Study Committee C5

Electricity Markets & Regulation

Paper 10628_2022

The Applications of Blockchain Technologies to Electricity Markets

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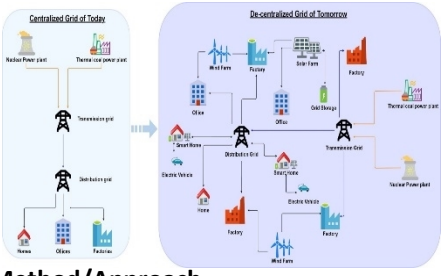
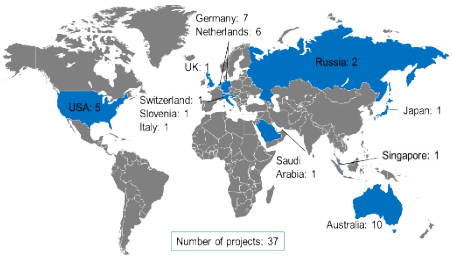
Motivation

- Power systems are transitioning to a decentralized structure which comprises of more RESs, Energy Storage Systems (ESSs), Distributed Generation (DGs), active power consumers, Virtual Power Plants (VPPs) and in a digital form.
- New emerging technologies, such as blockchain, can facilitate the rapid changes in the energy sector toward digitalization and decentralization



Method/Approach

This paper is a summary of the CIGRE Technical Brochure 824 The Role of Blockchain Technologies in Power Markets by WG.30. The Working Group members created a set of criteria for selecting projects. With these criteria, they identified 37 projects.



Only projects which meet the following characteristics will be assessed

- An operational project which affects real financial transactions with real customers;
- Has been operational for at least 3 months (since first operational transaction);
- A project which makes a significant use of block chain technology;
- A project which is connected to the main power system or is involved in the management of renewable certificates.

Projects Assessment

- Energy and power sector stakeholders are experimenting with blockchain technology along the energy value chain.
- Although a few energy blockchain products have been commercialized, most remain in the early stages of testing and business model development.
- Specific fields of using blockchain in energy markets is important to find, where blockchain strengths are critically needed for the markets' actors to provide people with clean, reliable, and low-cost power – the energy 'trilemma'.

Conclusion

- Three important and fundamental characteristics of blockchain are security, transparency, and immutability. These aspects are what make blockchain technology unique and a potential solution for energy and power applications.
- There is merit for blockchain in specific marginal use cases where it can optimize existing processes, such as storing, recording, and validating information about energy usage.
- What is needed is a fit-for-purpose solution that is specifically designed to optimize the energy trilemma and deliver a sustainable energy system for all. This may be an architecture that inherently balances itself, using decentralized control of energy exchange enabled by blockchain, or something similar.

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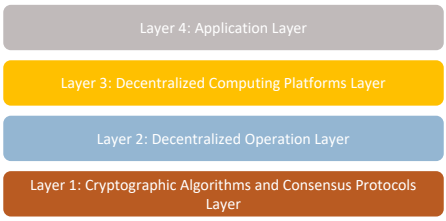
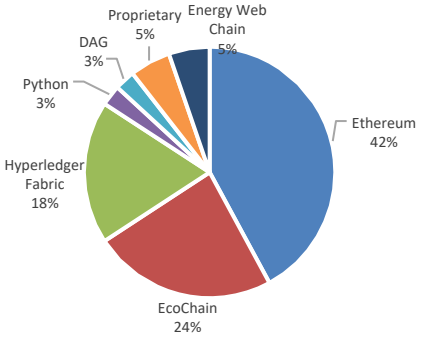
Blockchain Fundamental Principles

Blockchain has a multi-layer sequential framework with four major layers:



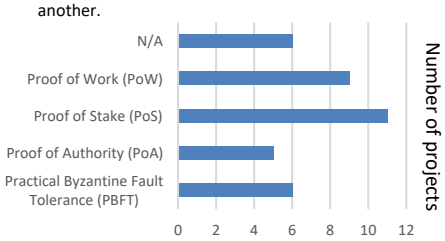
Blockchain Frameworks

- Ethereum is the most used blockchain framework. This may be due to Ethereum's ability to create and use smart contracts - computer protocols to assign the rules and penalties for an agreement and enforce those rules on the Blockchain automatically in a user-friendly manner.



Distribution of Consensus Method

- The figure shows how consensus is ensured in each of the projects. This information was not available for all projects, so the sample size is smaller. Proof of Stake is the predominant method although this result has been skewed by the 10 Australian projects all of which use this method. There are different advantages to using one consensus mechanism over another.



Potential Blockchain Benefits

Current Shortcoming	Possible Role for Blockchain
Electricity market prices do not always reflect the actual total cost of production	Combined with Internet of Things (IoT), blockchain securely records, stores and shares information about the time of generation/demand, location, type of generation/demand and other aspects to carefully transmit price signals to market participants.
Effects of large-scale RES integration into the electricity grid	Can be used for efficient, automated and decentralized grid management and control. Due to the presence of many producing and/or consuming entities, especially prosumers present in the distribution grid who might stochastically change direction of power flows, blockchains can be used to improve balancing of supply and demand. It can also improve coordination between TSO & DSO.
Power resource adequacy and lack of capital investments in the power sector	Cryptocurrencies, tokens and blockchains can help open new avenues of investments in RES. Cryptocurrencies can be used to 'tokenize' assets to create innovative and new markets or business models based on co ownership and sharing of assets.
Increased coordination between System Operators (SOs)	Efficient, automated and decentralized grid asset management and control, improved balancing of supply and demand between different network levels and network areas
Integrating Demand Response (DR) for Ancillary Services (AS)	Design smart contracts to engage and reward willing customers to help in DR activity to maintain the grid with greater economic efficiency. Blockchains can help discard an incumbent intermediary and unlock a variety of markets for its participants (e.g., P2P).
Lack of residential Demand Response	Enabling local energy and consumer-oriented marketplaces or microgrids with local storage and smart contracts.
Adequate cross-border power system data exchange	Blockchains can streamline the process by removing intermediaries, removing delays, and maintaining data integrity as data is not transferred but immutably shared.
Data privacy	Secured and authenticated transactions and data through cryptography, enabling protection of data against manipulation