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Blockchains in Power Markets: Decentralized Disruption or Incremental Innovation?

By **Max Luke, George Anstey, Will Taylor,** and **Adjmal Sirak**

Abstract

We consider the disruptive potential of blockchains in power markets. We reflect on the economic advantages of entrusting to centralized intermediary organizations, rather than decentralized blockchain applications, certain functions in power markets. We conclude that the advantages of centralized intermediaries mostly outweigh the risks. The physical features of electricity markets, and the economic importance of electrical availability, strongly favor centralized organizations over distributed approaches for certain market functions. Nonetheless, blockchains benefit market participants who want more independent agency over their electricity supplies and transparency in transaction details. Such participants include retail customers who want to choose and transact directly with individual generators, and large corporate customers who trade bilaterally with the support of intermediary exchanges or brokers.

Introduction

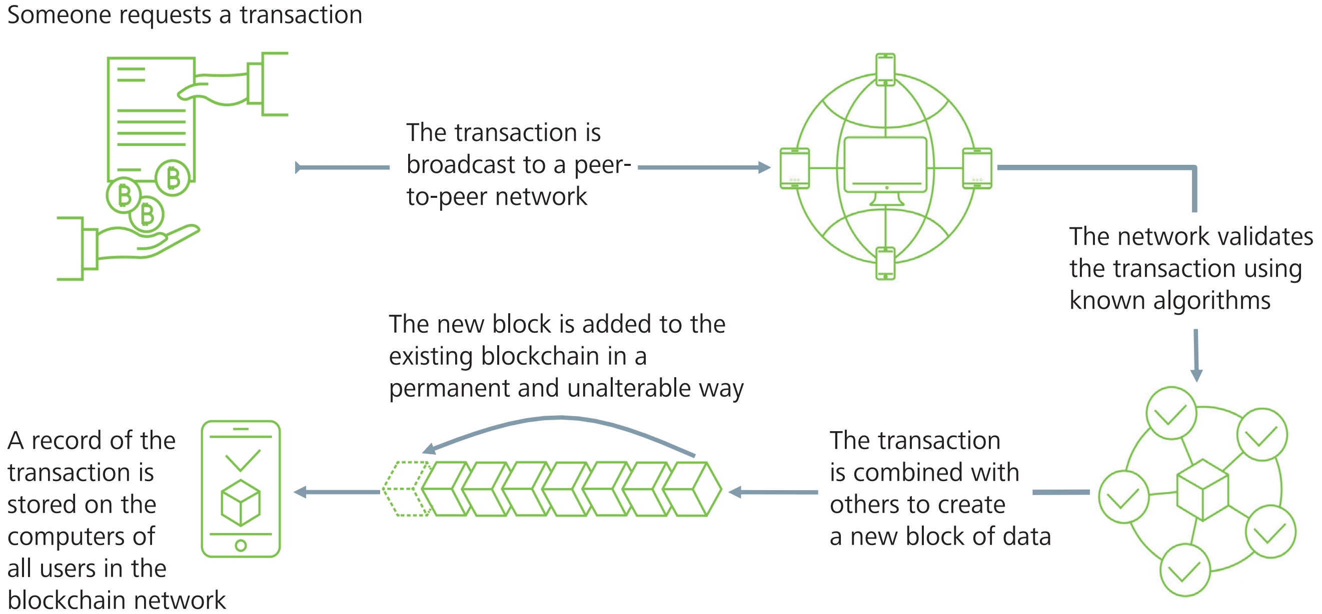
In most industries, the frictionless markets of classical economic theory are more theoretical abstractions than realistic possibilities. In real-world markets, imperfect information and transaction costs inhibit the exchange of goods and services that underpin economic development. To help resolve the limiting conditions of the real world, parties seeking to exchange goods and services often rely on centralized intermediary organizations—such as banks, government agencies, and brokers—to keep records of economic activities and identities and to trade on customers' behalf. In wholesale electricity markets, broker intermediaries facilitate bilateral trades and central power exchanges enable pooled trade. System operators coordinate electricity dispatch. In retail electricity markets, other centralized intermediary organizations—specifically, retail supply companies—conduct trade on behalf of individual customers.

However, the involvement of third-party intermediaries is not without problems of its own. Involving a third party may necessitate additional administrative costs. An intermediary may affect the terms of trade to its own advantage rather than that of the trading parties for whom it acts as an agent. Where a single intermediary concentrates liquidity and monopolizes trade, that single intermediary may extract economic rents from the trading process.

The emergence of distributed ledger technologies, or "blockchains," has led to questions about the need for centralized market intermediaries, not only in the power sector but also in the banking and finance, insurance, health care, manufacturing, and government sectors, among others. At their core, blockchains allow individuals to reach agreement on a common digital record of transactions. Blockchains secure individuals from the manipulation of that record, a function not previously available without intermediary record keepers or arbiters.

Blockchains are digital ledgers stored in multiple copies on multiple independent computers in decentralized networks. No single entity controls a ledger, and changes to ledgers can only be made if more than 50% of users in a blockchain network agree with the change. Credible entries to a ledger—such as transactions conducted in good faith by consenting traders—validate automatically by users in a blockchain network using known algorithms, and store automatically on the computers belonging to those users. Non-credible attempts to change a ledger—such as attempts to record non-consensual trades or transfers—reject automatically by users using those same known algorithms. For this reason, blockchain ledgers cannot be easily duplicated, manipulated, or faked. Figure 1 illustrates the general process by which a transaction is added to a blockchain.

Figure 1. **Blockchain-Based Transactions Are Decentralized and Cannot Be Easily Duplicated, Manipulated, or Faked**



Source: Adapted from Max Luke et al., "Blockchain in Electricity: a Critical Review of Progress to Date," Eurelectric and NERA Economic Consulting, May 2018.

Nonetheless, the future of blockchains in electricity systems is uncertain. Blockchains are immature technologies with yet no full-scale commercial projects in the electricity industry. Applying blockchains on a large scale has proven difficult. Financial investors have been skeptical about the novelty of business models and startups have struggled to develop pilot projects that are truly decentralized.[1] Moreover, decentralized blockchains are burdened by high costs, slow transaction speeds, and other limitations and risks. Compounding these challenges, several jurisdictions have imposed or considered regulatory restrictions on the use of initial coin offerings (ICOs), the primary funding vehicle for most blockchain projects.[2]

In Centralized Electricity Operators We Trust

Power markets are unlike other physical commodity markets in that production must always meet demand in real time. In most power systems, storing large quantities of electricity for subsequent use is expensive given current technology. As a result, real-time electricity prices can spike to many multiples of average electricity prices when supplies are tight. Imbalances in real-time electricity supply and demand jeopardize the integrity of the physical infrastructure upon which the delivery of electricity depends. Moreover, electricity networks are natural monopolies in that the average cost of network services declines as the size of the network grows (at least to a point). These features strongly favor centralized operators for certain market functions.

Centralized transmission system operators seek to maintain power system reliability by balancing grid-wide electricity supply and demand. All electricity trading—including bilateral and peer-to-peer trading—must be reconciled with the transmission system operator to maintain the security of the physical grid. Similarly, distribution companies maintain the reliability of local electricity networks by ensuring that the capacity of distribution network equipment is sufficient to withstand local supply and demand conditions. Transmission system operators and distribution companies keep detailed records of the operation and condition of electricity networks, and the generation and load profiles of generators and customers.

In many physical commodity markets (e.g., crude oil, agricultural products, metals, and natural gas), there is no need for central operators. Most physical commodities move relatively slowly on known routes (e.g., no faster than a railcar or truck bed on a predetermined rail or road route) and are stored and tracked easily. Deviations from contracted supply and demand are resolved over days, weeks, months, or years. Electricity moves at the speed of light on routes not easily predicted over costly physical transmission networks. Deviations in scheduled supply and demand may jeopardize the physical integrity of the electricity system if not resolved within seconds.

Compared to such rapid action, blockchains are slow. The Bitcoin and Ethereum networks—the two most popular public blockchain networks—validate transactions at rates of about seven and 15 transactions per second, respectively (in contrast, VISA processes up to 24,000 transactions per second). In general, the greater the security of a blockchain from cyberattacks, and the more decentralized a blockchain is, the more time- and energy-intensive its validation process. Blockchains with the highest levels of security and decentralization, such as Bitcoin and Ethereum, do not quickly process enough transactions to sufficiently manage deviations in supply and demand in large power markets, which may require dozens or hundreds of generators (or deferable load resources) to respond to imbalances within seconds or minutes.

Moreover, identifying and resolving system imbalances requires a high degree of central coordination on physical networks. The routes that electricity travels through transmission networks change in complex ways when supply and load conditions change. Supply and demand must balance in ways that respect the physical limits of transmission lines and minimize losses across those lines. Equipment failures and potential fault-causing conditions (e.g., a tree falling on a line) occur frequently. System operators often replace algorithm-generated dispatch schedules with manual dispatch instructions to deal with unforeseen grid conditions. System operators bear the legal and political responsibilities of maintaining good grid conditions and protecting against grid failures, which affect all the users in an electricity network.

Therefore, it is most likely that supply and demand will continue to be coordinated by centralized operators. As a result, blockchain disruption is more likely in other market segments not so closely linked to basic power system reliability. Next, we consider how blockchains promote transactions directly between parties (i.e., with no involvement from intermediary organizations) and benefit retail customers and traders who want more agency and transparency in their transactions.

Blockchains Promote Peer-to-Peer Electricity Transactions

In many electricity systems, retail supply companies conduct trade on behalf of individual customers. Startup companies like Grid+ and Drift use blockchains to link retail electricity customers with generators directly. Customers in such cases have full agency to choose the generators from whom they buy power. By linking customers with generators on a blockchain, customers see in real time the details of their transactions with generators (i.e., prices and generation quantities). Credible entries to the blockchain—data that match both traders' own records—validate automatically using known algorithms and store on a tamperproof blockchain auditable by customers and generators. Non-credible entries to the blockchain—data from one trader that do not match the other trader's record—reject automatically using those same algorithms. Inconsistent data are flagged and addressed manually.

Companies like Grid+ and Drift offer retail customers more agency and transparency than traditional retailers. Nonetheless, retailers offer other valuable services to customers that blockchain-based peer-to-peer technologies do not. For example, retailers can offer to eliminate price volatility in exchange for premiums that are included in the rates. Retailers offer customers new technologies, including advanced metering and control devices, solar photovoltaics, energy storage devices, and electric vehicle charging equipment. Retailers manage customers' energy supplies on their behalf, a value-added service for customers uninterested in procuring their own energy supplies.

Some larger customers do not rely on retail supply companies to deal with generators. Instead, they sign bilateral contracts with generators to hedge against future electricity market price volatility. Such customers use intermediary exchanges or brokerage companies to identify counterparties, execute trades, and ensure that trade volumes and payments are correct and consistent across accounts. Some such companies use blockchains to reduce traders' dependence on exchanges and brokers. For example, the company PONTON developed a software platform called Enerchain that enables energy traders to identify counterparties and execute trades without formal exchanges or brokers. Traders submit orders to a blockchain that automatically matches and executes trades. Forty European companies, including Centrica, E.ON, EDF, EnBW, Enel, Engie, Iberdrola, and RWE, match and execute trades on the PONTON blockchain.

Another company, BTL, uses a blockchain to help counterparties reconcile transaction data. PONTON, BTL, and other companies like them increase the transparency of data related to bilateral trades and reduce or eliminate fees associated with the use of exchanges and brokers.

Incremental Innovation, Not Decentralized Disruption

Ultimately, blockchains allow individuals to reach agreement on a common digital record of transactions. They secure individuals from the manipulation of that record, a function not previously available without intermediary record keepers or arbiters. In the electricity sector, blockchains help market participants who want more agency over their electricity supplies and transparency in transaction details. We expect blockchains to increase the number of retail customers that trade directly with generators, and the number of large and corporate traders that transact directly without exchanges or brokers.

But even in these most promising of applications, there are no full-scale commercial blockchain projects in the electricity industry. Companies have proven the technical viability of transacting electricity on blockchains, but face regulatory and legal challenges. The PONTON Enerchain project, for example, can only facilitate small prearranged trades until requisite contracts and bylaws enable live energy trades to execute on Enerchain.[3] The question of who will own the Enerchain platform poses a different legal challenge. PONTON is considering legally transferring its intellectual property rights for Enerchain to the consortium of 40-some companies that transact on Enerchain. Beyond such applications, we do not expect blockchains to significantly impact electricity markets. To the extent that blockchain-based applications significantly disrupt the electric power industry, other digital technologies that accompany such applications will have disruptive impacts larger than blockchains themselves.

Notes

1 Jules Besnainou, "Blockchain in Energy & Industry Raises $1 Billion—and Heads into Challenging Times," Cleantech Group, 3 May 2018, available at https://www.cleantech.com/blockchain-in-energy-industry-raises-1-billion-and-heads-into-challenging-times/.

2 Mark Schwarz, "ICO Regulations Worldwide 2018," A Bit Greedy, 26 June 2018, available at https://www.abitgreedy.com/ico-regulations-worldwide/#ico-regulation-by-country.

3 Authors' personal correspondence with Michael Merz, a Managing Director at PONTON.

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Contacts

For further information and questions, please contact the authors:

George Anstey
Associate Director
London: +44 20 7659 8630
george.anstey@nera.com

Max Luke
Consultant
Boston: +1 617 927 4506
max.luke@nera.com

Will Taylor
Senior Consultant
Auckland: +64 9 928 3292
will.taylor@nera.com

Adjmal Sirak
Economic Analyst
Berlin: +49 30 700 1506 17
adjmal.sirak@nera.com

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