DRAFT

Applications of Blockchain to the Energy Sector

Ripple UBRI Funding: Interim Draft Report

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What are the most promising applications of blockchain in energy and how are organizations tackling some of the biggest challenges to adoption?

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Introduction

In the last few years there has been a lot of discussion around how blockchain will impact the energy industry, from tracking of green credits to DER co-ordination and incentivisation, and wholesale energy trading. Many startups have entered the field to try and design some of these solutions, and most of the large energy players have started to make investments in blockchain research to varying degrees. This research analyzes the current landscape and explores some of the most significant barriers to implementation of these solutions, with a focus on the use case of electric vehicle charging and allocation of green credits.

There are many challenges to implementing a blockchain solution in any industry, including scalability, privacy, and base protocol design. Within the complex and highly regulated energy industry, there are a number of additional hurdles to be overcome. My research focused on the challenges which are most crucial to solving in this space. Some of these and a few example questions are outlined here:

- Oracle / IoT device technologies
    - How can the energy data inputs be validated? What is the best economic technology to achieve a reliable input feed?
- Financial reconciliation
    - How can blockchain be used to consolidate existing accounting databases? How does industry regulation impact the solution?
- Data sharing protocols
    - Who should control the data permissioning structures? How is each party approaching privacy concerns? What data is stored on chain vs. off chain?
- Blockchain protocol
    - Which base protocol is best suited to each application? Which consensus algorithm should be used for transaction validation? How can we ensure sufficient decentralisation?

Value proposition of blockchain

In October 2008, the unknown individual or group of individuals going by the name Satoshi Nakamoto release the first Bitcoin whitepaper. Since then academics, innovators and entrepreneurs have been hard at work building business models, writing software code and pushing the boundaries of economics to figure out where blockchain, the distributed ledger technology behind bitcoin, will have the greatest impact.

Ten years later, and blockchain projects have been run by industry giants from Walmart to Facebook and Louis Vuitton, and yet many of these are still in the phase of pilots or early MVPs, while a number of other organizations remain skeptical of blockchain's long-term value. The reason for this more cautious approach is the interdisciplinary nature of the technology. When applied to the right use case, blockchain can disrupt not just the backend software data structures, but also the methods of system governance and business incentives. Development of these use cases therefore requires collaboration and innovation across all corners of an organization. Furthermore, we can see that each industry requires its own specialized approach due to existing regulations and market structures. This report focuses on applications of blockchain within the energy sector; and before diving into detailed industry-specific use cases, it can be helpful to first outline the high level value proposition of the technology as it applied to a wide range of industries.

When most people talk about the value proposition of blockchain in industry, they are normally referring to the benefits of the blockchain data structure used in parallel with cryptographic identities and trustless consensus, with an application layer that enables development of smart contracts. Although these four things are technically distinct innovations, this report will also make the simplifying assumption of referring to this powerful combination of tools as simply 'blockchain'.

Using this definition, the value proposition of blockchain can be described by the four facets of decentralization, immutability, security and transparency. Decentralization refers to the idea of 'cutting out the middleman'; disintermediating third parties to enable faster verification, while eliminating the 'single point of failure' inherent with most centralized solutions. Immutability covers the append-only nature of blockchains, such that an audit trail of transactions is maintained in chronological order, reducing the need for multiple ledgers of siloed information. Security is ensured through protected cryptography and consensus protocols; by linking together each transaction in the chain, fraud can be effectively prevented. Finally, the property of transparency refers to the fact that all users of the network can view all previous transactions and the details of smart contract logic.

These high level value propositions cascade into the business advantages of reduced backend cost, faster processing times, reduced transaction or credit risk, lower barriers to market entry, programmable privacy, and censorship resistance.

In thinking about the value proposition of blockchain, it can also help helpful to divide applications into the two sub-groups of 'improving current business models', and 'enabling new business models'. The business advantages described above mostly fall under the 'improving current business models' category; in the same way people saw smartphones as a technology that meant you could take calls away from your landline. The second category of applications are much harder to predict; we can draw parallels with the internet and Uber or Lyft, who are disrupting the transportation industry with a business model that couldn't exist before the age of smartphones.

Identifying applications that improve current business models depends on an ability to recognize where value is currently being left on the table. Wherever time or money can be saved, there is a business incentive for change; these are the use cases where we are currently seeing the greatest traction across all industries, and are the focus of the use cases covered in detail below.

Summary of energy use cases under development

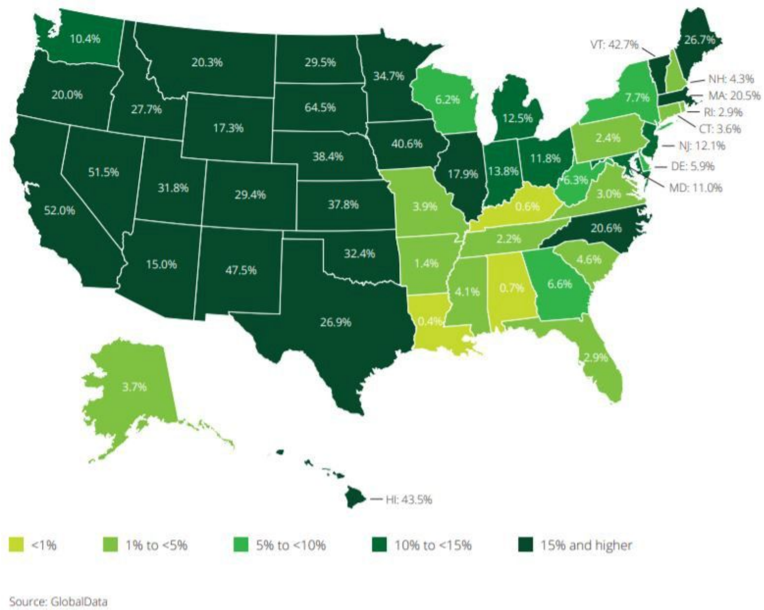
Our electricity grid is one of the most complex technological innovations of the 20th century. Figuring out how to use blockchains most effectively might end up being one of the biggest technological innovations of the 21st century. According to the November 2018 report by SolarPlaza, over 150 companies are currently looking at solving problems at the intersection of these innovations.

In the last year, it's been exciting to see a lot of the research move towards commercial pilots around the world, from New York to Thailand and London, as energy blockchain startups get stuck in working with regulators and utilities. However, given the noise and hype that still surrounds a lot of blockchain projects, it can be hard to figure out what's actually going. This section covered the top five energy blockchain use cases currently under development.

Coordination of distributed energy resources (DERs)

The exponential growth in distributed generation, electric vehicles, and energy storage offers huge potential for decarbonizing the grid, but also introduces significant co-ordination and load balancing challenges. This growth is happening quickly; Deloitte projected that, by 2030, variable solar and wind generation will contribute over 20% of our energy in 21 US states, up from just one in 2015. As a result, many of these resources are not yet being used to their full potential, particularly when it comes to ancillary grid services such as load following and energy imbalance. The introduction of blockchain-based virtual power plants, microgrids, and asset registration platforms are seeking to solve these problems through bringing transparency to all levels of the network. This transparency additionally enables more accurate calculations of the marginal value of DERs based on location and grid constraints, to inform future investment decisions.

Example players: Electron, OmegaGrid, PowerLedger, LO3, WePower



Predicted penetration of Variable / Distributed Energy Resources across the US by 2030 [SOURCE: Deloitte report on managing variable and distributed energy resources, 2015]

Green credit trading

Green credits have been introduced around the world to incentivize the generation and consumption of environmentally sustainable energy by imposing a 'price' or 'discount' for these attributes. Examples include Renewables Obligation Certificates in the UK and Low Carbon Fuel Standard (LCFS) credits in California. With multiple parties inputting data who have incentives not to trust each other, where it's also important to be able to track the history of transactions and avoid double counting, several players are making moves to solve these challenges using blockchain. The following section covers an in-depth analysis of this use case, as applied to LCFS credits.

Example players: PowerLedger, Volt Markets, Greeneum, Energy Web Foundation

Wholesale energy trading

Wholesale energy markets see a high throughput of high value transactions; where the order of incoming transactions and confirmations must be retained. The platform access and transaction fees currently charged by many of the centralized exchanges are the target of several blockchain companies in this space. In addition, increasing the speed of transaction confirmations is expected to significantly reduce issues of reconciliation and therefore reduce the risk carried by the exchange. Some of the more ambitious business models are also looking at bringing individual consumers into wholesale markets and bypassing retailers, using a blockchain-based trading bot that is responsible for meeting your household energy needs.

Example players: [VAKT](), [Ponton](), [LO3](), [Grid+]()

Renewables development financing

Financing of large energy infrastructure projects, such as the development of a new solar farm, is a complicated and often slow, drawn-out process. Blockchain accelerates the financing process and mitigates risk through automation and simplification of contractual compliance, which can be exceptionally complex in an industry whose contracts are riddled with covenants. Additionally, access to finance is particularly difficult in developing economies, where the financial system may be less transparent and projects often carry higher risk. Blockchain can enable the selling of future energy generation as tokens today to raise capital for investment, or fractional ownership of solar panels which distributes the financial burden across a number of parties.

Example players: Banyan Infrastructure, M-PAYG, Sun Exchange, WePower

Automated financial settlement

Ensuring that energy customers pay the right amount at the right time consumes considerable resources for utilities around the world. This settlement process often takes several weeks and counterparties carry significant credit risk. Automated and near-instantaneous payments can be made possible using blockchains, to speed up the process and reduce risk.

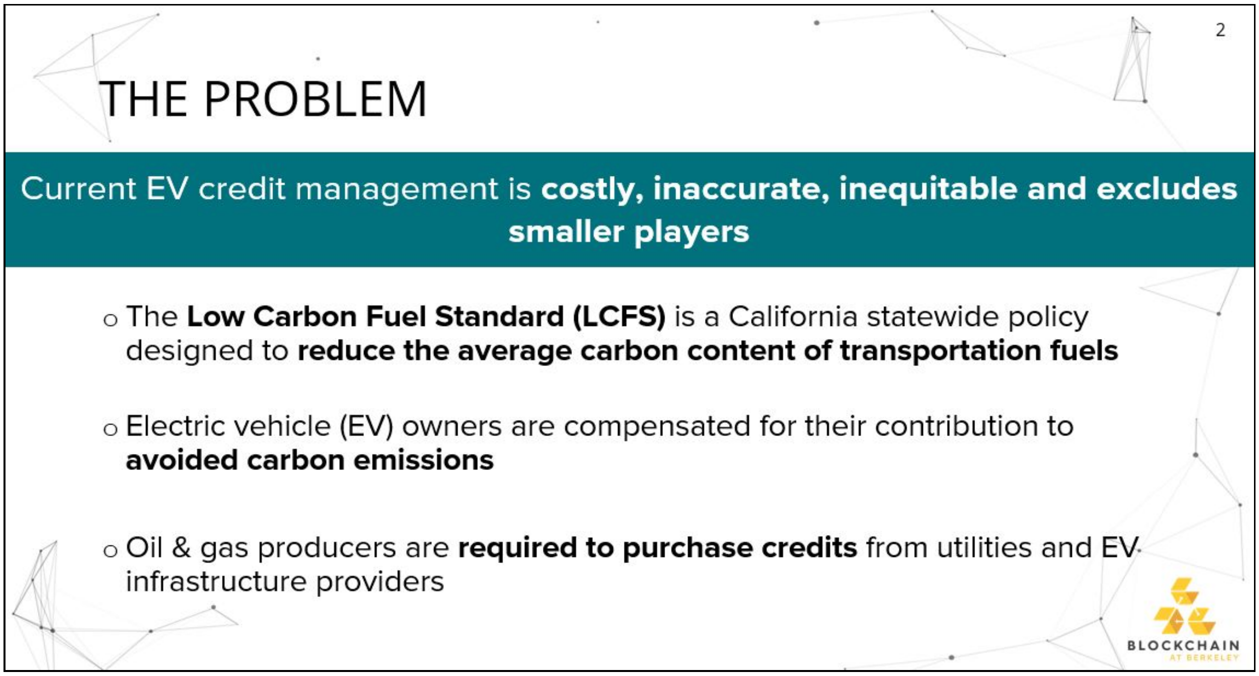
Example players: BTL Group, Causam Exchange, Verv, Grid+

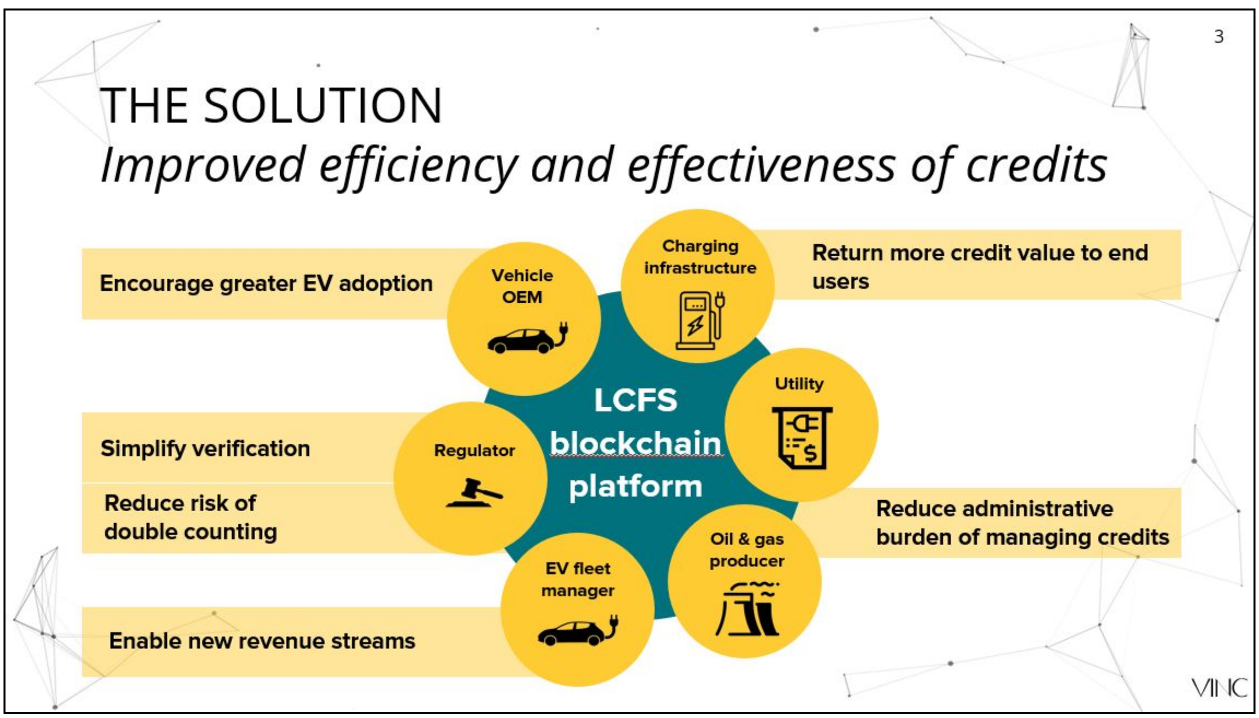
In-depth analysis: Green credit trading use case

Over the last four months, I have been leading a team of Blockchain at Berkeley developers to build a proof-of-concept platform for trading Low Carbon Fuel Standard (LCFS) credits, working directly with the utility PG&E and automaker BMW. This section covers the key learnings and insights from this research project.

Opportunity

Figure XX gives a summary of the problem our project was looking to solve. To relate this to the value propositions covered in Section XX above, decentralization, immutability and transparency are the biggest motivators of using blockchain for trading LCFS credits. The current LCFS credit trading process takes data from a number of siloed databases, and relies upon a third party to verify and confirm credit transactions. The California Air Resources Board (CARB, the energy industry regulator), governs the system, and needs to be able to be able to see how many credits each party owns, and has the authority to resolve any disputes arising within the network. The current system relies on complex contracts and manual processes that result in smaller players being excluded from the market; because the barriers to entry and cost of transactions is high enough to prevent parties with only a small number of credits from engaging in the exchange. Figure XX shows how the introduction of a blockchain platform for managing LCFS credits can provide benefits to each party within the ecosystem.





Challenges

During this project, we learned that there is a lot of excitement and appetite within the energy industry for blockchain projects which can solve real pain points with systems used today. We also came face-to-face with several challenges to adoption: Industry regulation, Integration with legacy systems, risk controls and Blockchain technology maturity.

Industry Regulation

As one of the backbones to modern society, the energy industry is very highly regulated. This is important to protect our security of supply, and can also change market incentives for new entry and innovation. We were fortunate to be working with PG&E and BMW, where both organizations put a high priority on innovation or new technology, and also have the connections and reputation to influence regulatory bodies.

One specific example here is the three-year rule making cycle.

Integration with Legacy Systems

Risk Controls

Blockchain Technology Maturity

Our project focused specifically on Low Carbon Fuel Standard credits, though it will be recognized that many of these benefits translate to all varieties of green credits; including, for example, Renewable Energy Certificates in Singapore, Australia, Canada and the USA, the Emissions Trading System in Europe, and Renewables Obligation Certificates in the UK.

Industry opinions

Opinions and expectations from industry interviews

Opportunities

Challenges

What's next?

Discussion of network effects: are utilities or start-ups best placed to lead this transition?

Conclusion

Precise estimates vary, but a report by Zion Market Research predicts that the energy blockchain market will reach $12bn by 2024.

I'm particularly excited about the sheer magnitude and breadth of impact that could come from improved DER management, and also recognize that some of the others, like carbon credit trading, might be easier to implement at large scale. However none of these are a simple path to take; the crucial dependencies on energy market regulation and different market structures in each jurisdiction means that implementing these business models requires bucket loads of innovative thinking and determination.

Acknowledgments

Huge thank you to everyone whose views and ideas helped to shape this work. Including:

Chinedum Umachi, Expert Product Manager, PG&E
Lydia Krefta, Energy Markets Innovation Manager, PG&E
Adam Langton, Connected eMobility, BMW
Abdel Banya, Co-founder, Banyan Infrastructure
Paul Ellis, Co-founder, Electron
Jojo Hubbard, CEO, Electron
Kevin Clifford, Product Manager, Advanced Microgrid Solutions
Ashley Lannquist, Blockchain Lead, World Economic Forum
Rika Sukenik, Product Manager, MyCrypto
Joe Bourg, Director of Business Development, Olivine
Josh Lehman, Product Manager, STEM
Dan Wohl, Business Development & Policy, TESLA
Jay Chugh, Blockchain Lead, Oracle
Sara Mulhauser, Senior Project Manager, Bloom Energy
Jim Duffy, Alternative Fuel Availability Manager, CARB
Michael Kennedy, Oregon Clean Fuel Forecast
Todd Jones, Director, Policy and Climate Change Programs, Centre for Resource Solutions

References