AGENDA: UTILITIES, NATURAL RESOURCES – AMY TONG AND ANNE NEVILLE-BONILLA

Notes:

- The authors are awaiting approval to use select quotes from interviews they conducted. As a placeholder in this draft document, pending quote approval is indicated in brackets.
- The authors are continuing to research certain issues and have also indicated this information in brackets.

Introduction

Blockchain is a flexible technology that theoretically has dozens if not hundreds of different potential applications in the utilities and natural resources sectors. While it has the capacity to facilitate changes and enhancements in these sectors, many blockchain applications are still hypothetical or have been tested only within limited pilot projects. Of these, most of the work has centered on the energy sector, and this is reflected in the media discourse, academic research and project analyses. For this reason, this report primarily considers examples in the energy sector with a limited focus on applications in other parts of the utilities and natural resources sectors. [Note: the authors welcome information about additional projects underway in these sectors.]

Potential Applications and Benefits

As demand for decarbonized energy grows, the energy sector is experiencing a shift towards more digitized and decentralized operations.[1] In their article titled "Blockchain Applications in Smart Grid – Review and Frameworks", Musleh, Yao, and Muyeen explain that "the main challenge [for the energy sector] is the appearance of the new type of grid user called the prosumer, who produces and consumes electrical energy in a local area. The additional challenge is the intermittent nature of renewable energy sources such as solar and wind energy. The principal task of the electricity grid is to transmit energy in a stable manner."[2] Blockchain could provide the technology needed to support prosumers, for example through smart contracts embedded in peer-to-peer (P2P) energy trading systems, and facilitate greater use of renewables. However, most experts agree that we are in the very early stages of understanding this use case. "We are still decades away from transactive energy," said Marzia Zafar, Director of Innovation and Insights at the World Energy Council.[3]

Modernized Grids and Improved Energy Transfer

Modernized grid concepts like smart grids, microgrids, and peer-to-peer energy transfer are popularly cited solutions to facilitate energy decarbonization, and they are also some of the most commonly cited examples of potential blockchain use in the utilities sector. At the root of these applications is the idea that energy grids need greater flexibility in order to accommodate energy from multiple sources, rather than a single centralized utility. A smart grid enables "bidirectional flows of energy and uses two-way communication and control capabilities that will lead to an array of new functionalities and applications."[4] "A microgrid is a localized energy system that can operate

independently of the traditional electrical grid that delivers electricity from public utilities to consumers."[5] And peer-to-peer energy transfer enables "direct energy trading between energy consumers," such as consumers with their own solar panels, for example. [6] All of these modernized grid concepts may be used separately or simultaneously within one system. They all allow for a more flexible grid that can increase energy resiliency and better integrate renewable resources.

Blockchain is a promising platform for these applications in a variety of ways. Blockchain could allow for detailed data collection on power consumption and creation from multiple different sources. Data could be shared in real time with any number of users and system managers, and the platform could automatically execute transactions. This is key to a grid that incorporates energy from multiple sources at once. Blockchain can also tokenize energy credits, making it possible to trade energy within a grid of many different users.[7]

Mike Orcutt, writing for the MIT Technology Review, explains the transition from a centralized grid to a decentralized, blockchain-based grid:

> "The electricity sector is, for the most part, still based on massive, centralized power plants that generate power sent long distances over transmission and distribution lines. In recent years, though, a growing number of smaller 'distributed' power generators and storage systems, like rooftop solar panels and electric-vehicle batteries, have been connecting to the grid.
>
> The owners of these systems struggle to maximize their value because the system is so inefficient . . . For instance, it generally takes 60 to 80 days for an electricity producer to get paid. With a blockchain-based system. . .producers can get paid immediately, so they need less capital to start and run a generating business."[8]

Blockchain-enabled grids could one-day have a significant impact on the energy industry. In fact, "investment banking firm Goldman Sachs predicts that using blockchain to facilitate secure transactions of power between individuals on a distributed network could result in transactions worth between $2.5 – $7 billion annually."[9]

[Other types of distributed ledger technology may also enable these applications. The authors plan to research this topic in greater detail for the next iteration of this paper.] Julie Hamill of the International County/City Management Association, which is an internationally-recognized association supporting "professional local government through leadership, management, innovation, and ethics,"[10] writes that although blockchain isn't necessary for a microgrid to function, "blockchain in a microgrid system will provide more transparency and efficiency."[11]

Improved Data Collection and Transparency

Even without restructuring distribution systems, utilities could use blockchain to improve data collection, which might streamline administrative functions like billing and data validation.[12] As with the modernized grid examples, utilities could collect real-time information from nodes at any level of the distribution process, whether to track fuel supply for power plants, monitor electrical lines, or gather data on individual home energy use. Improved data collection through blockchain could lower costs and increase efficiency for both utilities and ratepayers.[13] A benefit to exploring back-office solutions that are blockchain-enabled is that these administrative applications are far less likely to encounter regulatory restrictions compared to the front-end applications that are used to change how energy is used or sold.[14]

Blockchain offers an immutable ledger and easy data sharing. Within the utilities sector, this could allow utility operators to better detect breaches or defaults in distribution systems. It could also improve trust among regulators, utilities and consumers. "Blockchain can introduce a level of transparency not currently seen in the energy sector," said Zafar.[15] Zafar explained that the transparency and traceability benefits offered by a blockchain platform could help move regulation from a reactive process to a proactive process.[16] [Awaiting quote approval that suggests the following*:* from a regulatory perspective, blockchain could support more trusted data.] Data could also be shared with auditors, helping to reduce auditing costs and other administrative costs.

Challenges

Regulatory Environments That Are Not Constructed for Peer-to-Peer Transactions

The utilities and natural resources sectors often exist within highly structured regulatory environments, but the implementation of emergent blockchain technology does not always align within this existing structure. Dr. Neil Wasserman, professor of computer science at George Washington University, says that from his perspective, "a key obstacle to making [blockchain] work is the interface between the legal environment under which we understand transactions and software environment under which we understand transactions."[17] Blockchain allows for transactions and data collection in ways that regulations are not currently structured to manage.

For example, a microgrid pilot project in Brooklyn came across the following obstacles: "By law, individuals are not allowed to sell or buy electricity directly from each other. Brooklyn Microgrid participants are buying and selling tokens for energy credits, rather than actually exchanging U.S. dollars for electricity." The ICMA's Julie Hamill argues that "significant regulatory changes would be required for blockchain to have a major disruptive impact on the traditional utility business model. For blockchain to enable distributed energy users to transact directly in energy sales, the existing laws must be changed."[18] The coordinators of the pilot project have engaged in discussions with New York regulators to "sell energy through a utility bill, as required in New York State," without being subject to the same state utility regulations.[19] In this situation, it appears

that the prohibition is not against blockchain, but against peer-to-peer energy sales. That is, buying and selling energy directly under a regulatory scheme that prevents it would be unallowable whether the technology that enabled the transfer was blockchain, some other form of distributed ledger technology, or a low-tech solution altogether. In sum, while regulations prevent large-scale structural changes to the energy distribution system they do not prevent the use of blockchain in and of itself.

Some industry experts argue that uncertainty within the law regarding blockchain prevents companies from experimenting with the technology. [Awaiting quote approval that suggests the following: ambiguity and uncertainty around regulations pose a barrier to blockchain use and tokenization of energy credits. Regulators in other countries have encouraged the development of blockchain technology.] Parts of Europe and Australia have developed one regulatory tool – the "sandbox" - that gives companies more freedom to test out new technology, such as blockchain.[20]

At the same time, much like other new technologies, there continues to be a generalized concern among stakeholders that regulating blockchain this early in its development could stifle technological progress. Zafar writes, "regulators must clearly state their philosophy and long-term vision: The current regulation is defined for vertically integrated utilities. Regulators need to redefine policies so that they are suitable for and do not unintentionally constrain new business models enabling transactive energy systems."[21]

Some within the blockchain industry worry that cryptocurrencies and the media attention surrounding their use by bad actors has damaged blockchain's reputation. [Awaiting quote approval that suggests the following: perceptions around Bitcoin have changed the way people view tokenizing technology.] [Awaiting quote approval that suggests the following: some conflate Bitcoin and blockchain, leaving decision makers reluctant to take action.]

Limited Pilot Programs and Research

[Awaiting quote approval that suggests the following: a major barrier to implementing large scale blockchain projects is the lack of comprehensive pilot projects that consider every aspect of the use case and applicable regulations.] [Awaiting quote approval that suggests the following: current use cases are preliminary.]

[Awaiting quote approval that suggests the following: opinion that there is a need to educate people on blockchain technology and prepare them to more effectively work in the blockchain space.]

Security and Privacy

It is hard to say whether or not blockchain will add value to security in the utilities sector. Depending on the application, blockchain may be able to improve the security of the systems it manages. Hamill explains further:

> "There is no such thing as a purely immutable and unhackable system, in any context. Depending on the type of blockchain utilized (public or private), there are risks of a bad actor accumulating 51 percent of CPU power in a network and manipulating data, or it is possible that an authorized administrator of a private network is hacked or corrupt and manipulates or releases data. However, if the technology experts are to be believed, blockchain technology greatly reduces the chance of data manipulation, and any such manipulation could not occur undetected."[22]

Depending on the existing security of a utility's database technology, the secure and immutable nature of blockchain alone could provide improvement.

However, to understand where blockchain can add specific security value, areas of vulnerability in the system must first be identified. [Awaiting quote that suggests the following: blockchain users should first ask where the points of risk are in an operation, and then see if blockchain can fill those gaps.][23]

In terms of personal privacy, only some applications of blockchain within these sectors raise concerns. Blockchain in smart devices could track individual home power use, such as when you charge your phone or use the stove and for how long.[24] However, this privacy concern is more closely related to the smart devices, rather than the blockchain platform the information is stored on. Blockchain used in back-office systems would likely have little impact on personal privacy. [The authors plan to further examine this topic in future iterations of this paper.]

Pilot Projects

California Context

California is in the very early stages of integrating blockchain into utilities. Two often-cited blockchain-utility pilot projects in California are led by municipal utilities and focus on electric vehicle charging. Although these projects have limited scope, they offer a glimpse into how blockchain could be more widely used by California utilities. [The authors expect future iterations of this paper to include an overview of peer-to-peer limitations or opportunities in California.]

Silicon Valley Power (City of Santa Clara) Electric Vehicle Pilot Project

Power Ledger partnered with Silicon Valley Power, a not-for-profit municipal electric utility owned and operated by the City of Santa Clara, "to monetize electric vehicle infrastructure, creating the potential for tokenized energy."[25] [Awaiting quote approval that suggests the following: a blockchain platform helped simplify a utility's regulatory reporting processes.]

> "Using the Power Ledger platform, Silicon Valley Power tracks production and use of energy at the solar PV and battery-equipped six-story parking garage in the heart of the city's entertainment district. Digitizing electric vehicle (EV) charging transactions to help the utility earn credits under the California Air

Resources Board's (CARB's) Low Carbon Fuel Standard (LCFS)." [26] Charging data is tracked in real time and secure from alteration.[27]

[Awaiting quote approval that provides a project update.] [The authors plan to include in future iterations of this paper the perspective of the municipal utility in leveraging blockchain.]

Sacramento Municipal Utility District Electric Vehicle Pilot Project

The Sacramento Municipal Utility District (SMUD) "will utilize blockchain-enabled tokens as part of an effort to encourage EV owners to charge their vehicles at workplaces when local renewables peak during the day."[28] The project aims to incentivize customers to charge electric vehicles when renewable energy is peaking. [29] The charger automatically begins charging when a surplus of energy is available, and consumers are charged a discounted rate. [30] Consumers will be offered "rebates or credits on charging that they can accumulate as blockchain-enabled tokens."[31]

Brooklyn Microgrid Project

Brooklyn, NY has one of the most notable microgrid pilot projects in the world. In this pilot project, "blockchain technology allows for the transfer of electricity credits among participants through a secure, low-cost, and public digital ledger that all users can reference." [32] Participants installed smart meters that track energy generated through their solar panels.[33] Using blockchain technology, participants exchange energy credits.[34] Blockchain "records the terms of the contracts and tracks how many energy credits have been sold by each participant."[35] "The system acts as an instant and secure confirmation of both the verified ownership of a property and its exchange."[36]

Howver, the project has struggled to operate within existing utility regulations. "The problem with the blockchain microgrid is that, by law, individuals are not allowed to sell or buy electricity directly from each other. Brooklyn Microgrid participants are buying and selling tokens for energy credits, rather than actually exchanging U.S. dollars for electricity. Significant regulatory changes would be required for blockchain to have a major disruptive impact on the traditional utility business model. For blockchain to enable distributed energy users to transact directly in energy sales, the existing laws must be changed." [37] In late 2019, Brooklyn Microgrid applied to the New York State Public Service Commission to allow it operate a "peer-to-peer energy marketplace" within New York State's regulatory sandbox for energy.[38]

Natural Resources

Theoretically, blockchain could enable a multitude of technological advancements in the natural resources sector. Most information on this use case surrounds supply chain management. Blockchain offers the advantages of immutability and quick data sharing. Suppliers could use a blockchain platform to better police their supply chain, ensuring supplies are responsibly sourced and carefully tracking transactions.[39] Some

companies, such as De Beers and Provenance, hope to use blockchain to help consumers make informed choices about their purchases. Smart contracts could facilitate costly transactions between suppliers and vendors, and easily accessible ledgers could reduce auditing costs.[40]

Pilot Projects and Use Cases in Natural Resources

Water Management

Blockchain could help manage California aquifers by enabling water trading between farmers. Alex Johnson, from the Freshwater Trust, is using a blockchain platform to help farmers trade water in Solano County, California.[41] Johnson deployed "simple, solar-powered sensors, originally developed to monitor creaky groundwater pumps in East Africa. The sensors will be used to detect how much water is flowing in real-time."[42] Using that data, farmers will then be able to trade water on a blockchain platform.[43] The immutability that is inherent to blockchain is also what makes it attractive for this project. "'Water users are a suspicious bunch. They don't love government interference and suspect other water users are going over their allocations,' he [Johnson] says. That makes water and blockchain a good fit, he argues: It allows a group of people who don't necessarily trust each other to make deals, without the need for third-party oversight."[44] Like Brooklyn Microgrid, this project will also use smart contracts to facilitate the agreement between parties.

This pilot project demonstrates the potential value of blockchain in aquifer management, but there are many regulatory and geographic challenges to overcome before this technology can be implemented more widely.[45] [The pilot for this project began in summer 2019. Authors plan build-out this case in future iterations of this paper.]

Beyond aquifer management, a blockchain platform could enable a similar smart grid concept for the water and sewage sectors. For example, a blockchain platform could make water quality and quantity data more accessible, helping to inform consumers about the safety and availability of water in their area and perhaps guiding water conservation efforts.[46] However, the development of blockchain in this use case is still very preliminary.

Provenance Supply Chain Information App

Provenance, a London-based start-up, uses blockchain to track production information on the certification, origin, producer, and environmental impact of a given product.[47] Provenance created an app that suppliers can easily and securely add data to.[48] Consumers can access this information to better understand the sourcing process for a given good.[49]

De Beers Diamond Supply Chain Project

The diamond supplier created the first blockchain ledger for tracking diamonds across the supply chain.[50] The company hopes to increase transparency for customers who

want to ensure their purchases were responsibly sourced.[51] The new system aims to prevent conflict diamonds and synthetic diamonds from entering the system.[52]

BHP Sample Supply Chain Project

BHP, a mining firm, is using blockchain to track the transportation of rock and fluid samples between vendors. [53] The company's old system relied on spreadsheets, and they hope that blockchain will help the company improve internal efficiency and relationships with partners.[54]

Recommendations

Note: The authors are still researching potential recommendations.

At this draft stage, the authors observe that other countries and certain other states are facilitating experimentation through regulatory sandboxes. Additional discussion and research is required to understand whether this is feasible in California.

Several energy cases and the groundwater pilot also rely on blockchain-enabled smart contracts. The authors will review the draft smart contracts case study to inform additional options here.

The authors are also seeking to review additional literature and interview government experts from the National Association of Regulatory Utility Commissioners (NARUC), National Association of Chief Information Officers (NASCIO) and the National Governors Association to complement discussions with ICMA and the National Conference of State Legislatures.

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