An Overview of a Blockchain based Energy Industry

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Abstract

The energy sector is consistently being galvanized by innovations and improvements throughout the world. The introduction of renewable systems, electric vehicles, smart grids and meters are pioneers in revolutionizing the energy industry. In this very outlook, another emerging technology occupying a notable status in the energy and power sector is the use of blockchain to control commerce of electricity production, distribution and consumption. Blockchain, based on a distributed ledger technology, provides consumers with autonomy in power generation, real time data management and decentralized consumption without a local intermediary. However, there are certain challenges that the concept of blockchain has to supersede, which includes general acceptance among masses, infrastructural feasibility of its application in energy systems, among other technical inefficiencies. Keeping in approach the new energy market that calls for greater control and transparency, this paper presents an introduction to the use of blockchain for the energy industry, its advantages, applications, challenges and potential future scope.

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Blockchain Technology

Blockchain was a concept proposed in 2008 as a digital public ledger where all transactions that take place in a system are stored in a chain of blocks [1]. This ledger operates with a digital signature, which is called a cryptographic hash function and whenever a transaction has to be placed on the chain, the one making the transaction has to prove eligibility and verification via this hash function. There is also a consensus mechanism applied to each block, where the very users of the block also help vote over the eligibility of a transaction. As a result, blockchain ensures operation without any intermediary control, with greater transparency and untappable security [1]. Figure 1 shows the structure of nodes on a blockchain and the information each block contains.

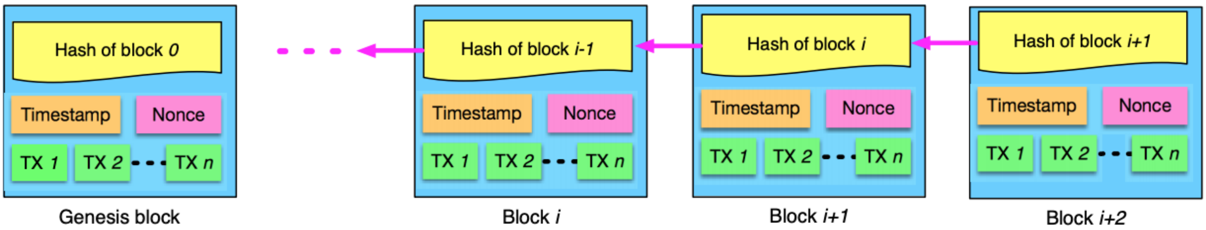

Figure 1. Structure of blocks on the blockchain [1]

A normal block on the blockchain includes certain definitions, such as **Hash of parent block** which points to the previous block, the **Timestamp** of when the transaction takes place and a **Nonce** value that increases with every hash that is calculated. For a normal transaction to be placed on the blockchain, there also exists a pair of public and private keys for the user. The private key is used to put the transaction on the blockchain and the public one is used by members of a node to access and verify it [7].

Blockchain-based Grid Systems

Generally, local energy markets have three stakeholders; producers, prosumers and consumers [2]. The energy trade takes place between these agents with certain aspects of investments and profits being made. Generally, this centralized market system runs on bidding auctions to buy electricity. A blockchain-based version of this energy market would uphold the auction mechanism over a digitally controlled ledger where every stakeholder is transparent to their buying, selling, generation and consumption. According to [2], blockchain also acts as an escrow agent to ensure settlement of potential transactions. This essentially means that consumers are buying directly from the producers without the need of third-party retailers. This could potentially reduce consumer bills by 40% [3] and result in a more equitable and stable energy market.

Another application of blockchain can be applied to microgrid systems powered in many cases by renewable energy. In this model, consumers themselves produce electricity and invest in blockchain nodes for their microgrids to be able to sell power to neighbors in small communities [10]. Such a microgrid project is being implemented in Brooklyn, New York [4], where the blockchain network manages transactions. The investment in the nodes is

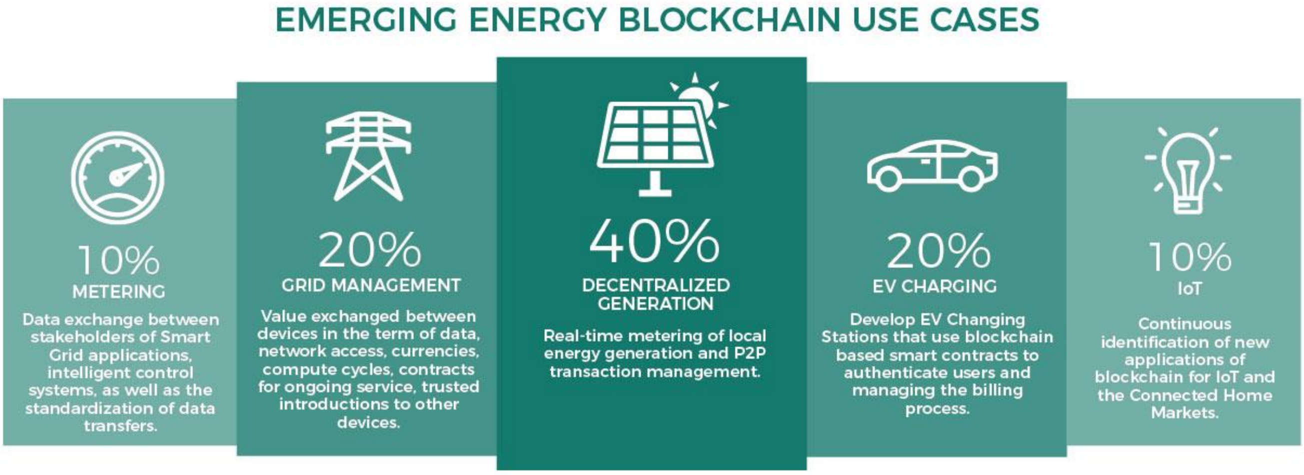

Figure 2. Different avenues of applications of blockchain in the energy industry [8].

made to enable more computing power and more data being passed along. Another such concept of blockchain in energy is for industries to sell unused power during low peak hours to a different region that needs additional power. Moreover, backup power from microgrids can be supplied to the central grid in failure situations with price management being done via a simple smart contract implemented over the blockchain [5]. Figure 2 shows different applications of blockchain being applied in energy production and distribution. All these operations can be carried out using blockchain in a manner that eases the trading process for both consumers and grid operators.

In the same effect, CO2 emissions can be tracked over blockchain registries for each producer/consumer [3][10], maintenance management systems can be automated to diagnose problems in emergency situations and configure reactions to them [4]. Moreover, an ease to existing procedures could be applied, such as meter registration with more than one power suppliers and switching among them. Furthermore, in terms of commodity trading in the energy industry, the trading of artefacts like oil and gas, blockchain application would maintain records and prices at all time instances [6]. The process would become cheaper, efficient, immutable and more secure than current proprietary systems applied in energy commodity trading [9].

Challenges

As with any new breakthrough technology, there are certain radical barriers that blockchain has to come through. There are also risks of adoption and regulatory policymaking processes that need to be implemented. In case of blockchain's application to energy systems the following real-life challenges are most potent:

- **Blockchain scaling** is an inherent challenge for the blockchain itself. Currently it only possesses a limited capacity to process transactions [7] and requires a high application of energy to sustain. Especially in the case of household generation and trading of energy where the frequency of trading could be thousands per second in one country, the scalability issues of blockchain would become more apparent.
- **Moving the existing systems to blockchain**-based setup would prove to be a significant challenge for both companies and consumers. All documents, records and

trends would need to be implemented over the blockchain and investments be made for complete migration which presents a considerable change.

- **Government regulations** and laws need to be applied to regulate the whole system which would otherwise collapse. American corporations like the FTC and SEC are already making headway in this regard [7].
- **Inertia from the current energy industry** could prove to be a huge challenge for blockchain technology to establish. The current market, controlled by certain conglomerates would resist the adoption to a decentralized model which would replace their revenue streams. Blockchain would have to overcome this inertia and even be backed up by the current stakeholders before becoming a recognized utility.

Conclusion

Blockchain technology essentially underlines the concept of a digital age that is touted by many to have arrived. It operates with a digital ledger-based system that stores all records and manages transactions in trading. The energy sector of the future has a great potential of application for blockchain, especially in avenues of energy trading, microgrid generation and commodity trading. Blockchain potentially makes operations of energy trade and generation more simplified. It also eliminates need for third-party retailers and provides the overall process more immutability, transparency and greater efficiency. There are, however, great challenges that blockchain needs to overcome before it is adopted as a controlling mechanism. These include challenges in scalability, migration, legislation and resistance from current stakeholders in the energy industry.

References

[1] Z. Zheng, S. Xie, & H.N. Dai, & X. Chen, Xiangping, H. Wang., "Blockchain challenges and opportunities: A survey.," *International Journal of Web and Grid Services*, 14, 4, 352. 10.1504/IJWGS.2018.095647, Oct 2018.

[2] E. Mengelkemp, B. Notheisen, C. Beer, D. Dauer, C. Weinhardt., "A blockchain-based smart grid: towards sustainable local energy markets.," *Comput Sci Res Dev*, 2017.

[3] F. Imbault, M. Swiatek, R. de Beaufort, R. Plana., "The green blockchain Managing decentralized energy production and consumption.," *IEEE*, 2017.

[4] J. Basden, M. Cottrell. (2017, March). "HOW UTILITIES ARE USING BLOCKCHAIN TO MODERNIZE THE GRID" *Harvard Business Review* [Online]. Available: https://hbr.org/2017/03/how-utilities-are-using-blockchain-to-modernize-the-grid

[5] J. Ellsmoor, "Blockchain Is the Next Big Thing for Renewable Energy," Forbes [Online], April 27, 2019. Available: https://www.forbes.com/sites/jamesellsmoor/2019/04/27/blockchain-is-the-next-big-thing-for-renewable-energy/#68c6855648c1

[6] Consensys, "Blockchain in Energy and Sustainability," [Online]. Available: https://consensys.net/blockchain-use-cases/energy-and-sustainability/

[7] M. Crosby, Nachiappan, P. Pattanayak, S. Verma, V. Kalyanaraman., "BlockChain Technology: Beyond Bitcoin," *Applied Innovation Review*, 2, Jun 2016.

[8] M. Peters, J. Rosling., "Demystifying Blockchain for Energy & Utilities," *IEEE Smart Grid Webinar Series*, Jul 2017.

[9] S. Deshkmukh, "The implementation of blockchain in the energy sector Shravan Deshmukh," Innovation Enterprise [Online], April 29, 2019. Available: https://channels.theinnovationenterprise.com/articles/the-implementation-of-blockchain-in-the-energy-sector

[10] S. Deatherage, "Mutually Evolving Technologies: Blockchain, Renewable Energy, and Energy Storage", American Bar Association [Online], Dec 13 2019. Available: https://www.americanbar.org/groups/business_law/publications/blt/2019/12/evolving-tech/