HOW DOES THE ENERGY SECTOR EXPLORE DISRUPTIVE INNOVATION: A BLOCKCHAIN CASE STUDY

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ABSTRACT

The goal of the this paper is to explore how the incumbents of the energy sector are exploring a technology that they deem disruptive and with what research questions. the current approach of researching focusses on incremental innovation and exchange of technologies and is not suitable to predict major disruptions due to technological innovations. Authors advise the energy sector to investigate disruptions or possible paradigm shifts together with outside parties that are leading the field of research. In this case researching the potential of blockchain technology together with the leaders in the blockchain community.

INTRODUCTION

Reports [1] and executives [2] in the energy generation and distribution sector have identified blockchain technology as a potential disruptive force that might transform the energy market.

Blockchain technology is a decentralized digital ledger of transactions and is currently being hailed as incorruptible and as a technology that will change money, business, and the world. [3]

The energy sector is looking at blockchain technology to possibly decrease energy transaction costs and facilitate a more efficient and a decentralized energy system, in a future in which households and small businesses not only consume but also produce energy, the transition towards renewable energy and the electrification of road transport

A wide variety of blockchain applications in the energy sector have been, or are being, tested as demonstrated by M. Adoni et. al [4], who identified and reviewed no less than 140 blockchain research projects and initiatives by the energy and distribution sector.

The Energy Web Foundation, a global non-profit organization founded by the Rocky Mountains Institute and Grid Singularity and collaborating with major players in the energy sector, believes that the technology has the potential to redesign how energy is distributed and transacted. They are building an open-source blockchain infrastructure, called Tobalaba, as a test network for blockchain applications in the energy system.

Blockchain is an very young technology that has barely the concept stage. Will it facilitate sustainable efficiency (cost decreases) or is it an innovation that will disrupt whole parts of the sector?

While blockchain applications are in transition from the early, exploration, stage of the innovation curve to the growth stage, interest in the technology is waning. Gartner states in its Hype Cycle for Emerging Technologies, 2018 that blockchain technology might have past “the peak of inflated expectations” and is moving towards the “trough of disillusionment” of the hype cycle.

Waning interest in the technology creates the risk that major disruptions could be missed as the development of killer-apps on the blockchain are being developed under the radar and then suddenly sprung on the electricity distribution sector, as has happened with for example the music industry of the radical new markets that have been enabled by the internet. Asking the right question becomes of even higher importance.

To draw a parallel, the Internet was described as the digital highway because the killer app, e-mail, was lightning fast. Nowadays we define the internet as an electronic communications network that connects computer networks and organizational computer facilities around the world, our view on the technology and its potential has evolved. How we are looking to blockchain ten years might very different.

Are we asking ourselves the right questions to spot major disruptions in time? While the term disruption is often used to describe a situation in which an industry is shaken up, it is hard to recognize and define a technology that proved to be disruptive, as well as predict the impact. How do the research questions hold up to those asked on the eve of for example the transition from physical CD stores to streaming sources.

A framework to recognize disruptive innovations has been put forth by Bower and Christensen in 1995 [6], who define disruption as a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses or transform the market as a whole.

For the incumbents it is important to recognize the type of innovation because different innovations, require different strategies in response to the new market environment.
It is rare that a new technology or product is inherently sustaining (also known as incremental) or disruptive but innovations always start as small-scale experiments and can easily be overlooked by the incumbent until the

business model allows the entrant to suddenly take over from the incumbent that is not able to react in time.

That is particularly of concern for us as DSO's being the incumbents distributing a society-critical commodity, given our investment of billions of euros in assets and our 30 – 40 year depreciation period.

Given that we operate and maintain critical infrastructure, do we have the room to be surprised by disruption? What would be the consequences for the consumers if there were sudden shifts as for example radical commercialisation in the energy distribution sector?

The goal of the this paper is to explore how the incumbents of the distribution sector are exploring possible innovative disruptions. Using blockchain technology as a use-case and to advise / propose on possibly missing research questions that help to explore possible disruption in a very early stage.

RESEARCH QUESTIONS

The research questions involved are: **If blockchain technology is deemed to be a disruptive innovation, how does the energy sector explore the disruptiveness of blockchain technology? How do the identified disruptions hold up to the theory of Disruptive Innovation of Christensen et al.? Are the research questions sufficient to recognize and classify disruptions in time?**

METHOD

The problem is that while blockchain is commonly mentioned in publications as a potential innovative, disruptive technology for the energy system, broader research or meta-analysis is lacking or not aiming to understand the disruptive potential of blockchain as well as blockchain in combination with other radical technologies.

Moreover, understanding the aspects and the nature of any disruption or radical changes in the energy system is not addressed at all. We seek to explore this by analysing how the sector is investigating the disruptive potential of blockchain on the energy system.

We briefly explore how proven disruptive innovations in the past have been addressed by the incumbents. How disruptions were able to hide because the incumbents never asked the right questions and thus were disrupted.

First, this paper will identify how the energy sector is looking towards blockchain with a qualitative analysis of 30 + publications on the applications and disruptive potential of blockchain for the energy sector by classifying publication types, the methodologies used, the identified applications of blockchain, the research questions and their aim.

Finally, this paper will analyse whether the research questions towards the disruptive potential of blockchain are sufficient to spot and predict radical changes in the complex energy system.

Blockchain

Blockchain technology enables recording and validating transactions, financial or otherwise, between members of a decentralized network, without the need of a central administration or management.

These transactions consist of individual records, or blocks, that are recorded together in a single list, a chain. Each transaction between two or more members of the network is validated by all the computers in the network that work together to ensure each transaction is valid, before being added to the blockchain. Once the transaction is validated, the record is added and the now extended blockchain is encrypted with a hash generated from all previous blocks.

This principle ensures a transparent ledger in which it is extremely difficult to alter past transactions, since all subsequent transactions in chains must be altered first which requires consensus of the validation nodes, the miners. The validation occurs through distributed consensus algorithms of which there are several different types. Together with the network architecture, these are the most distinguishing characteristics of the different kind of blockchains of which there are many. The most well-known are Bitcoin and Ethereum.

Every consensus algorithm comes with distinctive advantages and disadvantages that determines application suitability as well as transaction speed, scalability and security.

In general, blockchain technology can be applied to record or edit transactions that happen concurrently between multiple users that are interdependent on each other decisions and a central database is unwanted.

Disruptive Innovation

Recognizing disruptive innovations before they have happened has been one of most important focus points of management in order to avoid being (nearly) put out of business by disruptive innovations like Kodak (digital camera), Xerox (photocopier) or Nokia (Apple iPhone). Disruption theory can help management to make strategic choices between improving current services or adopting disruptive technologies.

According to the theory [6], disruption is defined a process whereby a smaller company with fewer resources is able to successfully challenge established incumbent businesses by exploiting new technologies to deliver new

or existing products in radically different ways. Whereas the incumbent keeps focusing on developing sustaining innovations for its current most profitable customers.

Digital, software-based, disruptions are even harder to predict and adapt to than physical, hardware-based, disruptions. Software can evolve at a much quicker pace and scaled much more easily, enabling sudden disruptions that appear to come out of nowhere. [7]

Digital disruption can be defined as the rapidly unfolding processes through which digital innovation comes to fundamentally alter historically sustainable logics for value creation and capture by unbundling and recombining linkages among resources or generating new ones. [8]

In other words, as soon as a radical new digital infrastructure has been established, new ecosystems can build on top of it with radical new business models or value creation that result from the use of the technology. Especially due to the relative ease in which digital innovations can be combined, the impact of synergies are even harder to predict than the impact of the individual technologies.

For example, all elements of the music industry have been disrupted: the product, the store, the distribution and the way to experience the music. Digital stores, web shops, have displaced brick-and-mortar stores by being able to offer a wider variety than any physical store ever viably could. Digital downloads replaced physical distribution and music players have been disrupted by iPods and smart phones.

The combination of the innovations have allowed streaming technologies (Spotify) and embedded markets in music players (iTunes) to completely disrupt the distribution model of music by offering equal or better quality, at lower cost and higher convenience and by-passing the dominant infrastructure and business model altogether in a period that is shorter than the typical depreciation period of buildings, CD factories and the like.

The incumbents should have questioned how they could offer the superior product, for both consumers and artists, instead of trying to fight only one element, illegal distribution and trying to maintain monopoly pricing.

The disruption of the industry has been further amplified because digital innovations have enabled musicians to produce and distribute music and enabled consumers to experience in completely new ways without he need of record labels to finance production, promotion of distribution. One can speak of a true paradigm shift, the power of the major players in the industry have shifted towards new parties.

This paradigm shift in the music industry due to digitization and the internet was unimaginable right after the internet bubble almost 20 years ago. Although digital content delivery has been predicted to penetrate 80% of the world's largest public enterprises by 2006 [8], the burst of the dot-com bubble and collapse of Napster have upended those predictions. It is not hard to draw similarities to Bitcoin and other cryptocurrencies after the loss in value that we have witnessed last year.

The theory of disruptive innovation is not only applicable to businesses in the private sector, but also to systems in the public sector like the electricity distribution system. [10] A system is "an interconnected set of elements that is coherently organized in a way that achieves something. A system must consist of three kinds of things: elements (stocks), interconnections (flows) and a purpose.

The energy distribution system can be described as a complex system consisting of multiple public (Regulators, Network Transmission and Distribution Operators) and private (Energy producers, traders, suppliers) segments.

A complex system is a system that, as a whole, displays characteristics that cannot be deducted from the characteristics of the separate elements in the system. Hence to detect major disruptions of the energy sector, it is not sufficient to study the how a technology might impact a single element.

In order to qualitative test whether the blockchain innovations as identified in the publications can be considered an disruptive innovation for the energy sector, the innovations and new business models must:

Qualitative test for disruptive technology
Differ from traditional technology
Be realizable by parties new to the market
Be less expensive than operate than the traditional technology
Maintain cost-competitiveness over time and in scale
Be enabled by rapidly evolving technology
Demonstrate effectiveness in real-world use
Offer low-risk innovation strategies for the entrant
(Radically) Change multiple elements of the energy system
Disrupt or by-pass critical assets and infrastructure

RESULTS

Authors have identified 36 cited and referenced publications on the subject of innovative application of blockchain in the energy sector using the references in literature reviews by M. Adoni et al. 2018, and Orlov 2017, Google Scholar and ScienceDirect.

Authors observe that 22 publications cover blockchain application in the energy sector, this is a low amount of publications, an indication of how young the technology is.

First, the literature on this topic consists mainly of journal articles (12) and market reports (10) with only a small number of academic publications (5).

Second, the most applied methodologies are (1) surveys to current (pilot) projects, (2) identification and exploration of potential blockchain applications, (3) qualitative analysis of applications in the sector and (4) conceptualization of new p2p-transaction systems.

The publications are mainly focused on theoretical applications of the technology or small-scale peer-to-peer pilots that are being conducted by market players.
The theoretical application of blockchain technology in the energy sector covers all facets where transactions of information, energy or payments occur. [1]

Category	Application
Automatic execution of smart contracts or automatic transactions	Trade & Settlement
	(Smart) Grid Management & Balancing Systems
	Peer-2-Peer Energy Trading
	Smart Contract Trading
Documentation of Ownership	Registering ownership of assets
	Asset Sharing (EV's, EV-Charing Stations)
	(exchange of) Guarantees of Origins
	Renewable Energy Certificates
Distributed Transaction Records	Metering & Billing
	Supplier Switching Management
	Cryptocurrency Based Payment Systems

Basically, all data and monetary transactions of distributed service operators are at least partially being explored to be decentralized or automated using blockchain technology.

While the literature describes where and how blockchain could be applied and states that it can be potentially disruptive for business models and roles of traditional utility companies, the publications do not substantiate this statement.

Authors have identified only one of the 34 publications publication that has defined disruption. Bertsch et al. 2017 [11] defined disruption in accordance to the Cambridge dictionary: 'changing the traditional way that an industry operates, especially in a new and effective way'.

However, in the report, it is concluded that neither peer-to-peer trading of electric power nor certificates presents a cost advantage for the producer or end user within the current framework. Also, levies, taxes, surcharges and operating cost add to the difficulty in making peer-to-peer trading economically feasible. It concludes that therefore, 'a sudden shift towards peer-to-peer trading of electricity or certificates is not expected, nor is a disruption of the overall market structure or operation. Appropriate regulatory measures are paramount for the disruptive potential and wide-spread adoption of any platform or underlying technology to take hold.'

The review of recent and current blockchain applications in the energy system by Adoni et al. 2018 [4], conclude that the number of projects and the parties involved as well as investor interest, show the potential value of blockchain, but that the real long-term value is yet to be proven.

This view is shared by Luke et al, 2018. Despite its potential value, however, blockchain's future in electricity systems is uncertain. The technology is currently burdened by high costs, slow transaction speeds, and other limitations and risks and has no scaled commercial projects as of now. The economies of scale and scope of traditional network operations challenge the ability of blockchain applications to scale competitively.

This sentiment is shared by Deloitte 2018 as well for blockchain applications in other sectors. "When looking at the insights developed from our 2016 survey, the data suggested that blockchain adoption—and its move into production—would have happened at a faster pace than we have seen so far in 2018."

In addition, although the literature and publications describe many theoretical applications and pilot projects of blockchain in the energy sector, none of the 34 publications provided real world business cases that can be compared to traditional business cases.

Therefore, there are no identified disruptions that can be tested according to the theory of disruptive innovation by Christensen [6]. That in itself is no surprise given it's a very young technology and the current research of blockchain applications is primarily focused on technical applicability and potential cost-reductions and therefore a sustaining innovation. That approach is not sufficient to identify major market disruptions.

CONCLUSION

The energy sector is still in the exploration phase and testing potential applications of blockchain technology in anticipations that a decentralized ledger might suit the anticipated decentralization of energy production, peer-2-peer distribution and trade as well as the increase of renewables and the electrification of road transport, as soon as the technology allows for new business models to be developed prove competitive.

From reviewing and analyzing the available publications, we have found that the current research is focused on applying blockchain technology by current market players to achieve efficiency and cost-advantages compared to a central ledger for transactions.

This approach is not suitable for predicting major

disruptions of technological innovations that could upend the position of the incumbents. Authors advise the sector to explore the thought experiments of the blockchain leaders who are evaluating radical concepts such abundance [14] and communization [15]. Challenging the concepts of markets and scarcity in a world where raw energy is free and abundant and already distributed everywhere, this could lead to surprises. Authors strongly suggest the energy sector and blockchain community to investigate possible paradigm shifts together.

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