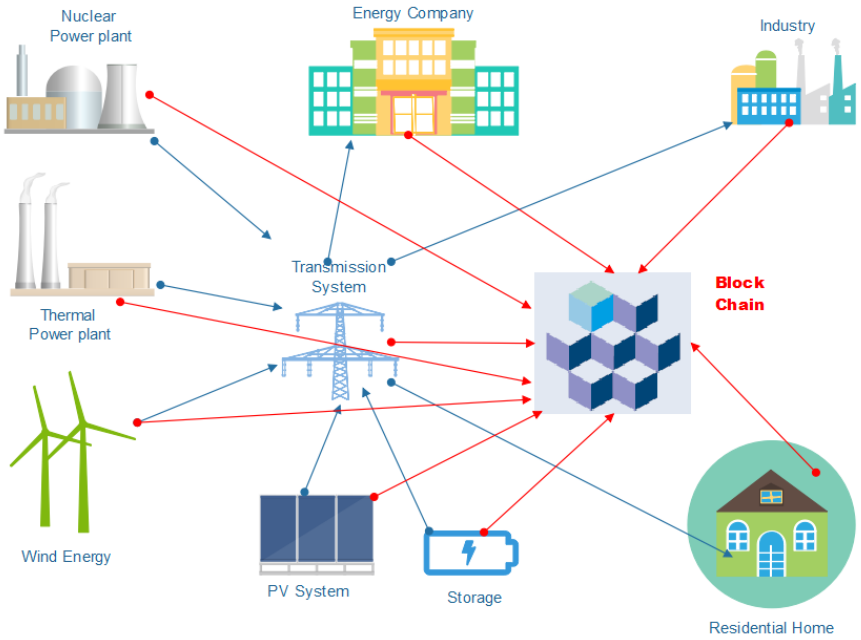


Figure 9. Implementing the blockchain in the energy sector

6. ECONOMIC ANALYSIS OF TRANSMISSION SYSTEM USING BLOCKCHAIN TECHNOLOGY:

Transmission cost depends on different factors like physical transmission rights which include parallel paths, market prices. Nodal prices will also vary based on the transmitted power, in any system generation, transmission and distribution have their constraints, and while modeling the transmission cost consider zero power transmission and maximum power generation and transmission. While calculating the transmission cost loss factors in the transmission network have to be

considered. There are different losses are encountered in the transmission network which includes variable losses like load losses, series losses, transport-related losses. Fixed losses are caused in the system due to hysteresis losses and eddy current losses in the transformer, corona losses in the transmission lines. Non-technical losses euphemism covers energy that is stolen from the power system.

Production versus purchase decision: \\\\\\\\\Creating the block in the blockchain network based on the contract sign between the generating stations based on the Load. Assuming that one company agrees to supply load by generating N plants to surplus the load with an optimal cost it's an optimal problem and is solved by different optimal methods and saved in the block. Mathematically it is given as

$$l(P_1, P_2, P_3, \dots \dots .. P_N, \gamma) = \sum_{i=1}^{N} C_1(P_i) + \gamma(L - \sum_{i=1}^{N} P_i) \quad (1)$$

Where γ is a new variable called a Lagrange

Variable losses $L = \frac{P^2+Q^2}{V^2}$ *R (2)

Function B(D) of the total demand D and that the hourly cost of electrical energy is given by the function C(P) of the total power P produced by the generators. This cost function C(P) represents either the actual cost of production or the bids that the generators have submitted Nodal prices is given as:

$$l(D, P, \alpha) = B(D) - C(P) + \alpha(P - D) \quad (3)$$

a. **Forecasting of electrical loads**: Load always cannot be predicted. There are different forecasting techniques are available and the forecasted value should be created as a block it should be added to the blockchain.
b. **Voltage regulation and reactive power management**: To improve the voltage profiles the transmission cost includes the installation of HVDC systems, FACTS devices, grid integration equipment devices, etc.The list of blockchain technologies in the energy sector is presented below table 3.

Table 3. List of technologies used in the blockchain in the energy sector

Cryptocurrencies	**Ethereum** **Started in 2016 in the USA for a joint venture between LOZ energy and consensys**	**Coin**	**Solar coin** **www.solarchange.co**	**Bitcoin** **Ripple**
Developers	Slock. it	Oneup		
Decentralized energy transaction and supply system	MYPAG It is from Denmark working with leverage blockchain technology	Bankymoon It is using in South Africa. Bitcoin-based billing for the smart meters.		
Solar power certification	LINQ and NASDAQ Started using it in 2016 in New York.			

7. CONCLUSION:

The rapid development of blockchain technology in the energy sector leads to an increase in the decentralization of the entire energy sector. Frequently cited issues like minimum and maximum power generation were irrespective to load conditions which leads to consumers paying service charges to energy industries. While solving the optimization problem based on the purchaser cost based on production and block is connected to the blockchain so that the consumers will know the production cost. By installing the RES the prosumers will pay the exact amount. In the future, the blockchain is implemented in all energy projects including smart

contracts, energy payments, etc. which leads to fewer transaction charges, and brokerage fees will reduce. The tampering of documents during the bids will decrease. The possibility of providing a secure system for communication, automation, and documentation with the blockchain is particularly interesting for the energy industry.

REFERENCES:

Ahl, A., Yarime, M., Tanaka, K. & Sagawa, D. (2019). Review of blockchain-based distributed energy: Implications for institutional development, *Renewable and Sustainable Energy Reviews*, *107*, 200–211.

Iacomelli, A. (2005). PhD, Renewable Energy (RE), Energy Efficiency (EE) & Energy Services: The Energy Market Transformation, Pisa University, ISES ITALIA Italian Section of International Solar Energy Society, Renewable

Energies for Central Asia Countries: Economic, Environmental and Social Impacts, Earth and environmental sciences Vol.59.

Clark, A., (2017). *Blockchain Based Recycling Initiative to Benefit Third Sector*, Charity Digital News, 7 November 2017. Retrieved from: https://www.charitydigitalnews.co.uk/2017/11/07/blockchain-based-recyclinginitiative-to-benefit-third-sector/ (link as of 03/09/18).

Dinh, T. T. A., Liu, R., Zhang, M., Chen, G., Ooi, B. C. & Wang, J. (2018). Untangling blockchain: A data processing view of blockchain systems, *IEEE Transactions on Knowledge and Data Engineering*, 30(7), 1366–1385.

Eid C, Codani P, Perez Y, Reneses J, Hakvoort R. (2016). Managing electric flexibility from Distributed Energy Resources: a review of incentives for market design. *Renew SustEnerg*; *64*, 237–47.

Guadamuz, A., & Marsden, C. (2015). Blockchains and Bitcoin: Regulatory responses to cryptocurrencies. *First Monday*, *20*(12-7).

IRENA (2020), Renewable capacity statistics 2020 International Renewable Energy Agency (IRENA), Abu Dhabi, Retrieved from: https://www.irena.org/Statistics/Download-Data.

Peters, G. W., & Panayi, E. (2015). *Understanding Modern Banking Ledgers through Blockchain Technologies: Future of Transaction Processing and Smart Contracts on the Internet of Money*. Available at SSRN.

Plansky, J., O'Donnell, T., & Richards, K. (2016). A Strategist's Guide to Blockchain, strategy business, 11 January 2016: Retrieved form: https://www.strategy-business.com/article/A-Strategists-Guide-to-Blockchain?gko=0d586 (link as of 03/09/18).

Sunil Kumar, J., & Tuka, M. B. (2014). Line Losses in the 14-Bus Power System Network using UPFC, ACEEE Int. J. on Electrical and Power Engineering, *5*(1), February 2014

Swan, M. (2015). *Blockchain: Blueprint for a New Economy*, O'Reilly Media.

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