BLOCKCHAIN TECHNOLOGY IMPACT ON THE ENERGY MARKET MODEL

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Abstract

Rapid development of distributed energy resources technologies, along with network constraints, plus few consumer-oriented business models, has led to a search for radically different power system configurations. This is the basis for exploring an energy market model which meets the requirements of the changing environment. This model could be referred to as a transactive energy model whose main focus is on trading energy by a peer-to-peer principle, where the power company is replaced with a fully trusted trading platform based on distributed ledger technologies, i.e. blockchain technology. The aim of this paper is to analyze energy sector solutions related to the use of blockchain technology. The emergence of these solutions indicates, on the one hand, the need for verification of the existing energy market model and, on the other hand, the need to modify the approach towards the changing environment. Blockchain technology not only means the use of cryptographic mechanisms to build trustworthy agreements without intermediary institutions between the unfamiliar users of transactions: it is also a new philosophy of life based on trust.

Introduction

Blockchain is a decentralized database technology based on cryptographic security. Its application is not only in digital currency, but also in almost every part of our lives, with particular emphasis on finances, public administration, pharmacy, health care, energy, logistics, entertainment, and much more. Hundreds of startups, governments, and the largest world corporations are working on blockchain technology solutions.

This new technology foreshadows a revolution primarily in the financial market. However, its innovative nature may bring about a radical change in thinking about different markets, therefore, it may be expected to step into the energy market, too.

The dynamically growing market of distributed energy resources, photovoltaic systems, storage, and microgrids have shifted the balance of power from centralized enterprises to a place where citizens can exercise control over many processes. And it is not only a question of controlling energy costs; it is also a matter of people's desires that their energy resources are more sustainable, socially responsible, more resilient, and more democratic. This reflects everything that is needed to initiate a revolution in the energy trade model that is taking control of the big players in the market and making citizens responsible for the energy future they co-create. Currently, it seems, this part of the economy is witnessing a revival in research on how to apply both new technology and the blockchain philosophy. The possibilities of using this technology in the highly regulated energy sector may lead to a revolution at a much larger scale than the current changes which have only introduced minor adjustments in the existing market model (Power Ledger 2017: 8-10).

Taking the above into consideration, one should pose the question: will the next revolution in the power sector result in changes in the current energy market model? If so, how deep will these changes be? Will they only focus on selected segments of the energy market or will they give grounds for building a new energy market model?

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Blockchain can offer a reliable and cost-effective way of carrying out financial transactions or trading operations that will be recorded and validated within a distributed network without a central authority. As in the case of finances, this capacity is a stimulus for research with the thesis that one day blockchain can replace some public utilities and contribute to the end of third party interference in transactions also in the service industry. This problem, however, is complex, as there is a lack of understanding that there may be a change in the already existing rules and regulations based on trust generated by the cryptographic mechanisms creating smart contracts on the Ethereum platform.[2] In the face of such radical changes, the future energy market model is expected to be based on a decentralized blockchain technology.

The development of blockchain ideally goes in line with the times we live in, when widespread surveillance and the loss of confidence in large, centralized institutions is a daily matter. Blockchain, contradicting the above model and being a viable alternative, fits the needs of the 21st century. Apart from being a new approach to payment and a new kind of technology used in programming, it is also a philosophy that defines the approach to the reality which surrounds us.

The paper analyzes blockchain technology projects in the power sector. The analysis begins with a brief indication of where the blockchain idea came from, how it evolved, and to which walks of life or the economy it could be adapted. Based on such knowledge, examples of blockchain technology in the electricity industry have been analyzed. Furthermore, an attempt has been made to identify its impact on the current electricity market model, indicating possible changes in its shape.

This new technology implies a profound change in our everyday environment; at the same time, it is characterized by a high degree of complexity which determines the need for research aimed at an in-depth analysis of all elements that will have a significant impact on the energy market. Given this, the basic scope of the study which is worth exploring is indicated at the end of this paper. It may enable more effective revolution in the energy sector, with the highest diligence in pursuit of the good of all energy market participants.

The philosophy of blockchain technology

For years economists have been exploring people's behaviors: how we make decisions, how we act in groups or as individuals, in what ways we exchange values. The subjects for study are those institutions that facilitate our trade: legal systems, corporations, marketplaces. Yet, there is a new technological institution that will fundamentally change the way we exchange values. It is called the blockchain. Although blockchain technology is relatively new, it should be viewed as a continuation of the history of economics.

As humans we look for ways to reduce uncertainty about each other to exchange our values. Nobel economist Douglass North was one of the first to explore the idea of institutions as

[2] Ethereum is a decentralized platform that runs smart contracts: applications that run as programmed without any possibility of downtime, censorship, fraud or third party interference. This is an open source blockchain platform combining Smart Contract, offering decentralized virtual machine to handle the contract, by using its digital currency called (Iuon-Chang L., Tzu-Chun L.,2017: 655).

an economic tool for lowering such uncertainties so that we can thoroughly conduct a trusted trade. He pioneered in the so called "new institutional economies"; what he meant by institutions were real, formal rules such as a constitution. However, there are also informal restrictions, e.g. bribery (North D.C. 1991:97-98). These are those institutions which make the functioning of economic principles and the study of their development through the years possible.

While developing, our society has become more and more complex with its expectations of trade and transactions. This has led to the creation of more formal institutions. These institutions help us manage our trade and decrease our personal control (North D.C. 1993: 9-10). Eventually, we have moved these institutions into the Internet. We have built up a platform marketplace like Amazon, Allegro, eBay, all of which are much faster and function as intermediaries to facilitate human economic activity.

These institutions are a tool for lowering uncertainty, so that we can combine and exchange all kinds of values in society. Now we are entering a further and radical evolution of how we interact and trade, because for the first time we can lower our uncertainty not just with political and economic institutions, but also with the use of technology itself - blockchain technology (Rosati P., Nair B., Lynn T. 2016).

Blockchain database architecture was first proposed in 2008 by the creators (also known by their pseudonym Satoshi Nakamoto) of the first digital currency – Bitcoin (Nakamoto S. 2008: 2). Bitcoin is the first global system of digital buy and sell operations not based on trust in a central institution, as in the case of traditional currency, where the role of the institution is fulfilled by a central bank responsible for creating and controlling the money supply into the economy (Bonneau J., 2015: 112).

Blockchain technology is a decentralized database that stores its registry of assets and transactions through a peer-to-peer network. In other words, it is basically a public registry of those who own and perform transactions. Transactions are secured through cryptography and, with time, their history gets locked in blocks of data that are then cryptographically linked together and secured. This creates an immutable, unforgettable record of all the transactions within the network. This record is replicated on every computer that uses the network. It is not an application, not a company: we can think of it as an open infrastructure that stores many kinds of assets. The registry is not controlled by one, but by all users of the decentralized system. Blockchain technology is characterized by the irreversibility of its transactions. It stores the history of custodianship, ownership, and the location of assets like digital currency - Bitcoin and other digital assets. It could be a certificate, a real world object, a contract, even personal identifiable information (Zheng H., 2016: 4-7).

The Economist magazine has described blockchain as 'trust machine'. The distributed system architecture enables each user to view a full transaction history, providing anonymity at the same time. Two basic types of blockchain technologies, called public and private systems, are also worth considering. These systems differ in the level of trust between the system users. Thus, it leads from a total lack of trust in the public system to a high one in the private system;

this is the public system which is a truly decentralized blockchain solution, where anyone can be a user. What is important in this system - there is no possibility of modifying historical data. On the other hand, a private blockchain solution is fully controlled by one organization and can't be considered decentralized. Nevertheless, in this kind of system, historical data may be modified, if it is the will of all the system users. The above set does not exhaust all the details characterizing blockchain technology, but it is the basis for understanding this philosophy and its operational mechanism (Berkley J., 2015).

Blockchain applications

Blockchain technology can be applied where there is a need for any activity of intermediaries, centralized data registers, or institutions entrusted with confidence. This primarily refers to the financial market (banking), but also to the business sector. A survey conducted by IBM in 2016 shows that 15% of banks and 14% of financial institutions are going to introduce a blockchain solution in 2017 (Hablen M., 2016). Implementation of this type of technology is identified in the context of improving efficiency in speeding up transactions, reducing operating costs in banking, and increasing confidence in the financial sector, whose reputation is subject to continuous testing due to the disclosure of irregularities.

The future of blockchain technology is difficult to predict due to its short track record. Most projects are either in a beta testing stage, midway through an initial pilot, or have just completed a pilot. For sure, technology is effective at enabling secure virtual currencies, but it is still too early to tell whether other applications will have staying power. While blockchain technology proponents tend to assume that centralized solutions are always 'second best', this may not be the case. The most likely outcome is that the frenzy of interest in blockchain-based solutions will evolve in the same manner as the dot-com bubble[3], with most companies failing to achieve liftoff while a select few create business models that transform the sectors they operate in (Pisa M., Juden M., 2017).

As for the enterprise sector, one basic prospect of the implementation of this technology is the possibility of broadening cooperation between different companies. By optimizing coordination between co-operating companies, cost optimization throughout the supply chain is seen (Goertzel B., Goertzel T. 2017: 65-73). Additionally, blockchain-based solutions would provide a powerful tool for verifying the origin of the individual components of a product. In other words, control would take place at every stage of the supply chain, also over the quality of the proposed components. This means that the specific application of the technology can also be used for quality certification (White G.R.T., Holden J. 2016: 3).

Some other implementations of blockchain technology may cover fast confirmation of identity, compliance of user-submitted data, acceptance of financial transactions, even loans or investments, issues of securities, and digital currencies (Bashir I. 2017: 415). Irving (Irving G.,

[3] The dot-com bubble was a historic economic bubble and a period of excessive speculation that occurred roughly from 1997 to 2001, a period of extreme growth in the usage and adaptation of the Internet by businesses and consumers. During this period, many Internet-based companies, commonly referred to as *dot-coms*, were founded, many of which failed (https://en.wikipedia.org).

Holden J. 2016:1-6) also points out that technology can be used in the medical sector as a tool to prevent the manipulation of clinical trial results – which means an increase in trust and elimination of social acceptance for low clinical efficacy or a low safety profile.

In the blockchain literature, there are a number of other suggestions for using this technology to protect privacy in the sense of data ownership or personal property (Halicki M., Lustofin P. 2017: 37-39). This includes the registration of buildings, land, and patents. The blockchain solution is highly resistant to manipulation of the data contained in the encoded chain of blocks, which is of fundamental importance in the context of sensitive and confidential data stored in the above registers (Zyskind G., Nathan O., 2015: 180-184).

Blockchain in the power sector

Although it is a new technology, the market for its applications is growing day by day utilizing solutions based on it in different areas of life. Thus, the energy sector cannot be excluded from this development, either. These are projects based on the rules of the shared economy phenomenon. Some of them are identified as the most important in the context of creating a new energy market model, e.g., sharing and clearing of charging stations for electric vehicles, flexible management of the electricity grid, electricity trade, and the possibilities of its application in microgrids and energy clusters. The above issues are complementary to each other, consequently they include both generating (especially from renewable sources), trading in energy, its distribution, and other services available on the energy market.

Sharing and clearing of charging stations for electric vehicles

It would be worth mentioning here a project by innogy SE[4] and a start-up, Innovo Innovation Hub Share & Charge, which provide access to charging stations for electric vehicles. According to this project it has been possible to create more than 1,200 charging stations based on blockchain technology; therefore, the start-up is thought to be the first company in the world to be involved in such a large-scale project promoting the development of blockchain technology (Lielacher A., 2017).

The central registration platform for electric car owners and charging station operators is the Share & Charge application, which is available to users free of charge. Companies and persons who have their own charging stations can make them also available for electric car drivers, decide on rates, or even create their own tariffs for friends and acquaintances. They can also share and charge for parking spaces at the charging stations. Such a model of behavior creates a completely new economy based on the sharing economy - in this case using the public platform Ethereum as a transaction layer. In addition, owners of electric vehicles have the opportunity to search for a charging station using an interactive map. This solution allows electric car owners to charge their vehicles at any of the new charging stations configured by the start-up as well as at existing charging points, by making digital payments. The Share & Charge application provides all participants with a transparent and secure payment system using blockchain,

[4] innogy SE is an established European energy company.

which by decentralizing databases does not require a central computer. At the time of charging, in real-time, revenue is charged to the owner of the station and the cost of purchasing it to the electric vehicle user. This virtual wallet in the form of mobility tokens, which are digital tokens, and the currency of settlement being the Euro, can be completed by credit card, PayPal system, or transfer. Each transaction is invoiced, which is also stored in the system and the user has the possibility of accessing, downloading, or printing it at any time. The mobile application allows everyone to use a secure, cryptographic platform without technical details, making it as easy to use as any other mobile solution. In addition, it provides the automation, immutability, or durability of a transaction history, plus a lack of intermediaries, significantly reducing costs, and creating unprecedented peer to peer services. It is worth noticing that the charging service in this case is done without the presence of the distribution system operator and the energy trader (innogy, 2017, 50).

Flexibility grid management

More and more, power consumers will play an increasingly important role in transforming the status of passive electricity consumers into active, conscious, energy market participants (Mirowski T, Sornek K., 2015, 77). Connecting distributed and unpredictable sources of energy brings significant challenges for performing basic responsibilities in the management and maintenance of the electricity grid. A new role for the network operator is to ensure that each network realizes its goals. This change requires increasing the dynamics of the network, where it is crucial to maintain both high quality and reliability of the electricity supply, secure and stable network operations, and create a level playing field for innovative services. This transformation poses a number of technical challenges, as the current network is not yet ready to work with a large number of distributed sources – it was designed for one-way flows. In addition, it is neither ready for new types of receivers such as charging stations for electric vehicles nor energy storage, nor for the actual activity of consumers in terms of controlling their own consumption. Supporting all user behavior of the system is *sine qua non* of the issues of network flexibility. This extremely complex mechanism, which uses a huge amount of data processed in real time, can be effectively managed by using the blockchain solution. In the future, an additional advantage of this solution should be a technology with elements that use machine learning (Merz M., 2016: 20).

For today, there are few projects that rely on blockchain technology test solutions for managing grid flexibility. Typically, these are projects in the initial phase, one that has not yet generated measurable results from its implementation, since operations began in 2017. One such project is being created by the British company Electron, which has received government funding for the development of a new blockchain transactional prototype platform. Its primary task will be to manage network flexibility at the DSR (Demand Side Response) level. The company's application for funding was supported by the National Grid and Siemens, which will participate in the project. Electron claims that its platform will use blockchain technology in a way that allows multiple parties to coordinate and share the value of individual consumer

behavior in managing their demand. Applying this large-scale solution means that the company will maximize the overall value and liquidity of the flexibility market, while at the same time enabling individual buyers to have the flexibility to participate in revenue sharing as well as cost. The company refers to this concept as a trade based on collaboration, in other words on the economics of sharing, according to the assumptions of the blockchain, and in this case we are dealing with a way to enter into a transaction without a central authority. This allows the defining of new collaboration models on an efficient, fully trusted platform (Cummings D., 2017).

As renewable electricity generation is increasingly involved in the overall supply of energy, the electricity grid is becoming unstable. This situation is most evident in Germany, where in the coming years it is forecast that there will be situations in which conventional energy sources will not be able to fully satisfy the stability of the network. With the above, TenneT, Sonnen, Vandebron, and IBM have joined forces to develop a blockchain power management solution. This innovative technology is the next step for decentralized energy sources to play an active role in power management and flexible services. In early November 2017, there was the first launch of a pilot project in Europe, which uses decentralized network home energy storage systems with blockchain technology to stabilize the grid. The TenneT transmission system operator uses these home energy storage systems as storage for stabilizing network performance. Thanks to this, after several months of preparation, TenneT and the world's largest energy storage company, Sonnen, started a pilot phase of the project, which is to be continued until mid-2018. Then, the decentralized energy storage systems will be integrated into the TenneT network through blockchain technology. The blockchain solution was developed by IBM; Sonnen provides the proper number of home energy storage systems to create a network serviced by Sonnen's e-Services. Intelligent management of energy storage systems meets individual requirements to fit into the particular situation in the TenneT network. As a result, network resources of energy storage systems can take or give power within a few seconds, when needed, to help reduce network bottlenecks. This project is part of a wider TenneT initiative to improve flexibility through increased use of data and the development of new flexibility options that will allow the network to meet the challenges and opportunities associated with energy transformation (Kastelein R., 2017).

In addition, as part of a wider digital transformation program, TenneT is exploring a network based blockchain technology that uses the Hyperledger Fabric[5] solution to integrate flexible services provided by electric vehicles and power warehouses. This means that owners of electric vehicles can also help keep the network frequency at the required 50 Hz. In this pilot project, Vandebron will work with customers who own electric vehicles to share the capacity of their car batteries to balance the local area. This also guarantees customers access to their cars to satisfy their own needs. Blockchain allows each vehicle to participate by recording its availability and performance in response to signals from TenneT. To manage and store all billing and charge data, a fully automated, worldwide authentication charging and billing system without

[5] Hyperledger Fabric is a platform for distributed ledger solutions, underpinned by a modular architecture delivering high degrees of confidentiality, resiliency, flexibility and scalability (Hyperleger, 2017).

intermediaries is being created by using a computer chip in the charging station, smartphone interface, and blockchain applications (03.ibm.com, 2017).

Electricity trade

Powerpeers, a startup developed with the involvement of the Dutch energy company N.V. Nuon Energy allows for direct electricity trading between any registered users. Blockchain applications enable the marking of every unit of produced and consumed energy, automatically save each transaction, and settle bills in a virtual wallet. This means that a part of the surplus generated energy coming from, e.g. photovoltaic panels installed on the roof of a neighboring house, may be sent to a different location. This method allows identification of the source of purchased energy. Hence, a company that produces organic food can prove to its customers that it has bought energy from a nearby hydro or wind power plant. This peer-to- peer identification and trading system is possible thanks to intelligent metering of customers and producers participating in the project.

Time-consuming activities related to the energy trading in a traditional model such as contract signing, change of the seller, or settlement, are extremely simplified or absent. Most of these functions are implemented by the application and its owner – that is, Powerpeers (which holds a concession for energy and gas trading). Power infrastructure is used locally, and the reliability of the supply and preservation of the network is maintained by the distribution system operator. In essence, it implements the idea of an energy cluster without special regulation. Such a system works only in the Netherlands, where Nuon and Vattenfall are gaining valuable experience in this business model, bearing in mind that it represents a huge potential for development on a large scale (IEA 2015).

Another example is the Dutch Oneup start-up, which has developed and tested a similar prototype of a decentralized electricity transaction (trading) system with the use of energy data from ten households. Households within the same neighborhood produce electricity using photovoltaic panels. Any energy not consumed by the household itself is delivered to its neighbors and settled by a system based on blockchain technology. All transactions in the project are realized through smart contracts. Each building also has a smart meter connected to a Raspberry Pi computer, which, turn, is connected to the network. The computer is configured in such a way that enables real-time verification of whether the terms of the agreement are being met; secondly, it collects and processes signals that individual households are able to provide a sufficient amount of energy and whether there is demand for that energy. The software automatically initiates the supply of the energy and the corresponding payments through its own cryptocurrency. It is also important that the cryptocurrency can be exchanged for euros (PwC, 2016, 22).

One of the most challenging ideas for blockchain use in the energy sector is certainly a project set up by 25 European energy trading companies whose aim is to assure wholesale market participants that they can trade freely and directly with energy as well as with other goods within a private blockchain. That means the absence of any central platform or settlement institutions does not require transaction fees (Merz M., 2016: 19).

Microgrids and Energy Clusters

In April 2016, a joint venture between LO3 Energy and ConsenSys called TransactiveGrid launched a pilot project called Brooklyn Microgrid. The project tests the integration of buildings with distributed generation systems in a decentralized peer-to-peer network. This means that the use of blockchain technology is explored here in the context of direct energy sales between neighbors. The technology used in the project is based on the Ethereum blockchain. Ten buildings were connected in a microgrid, five of which are equipped with photovoltaic panels. All unconsumed energy by the buildings themselves is sold to the five neighboring households. All the buildings are connected via a conventional power grid, and transactions are managed and stored using a central blockchain. This configuration shows how it could look. In this way there is the opportunity to see if consumers actually benefit from the possibility of exchanging energy among themselves (PwC, 2016, 21). With this new technology, the market can reach a point where one person with a single solar panel can participate in the end-user market. This is a chance for prosumers, which allows them not only to supply excess energy to the network, paying a fixed fee but placing it on the market individually. The plans provides for all renewable energy resources to be owned by the community itself and that members will jointly decide how to catch and share revenue. This means that the current electricity sales model would have to change in a way that would allow such transactions.

From the beginning the concept of energy clusters, supported by the Ministry of Energy, has attracted great interest as well as doubts about its practical implementation. The most obvious doubts are those about the manner of settlement, responsibility for network management, demand balancing, quality of supply including network losses, break times, voltage. The above pilot project demonstrates that by using blockchain technology, building a functional application layer and an information and marketing campaign, it is possible to implement the cluster idea in an effective way. In addition, the application of solutions presented in the projects on network flexibility, storage, or integration and billing of electric car charging stations has great potential for the development of local communities, changing fundamentally the shape of the current energy market model.

Energy market model

The current energy market model is based on provisions that require energy companies to separate network activities (regulated activities) from energy trading (competitive activities). Customers are entitled to choose freely a supplier. Free choice in this context means that customers can only choose from suppliers authorized to run such activities.

The implementation of a decentralized market model based on blockchain technology is likely to change the currently functioning market roles and connections between participants in this market. In theory, using smart contracts, transactions could be made directly, i.e. a customer in the energy market would not need to choose a supplier who would buy energy on his behalf and conduct its settlements. Blockchain technology enables direct establishment of contractual

relations between consumers and producers. Of course, the direct sales model does not exclude the existence of a supplier, aggregators, or other entities that will be entitled to provide such services. It is the client who decides about his future relations with existing entities on the market.

However, it should be remembered that the omission of intermediaries in energy trading may lead to a fall in energy prices as a result of greater competition associated with the entry of new participants onto the market. One of the main benefits of the blockchain transaction model is that all electricity supplied to the network can be clearly assigned to individual customers. In addition, this assignment may be implemented in small time-units (e. g. 15 minutes). This means that all produced and consumed energy can be very precisely distributed and managed in accordance with the economy of dynamic prices - which will significantly reduce costs for consumers. It is worth noting that the physical flow of energy will be carried out to the end user directly from the nearest generator. Settlements for the purchased energy, including payments made in the blockchain technology, would enable making direct payments in real time without an intermediary, like a bank.

To implement such a solution, it will be necessary to install smart meters to all interested entities and recipients. The role of the DSO operator, which in the current energy market model is responsible for the measurement data will change. These data will no longer be collected and recorded in local databases, as all the data on consumption and transactions will be exchanged automatically in a way that guarantees the correctness of data via blockchain (smart contracts). The transactional data necessary to set network tariffs will also be available in the blockchain network.

Distribution system operators will have information about the transactions they need to charge customers for network costs. Provided that the decentralized transaction model is fully implemented, transmission system operators will no longer require data for billing purposes, as all transactions will be executed in real time and settled solely on the basis of actual consumption. What is more, after the implementation of smart meters (which is a prerequisite), the functioning of the blockchain as a distributed transaction data register can be used to create a comprehensive archive of all electricity billing data.

The method of calculating network rates in reality, based on blockchain technology, still remains the issue. Since it will be possible to trade between neighboring clients (prosumers), the model of setting these rates must change so that it takes into account the actual costs of such supplies.

Conclusion

The process of changing the seller, integrating smart home devices, making graphics of generating units, reporting to the transmission network operator, or balancing the distribution system to allow network flexibility, are only some selected applications of blockchain technology – conceivable, but not fully tested. The catalog of analyzed solutions may not be large, but it clearly indicates the direction of future changes in energy sector projects implemented

all over the world, which are more and more willing to engage in the implementation of new solutions based on blockchain technology, seeing in it great potential for the future operation of the power sector. However, the implementation of projects requires both smart meter technology and blockchain software with integrated functionality of an intelligent contract. Intelligent meters are needed to record the amount of energy produced, blockchain software to carry out transactions between neighbors, and intelligent contracts to conduct and register transactions in an automatic and secure manner. Additional applications thanks to which the entire system can be controlled, are also needed, e.g. by defining certain parameters, such as prices, which are to be purchased from producers or simply neighbors. All transactions must then be carried out fully automatically in accordance with pre-established rules. It is also necessary to integrate the above solutions with the entire power system to ensure stability and security.

It should also be remembered that the implementation is to take place comprehensively, simultaneously, in all areas of life. To make it possible to implement in an effective way, it is necessary to cooperate with business, science, regulatory creators, government agencies, and ordinary people. We must begin to prepare ourselves now if we want to confront a world in which dispersed, autonomous institutions will play a key role in the economy of every country. Further development will depend on technological progress and competitive technologies as well as on regulatory and government practices in individual countries. Yet, one can assume that blockchain technology will promote the emergence of new innovative business models in various industries.

One should also be aware that different, non-standard approaches can have a destructive impact in the future and should be subject to additional regulatory intervention. With this in mind, for the correction of the negative impact that may accompany the development of technology, future research should focus on such issues as:

- identification of the whole energy architecture and identification of blockchain entry points,
- designing blockchain system architecture to deliver different government, industry and consumer objectives (e. g. grid balancing vs product innovation),
- importance of data privacy and governance in a public and permitted blockchain,
- demand Side Response identification and authentication using smart metering and IoT sensing, actuation and control,
- designing transactive energy schemes to maximize consumer engagement,
- identifying social, psychological, and financial value to consumers,
- working out how to equitably socialize the cost of a robust universal energy service,
- avoiding social marginalization arising from product differentiation and energy gated communities,
- designing one platform that delivers multiple value streams (social, psychological, and financial),
- classification of barriers to the introduction of a public blockchain platform,
- identification of potential threats and benefits for the individual as well as for the entire economy resulting from the development of blockchain technology,

– study of the economic environment characteristics in which it will be possible to introduce blockchain technologies in the sector,
– initiation of the regulation and development of a new strategy for the development of companies that are actually based on blockchain.

The involvement of serious players of the energy sector in exploring and developing blockchain technologies is strong evidence that they are considered to be prospective and potentially revolutionary. And this will ultimately change the currently applicable energy market model into a decentralized one in which the main role is played by active consumers.

To sum up blockchain technology's impact on the energy market model, it should be pointed out that the final shape of the market will depend on future regulations, primarily at the national level. These regulations will certainly take into account the aspects related to treats brought about by the development of this type of technology. Importantly enough, this type of regulation currently cannot be properly defined, due to the lack of thorough analyses of projects still in the development phase. However, it is possible to review areas that should be regulated to provide customers in the energy market with security in terms of transactions while maintaining the stability of the energy system. These issues are broad enough to require future research

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