THE POSSIBILITY OF IMPLEMENTING BLOCKCHAIN TECHNOLOGY WITHIN ENERGY COMPANIES

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Abstract In the energy industry, contemporary solutions are constantly applied and are always welcome if they reduce the total operating costs of power plants or affect the reduction of environmental pollution. In addition to smart processes for the production of electricity and heat, the change in the relationship between energy producers and consumers is also observed through the framework of innovative blockchain technology. Given that the energy sector is very complex and that there are many actors in the electricity supply chain, it is very difficult to ensure transparent and reliable monitoring of the activities of all participants. Intermediaries are also involved in the energy trading process, whose business engagement contributes to the increase in the price of energy for end users. Blockchain technology has the potential to increase the transparency of monitoring energy flows within the supply chain and to ensure a higher degree of trust between participants in the electricity market. Consequently, this paper provides an overview of the possibilities of applying modern principles of blockchain technology within the business of companies from the energy sector. The paper systematically describes the way in which the blockchain affects the improvement of business performance of energy companies with the aim of solving the most important energy challenges of today, such as doing business in the conditions of the energy crisis and reducing the negative impacts of climate change.

Keywords: energy companies, blockchain technology, business performance

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1 Introduction

Economists believe that market forces enable equilibrium in the long term regardless of the state and availability of physical resources. Profit-oriented actions and orientation towards the impact of short-term energy price changes redefines the expansion of energy demand in developing countries, changing the conditions and ways of doing business in electricity markets. In the economic sense, energy can be defined as a set of activities on the basis of which the supply of energy for consumers is realized by finding new sources of energy that are then transformed into artificial sources, in order to be delivered in production and final consumption (Mandal et al., 2010).

The interests of economists focused on the field of energy are complementary to knowledge from other scientific fields and, although they complement each other, they are more concerned with uncontrolled market forces and expected tendencies on the side of demand for energy products. Broadly defined, the energy economy includes drivers that motivate companies and consumers to supply, convert, distribute or use energy. It also includes an examination of the market and regulatory measures, the economic consequences for the environment, as well as the economically efficient use of energy sources (Sickles & Huntington, 2018).

Three global challenges for the field of energy economics that stand out are: the increased risk of energy supply disruption, the threat of a negative impact of energy production and consumption on the environment, and the persistence of the problem of energy poverty (Birol, 2007). From the perspective of creating an energy policy, six key challenges can be defined: (1) potential danger from the formation of an OPEC (Organization of the Petroleum Exporting Countries) cartel, (2) aspects of the energy sector's impact on the environment, (3) regulation of disruptions on the side of energy supply, (4) problems with storage and conservation of energy on the side of final energy consumption and production, (5) regulatory policy, price control and taxation of oil and natural gas sales, (6) research and development in the field of energy, especially the one related to the use of modern technologies (Griffin & Steele, 2013).

2 Challenges in the energy industry

For the needs of advanced research in the energy sector, it is especially important to identify the time and space factor of the investigation, then balance between uncertainty and transparent reporting, point out the problem of the growing complexity of the energy system and include the components of consumer behavior, in order to reduce the social risks of the energy sector development (Pfenninger et al., 2014). Even more simple economic models should answer the following strategic questions regarding the energy sector (Zweifel et al., 2017):

- How much should be invested in research, development and distribution of new energy sources?
- What quantities of production limiting factors should be allocated for the existing deposits of lower quality energy sources?
- To what extent should the limiting factors of production be made available for the substitution of conventional fuels with renewable energy sources or some other energy efficient measures?
- How much should be invested in the processes of reducing the emission of harmful greenhouse gases?
- How much and in what way should be devoted to improving the security of energy systems?

Taxation of emissions of greenhouse gases from inadequate use of energy sources alongside with modern concepts of creating a framework for efficiency support mechanisms encourage new directions for slowing down the depletion of natural resource reserves. Through the "cost-efficiency" ratio, the ratio of total costs of support mechanisms for energy-efficient systems and the total prevented emission of tons of carbon dioxide is observed. Arguments in favor of energy efficiency regulation can be summarized in four, mutually complementary points of particular importance, namely: (1) saving state funds, (2) reducing energy dependence, (3) mitigating the consequences of greenhouse gas emissions and (4) reaching sustainability of economic development (Anderson, 1993). The world population growth and the demand for energy from developing countries will certainly reduce the possibilities of achieving higher energy efficiency. Also, the effectiveness of investment in energy sources “relies on a significant number of interconnected factors, which gives an insight to the current state of the energy sector and form a framework for its further development" (Backović & Ilić, 2022, p. 343).

The new research fields on how to improve companies energy efficiency can be divided into (Brown & Wang, 2017):

1. quantification of the greenhouse gas emissions reduction, in order to determine the heterogeneity of fuel types,
2. consideration of the energy services quality,
3. improving the measurement and assessment of efficiency growth resulting from energy policy regulations,
4. strengthening the empirical foundation of transaction costs, discount rates and feedback effects with the intention of shaping them according to regulatory policy and
5. using a multidisciplinary research identity in order to better understand consumer preferences and the use of efficient technology.

The problem of information asymmetry causes the bounded rationality of consumers, which is another challenge for energy modeling. As Friedrich Hayek stated, "the economic problem of society is not only the problem of how to allocate the available natural resources, but it is also the problem of using knowledge that is not fully given to anyone" (von Hayek, 1945). Regardless of the fact that the demand for energy arises on the basis of economic decisions and personal preferences of consumers, they depend a lot on the socio-technical system, which shapes, maintains and stabilizes them. (Sorrell, 2015). The mentioned limitations can also be a challenge for the introduction of new generation technologies. In order to create a holistic approach to this issue, there is a need to systematize modeled solutions.

Table 1: Types of constraints for markets based on "clean" energy

Type	Description
Imperfect and asymmetric information	Agency problem can lead to underestimation of life cycle costs by producers and irrational consumption of electricity users.
High transaction costs	Problems with optimizing the cost of advanced equipment inventory and using the potential of personnel resources. Complex implementation of renewable energy projects.
Limited cognitive abilities	Bias in the assessment of energy alternatives. Individuals and companies are averse to investment risk.
Imperfect competition	Regulations and support mechanisms can enable certain business entities to have a monopolistic position on the market.
External costs and benefits	Security assessments of the distribution of energy resources are often immeasurable. There is a challenge of monitoring and projecting environmental externalities from the use of fossil fuels.
Exclusivity	The problem of availability of modern technologies for the end user. A carbon tax can be a burden on individuals who cannot substitute inefficient technologies.
Monetization Limitations	Potential danger to the health of citizens and plant and animal species.

Adapted by: Sovacool et al., 2016

The complexity of meeting energy efficiency requirements is not always fully shown through models. The application of energy efficiency programs is difficult to quantify and there is a real threat of hidden costs of the project, so the energy policy framework should take into account all the advantages and disadvantages of instruments supporting new technologies and then adapt them to a polycentric system (Brown & Wang, 2017).

Energy models can navigate decision-makers towards investing in additional electricity generation capacities by proposing them different strategies for meeting future energy requirements and environmental protection goals. (Heuberger et al., 2017). These authors also claim that energy models can clarify the economic justification of technologies within the power system and indicate the optimum point of investment. Accordingly, for models of modern energy systems it is a big challenge how to include the high degree of variability and complexity of the energy system, while including at the same time all the technologies being used.

Pfenninger et al. (2014) presented the following energy system modeling challenges: (1) resolution in time and space, (2) uncertainty and transparency, (3) integration of the growing complexity of the energy sector, and (4) integration of behavioral economics components. Consideration of technological learning in energy models is of key importance, so the experience curve method can be applied from the aspect of analyzing the relationship between cumulative installed capacity and reduction of unit costs of technology (Schreiber et al., 2020). In addition, there are numerous factors that are listed as possible criteria for the optimization of the energy system, such as gross income, gross production, profit, amount of energy, gross national product, energy performance and others, assuming the existence of limiting factors of electricity production (Jebaraj & Iniyan, 2006).

3 The concept of blockchain technology within energy companies

In the modern business of energy companies, blockchain technology is gaining particular importance. Blockchain serves as a database that is developed on a peer-to-peer network. Its main characteristics are that it is decentralized, distributed, replicated and completely transparent. Kasireddy (2017) defined blockchain as a technology with a shared state of all the transactions, secured with asymmetric cryptography. Access to the network is allowed to any device connected to the internet. All of the devices, nodes, that are part of the network have copies of all transactions that have ever happened. Nodes continually communicate with each other and synchronize recorded transactions.

Interaction between participants is done through transactions. In order for a transaction to be saved on a network, it has to be validated. Nodes use consensus algorithms to reach an agreement saying that the transaction is valid. After that, multiple transactions are grouped and placed in one block. Blocks are encrypted and linked to each other. Any transaction that has ever been executed and saved on the network cannot be modified or deleted (Mitrovic et al., 2022).

In the era of digitization of business and society's growing needs for energy, the complexity of energy systems management is also increasing. The energy sector is complex due to numerous factors (Bhattacharyya, 2011):

- component industries are highly technical in nature, which requires an understanding of the basic, that is, accompanying processes and techniques in order to systematically approach the solution of economic issues;
- each segment of the energy sector has its own specific characteristics that require special attention and orientation towards all processes;
- considering that energy affects overall economic activities, and the availability or lack of energy affects society as a whole, it could be stated that there are extensive social challenges on which the sector depends, unlike most other sectors;
- interactions between business entities and stakeholders at the international, national and local levels shape the energy sector and contribute to the development of various scientific subdisciplines in this field.

According to Meadows et al. (1972), a model is an ordered set of assumptions about a complex system, an attempt to understand a particular aspect of an infinitely varied environment by selecting from past experience and knowledge through a set of general observations that are applicable to the problem under consideration. With the growing complexity of energy systems at the national and global level, the volume of data and the number of imposed technological restrictions grew, and the organization and division of labor within the sector became less and less clear. (Kavrakoğlu, 1979). Nowadays, due to the advanced possibilities of using computers and computer programming, the total number of energy models and their complexity are constantly growing.

One of the ways blockchain could be applied within energy companies is energy-saving encryption, which has great potential to make the electricity market secure. From bank payments to fees paid to energy service companies and technology providers, all of these services rely on encryption. Data security has become a critical issue within the enterprise digitalization process, and blockchain can provide an opportunity to secure customer energy savings data for higher energy efficiency at the market level. In addition to the above, blockchain is also important in the event that individual market participants intend to trade the energy they have saved (Burger & Weinmann, 2022). Specifically in that example, blockchain technology offers the chance for energy saving data to be encrypted and stored via blockchain platforms for balancing energy bills or purchasing additional energy services. Thus, the blockchain would support the automation of the energy trading process and in the process of evaluating energy efficiency at the company level.

The transparency of data distribution is also an extremely important segment of the application of blockchain technology within energy companies. Since blockchain is a distributed ledger technology, data can be shared on a secure platform that is protected from unauthorized access. Interfering with data shared on blockchain platforms is practically a technically impossible process. To that can be added the convenience that the blockchain does not require intermediaries and the transaction could take place peer-to-peer directly, which reduces the complexity of the process and the associated transaction costs of implementing energy contracts. By applying blockchain technology, the streamlining of ESCO (Energy Service) companies, banks, utilities and customers through the entire blockchain process can reduce the company's overall transaction cost (Khatoon et al., 2019).

As the electricity grid develops, there are more and more participants who buy, sell, exchange and share electricity. The entire sector is moving from a centralized way of management to a decentralized system with a multitude of participants. It is precisely the high complexity of the energy network that has led to system participants not having access to all relevant information without delay and data distortion.

Smaller producers of electricity from solar, wind and hydro energy should help to produce electricity where it is most needed and at the right time, in order to avoid overloading the electricity grid. But it is actually these producers who manage the greatest risk in production and have particular great difficulties in managing energy systems. They are often very badly or almost not at all connected to the rest of the participants in the power grid. Due to poor coordination of information, they cannot use their full potential and properly respond to the needs of the modern market (Baush et al., 2019).

Small, decentralized consumers deliver electricity to the grid through which it reaches those who consume it. But when gridlock occurs, network overload, delivery from decentralized producers stops for security reasons. Then a decentralized power company management system, based on blockchain technology, can help power producers meet local needs without a centralized intermediary. Technology can enable real-time monitoring of information, payments for current services and direct communication between participants, in a reliable and transparent manner (Baush et al., 2019).

In addition to the above, according to Khatoon et al. (2019), one of the cases where blockchain technology can help is in automating the awarding of electricity saving certificates. Due to transparency and the possibility of automating tasks through smart contracts, it is now possible to effectively control consumers' electricity consumption and automate the process of awarding certificates, once all legally prescribed conditions have been met. Data is stored on the blockchain network, and smart contracts allow only authenticated users to access the energy system. External organizations can see which consumers have certificates and perhaps use certain programs to further encourage participants to save energy. Figure 1 shows the above concept.

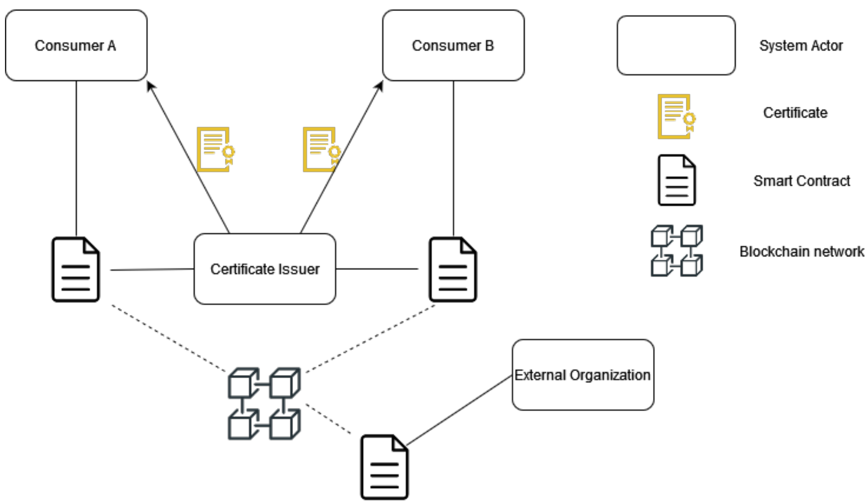

Figure 1: Blockchain-based system concept proposal for energy certificates
Source: Author's illustration

4 Conclusion

The application of modern technologies enables the improvement of the overall performance of companies in the energy sector. Blockchain technology solves the problem of establishing trust in a decentralized system (Di Pierro, 2017). It is a mechanism for establishing trust between anonymous individuals. Individuals conduct transactions between themselves using secure technology that is not controlled by any individual or any central institution (Nakamoto, 2008). That is why blockchain technology has the ability to change the current role of central institutions and enable the liberalization of transactional business.

Blockchain combined with other new innovative technologies can enable the decentralization and digitalization of the energy sector. Due to the characteristics of the technology itself, blockchain can adequately help all participants to better understand, monitor and control energy needs (Khatoon et al., 2019). Data on the electricity produced by thousands of small producers can be encrypted and shared over the aforementioned network. In this way, the transparency of the entire sector is significantly increased, with the flow of information with safe and reliable access, participants can make decisions that will ensure more efficient operations and greater savings (Rogers, 2018). Bearing in mind that there are many actors in the energy sector supply chain, it is expected that the adequate application of blockchain technology will ensure a greater degree of trust between participants in the electricity market, continuous monitoring of all business activities, as well as improving the success of energy companies.

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