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Summary

- *The blockchain industry is moving away from energy intensive versions of the technology.* Early blockchains such as Bitcoin and Ethereum are energy intensive, but there are two much less energy intensive alternatives in late stages of development. These alternatives are not without tradeoffs, but it's become clear to the industry that the energy intensity of Bitcoin and similar networks is a critical problem to be addressed.
- *There are valuable potential applications of blockchain in the energy sector.* Blockchain's novel functionality can render energy markets more efficient and more open.
- *There are still barriers to be overcome before blockchain can contribute to the energy sector at scale.* More work is needed–in particular in the US–to address these challenges and establish the value of blockchain in the energy sector.

The Blockchain Industry is Moving Away from Energy Intensive Versions of the Technology

With Bitcoin's Growing Popularity Comes Growing Energy Use

With its increasing popularity[1], estimates of Bitcoin's global electricity consumption have grown to between roughly 1 TWh and 32 TWh[2] per year, depending on methodology. The former is enough to power roughly 90,000 U.S. homes for a year[3], the latter is on par with the annual electricity use of Denmark. Today a single Bitcoin transaction can consume as much electricity as an average American home does each week. And that's just Bitcoin; there are hundreds of other blockchains that, though they are less used, can be similarly energy intensive per transaction.

Not All Blockchain Networks Are Created Equal

Bitcoin's consensus protocol—the mechanism by which the computers in the network validate and agree upon transactions—is called "proof-of-work" (PoW). It is so named because miners work hard (i.e., devote real-world resources like computers and energy) to solve an equation and prove it to the rest of the network. Though inherently energy-intensive, PoW has the benefit of setting an extremely high bar for validating blocks, making it exceedingly difficult to manipulate or corrupt the blockchain.

PoW is only one way to validate transactions, and at least two alternatives hold promise as blockchain approaches with lighter energy footprints:

- *Proof-of-Stake (PoS):* Under a PoS system, network participants own a share of the system's digital currency and are selected to validate blocks in proportion to their share. This proportional stake—and the risk of losing this "deposit"—disincentivizes malicious actors. Since there isn't computing competition among all participants to solve an encryption problem, as in a PoW network, PoS blockchains use a fraction of the energy.

[1] Wall Street Journal
[2] Energy Web Foundation
[3] EIA

However, PoS has a cost of capital for deposited money, creating economic cost and skewing decision-making power to the wealthy.

- *Proof-of-Authority (PoA):* PoA systems rely on a trusted set of authorities to create and validate blocks. To ensure good governance, there are rules that regulate how authorities join the network and how transactions are validated. Such PoA networks are well-suited to regulated industries where entities responsible for maintaining the network (authorities) need to be known, rather than remain anonymous, as in PoW or PoS chains. Since only approved authorities are validating the blockchain, there is no competition amongst authorities to race each other, which means drastically less power consumption than PoW blockchains. However, PoA requires a set of trusted intermediaries, reducing the distributed nature of the blockchain.

The Industry is Moving Away from Energy Intensive Networks

Blockchain's energy use will not change overnight, but the most widely used chain, Ethereum[4], is actively moving away from Proof-of-Work.[5] Bitcoin may take longer to change, but the industry's overall energy usage will decline as existing networks move away from Proof-of-Work and new networks go live with PoS and PoA. The Energy Web Foundation, for example, was founded in part to address these and other technical limitations of blockchain. We are currently running a Proof-of-Authority test network that we will launch live in 2019.

Blockchain Has Novel Functionality That Could Transform Energy Markets

Blockchain's Functionality is Relevant to the Energy Sector

Blockchain has the potential to play a valuable role in energy markets, providing several novel functionalities:

- *Increased Market Access*: with smart contracts automating many of the functions necessary to bid, settle and participate in markets, blockchain can open up high-barrier-to-entry energy markets to smaller participants.
- *Enhanced Traceability*: by creating unique and trusted digital identities and allowing all users to work off a common ledger, blockchain can seamlessly track ownership of assets (e.g., electric vehicles) and data (e.g., smart meter data), increasing certainty of the origin of assets and electricity.
- *Direct Ownership*: through automated smart contracts, blockchain makes it possible to raise financing for an asset that directly represents an ownership stake and right to partial profit, allowing for enhanced execution of locally owned energy projects.
- *Asset Agency*: through unique and trusted digital identities, blockchain can enable assets like batteries to participate directly in markets without the need for a human intermediary, increasing grid efficiency and decreasing overall electric costs.
- *Data Sovereignty*: by creating unique identifiers for asset owners, assets, and the data produced by those assets, blockchain can create direct data ownership and selective permissioning, allowing for better customer data management and privacy.
- *Distributed Cybersecurity*: through its distributed ledger and distributed consensus mechanism, blockchain ensures that there is no single point of failure for grid control systems, increasing the robustness of the grid to certain types of cyber attack vectors.

[4] The Ethereum main-net processes up to 1,300,000 transactions per day (Etherscan), more than the number of transactions processed by all other public blockchain (excluding Ripple) combined.
[5] Coindesk

Blockchain Can Make Energy Markets More Efficient and More Accessible

One concrete example of a blockchain energy use-case is the Energy Web Foundation's reference application, *Origin*, a blockchain based tracking system for renewable energy credits. Current renewable energy credit markets have high transaction fees, are opaque, and are closed to small participants. Blockchain technology, through its trusted common ledger and automated transactions, allows for drastically lower transaction costs, higher functionality, and greater market access. This has the potential to create new sources of revenue for households with self-generation and allow all customers to buy renewable electricity at their discretion.

While renewable certificate markets are relatively small worldwide, a similar use of blockchain technology could apply to wholesale electricity markets. *Origin* is intended as a reference for commercial actors to build applications in global energy markets of all types.

There Are Barriers to be Overcome Before Blockchain Can Contribute to the Energy Sector at Scale

Barriers, Beyond Energy Use, Are Limiting Blockchain's Usability

The technology is at an early stage of development. Remaining barriers to deployment include:

- Enabling secure and seamless connections with real world assets
- Increasing transaction throughput
- Implementing low-cost data storage
- Educating IT professionals in the energy sector how to use the technology
- Educating energy sector regulators about the potential benefits of the technology
- Deploying a governance mechanism for actors to agree upon needed software upgrades

Energy Web Foundation (EWF) is Working to Address These Issues

EWF has assembled a consortium of 80 Affiliates ranging from large energy companies (such as PG&E, Duke, and Exelon) to small blockchain and energy startups (such as Electron, LO3, and Share&Charge), all focused on creating industrial-grade applications of blockchain technology in the energy sector. EWF's primary project is to develop and deploy the EW Chain, a public, open-source blockchain, purpose built to support applications in the energy sector. The EW Chain currently uses a proof-of-authority based consensus mechanism, enabling it to run with the energy footprint of a medium-sized office building, not a medium-sized country.

This Technology is at a Promising Early Stage; Government R&D Support is Needed to Establish the US as a Leader in this Space

Blockchain technology is at an early stage and more work is needed to address the limitations of the technology and understand its nuanced benefits for electricity grids and the energy sector. The DOE-funded research on blockchain's cybersecurity benefits is a good example of how the federal government can support the technology.[6] However, Europe is far ahead of the US when it comes to blockchain demonstrations and expertise. Without further research and development funding, the US is at risk of falling behind as this technology quickly develops.

[6] Department of Energy