

Електронний журнал «Ефективна економіка» включено до переліку наукових фахових видань України з питань економіки (Категорія «Б», Наказ Міністерства освіти і науки України № 975 від 11.07.2019). Спеціальності – 051, 071, 072, 073, 075, 076, 292.
Ефективна економіка. 2023. № 4.

DOI: <http://doi.org/10.32702/2307-2105.2023.4.17>

УДК 336.621

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BLOCKCHAIN-BASED SOLUTIONS IN ENERGY SECTOR. EU BEST PRACTICES AND UKRAINE'S PERSPECTIVE – LEGISLATIVE AND REGULATORY ASPECTS

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РІШЕННЯ НА ОСНОВІ БЛОКЧЕЙН В ЕНЕРГЕТИЧНОМУ СЕКТОРІ. НАЙКРАЩІ ПРАКТИКИ ЄС ТА ПЕРСПЕКТИВА В УКРАЇНИ – ЗАКОНОДАВЧІ ТА РЕГУЛЯТОРНІ АСПЕКТИ

Blockchain technology has the potential to revolutionize the energy sector by enabling more efficient, secure, and decentralized transactions between energy producers, consumers, and grid operators. The energy sector is highly complex, with numerous stakeholders involved in the production, transmission, distribution, and consumption of energy. Blockchain can streamline these interactions by providing a transparent and tamper-proof platform for recording and sharing data. One of the most promising applications of blockchain in the energy sector is in the creation of peer-to-peer energy markets. With blockchain, individuals and organizations can buy and sell energy directly to one another, bypassing traditional intermediaries such as utilities. This can reduce costs and increase efficiency, while also promoting the use of renewable energy sources. Blockchain can also facilitate the integration of distributed energy resources, such as solar panels, wind turbines, and energy storage systems into the grid. By creating a decentralized system for monitoring and controlling them, blockchain can help to optimize their use and reduce waste. In addition to these applications, blockchain can also enhance the security and reliability of the energy sector. By providing a tamper-proof platform for recording transactions, blockchain can reduce the risk of fraud and cyber attacks. This is especially important in a sector where large amounts of money and sensitive data are at stake. Overall, blockchain technology has the potential to transform the energy sector by increasing efficiency, reducing costs, promoting renewable energy, and enhancing security. As the technology continues to mature, we can expect to see more widespread adoption of blockchain in the energy sector, with significant benefits for all stakeholders involved. The regulatory aspects of blockchain implementation in the energy sector of Ukraine are complex and evolving. While there is no specific legal framework for blockchain technology, there are several regulations and guidelines that are relevant to its use. Any blockchain-based solution must comply with the relevant regulations, and regulatory approval must be obtained before implementation. The adoption of blockchain technology could bring significant benefits to the Ukrainian energy sector, but it will require a respective regulatory shift.

Технологія блокчейн має потенціал для революції в енергетичному секторі, забезпечуючи більш ефективні, безпечні та децентралізовані транзакції між виробниками енергії, споживачами та операторами мереж. Енергетичний сектор є дуже складним, у виробництві, передачі, розподілі та споживанні енергії беруть участь численні зацікавлені сторони. Блокчейн може оптимізувати ці взаємодії, надаючи прозору та захищену від

несанкціонованих дій платформу для запису та обміну даними. Одним із найбільш перспективних застосувань блокчейну в енергетичному секторі є створення рівноправних енергетичних ринків. Завдяки блокчейну окремі особи та організації можуть купувати та продавати енергію безпосередньо один одному, минаючи традиційних посередників, таких як комунальні послуги. Це може зменшити витрати та підвищити ефективність, а також сприяти використанню відновлюваних джерел енергії. Блокчейн також може полегшити інтеграцію розподілених енергетичних ресурсів, таких як сонячні батареї, вітрові турбіни та системи зберігання енергії, в мережу. Створюючи децентралізовану систему для моніторингу та контролю, блокчейн може допомогти оптимізувати їх використання та зменшити відходи. Окрім цих додатків, блокчейн також може підвищити безпеку та надійність енергетичного сектору. Забезпечуючи захищену від втручання платформу для запису транзакцій, блокчейн може зменшити ризик шахрайства та кібератак. Це особливо важливо в секторі, де на карту поставлені великі суми грошей і конфіденційні дані. Загалом технологія блокчейн має потенціал трансформувати енергетичний сектор шляхом підвищення ефективності, зниження витрат, сприяння використанню відновлюваних джерел енергії та підвищення безпеки. Оскільки технологія продовжує вдосконалюватися, ми можемо очікувати більш широкого впровадження блокчейну в енергетичному секторі зі значними перевагами для всіх зацікавлених сторін. Регуляторні аспекти впровадження блокчейну в енергетичному секторі України є складними та розвиваються. Хоча немає чіткої законодавчої бази для технології блокчейн, існує кілька нормативних актів та їх проєктів, що регулюють використання цієї технології. Будь-яке рішення, засноване на блокчейні, має відповідати певним нормам, а перед впровадженням необхідно отримати схвалення регуляторних органів. Впровадження технології блокчейн може принести значні переваги українському енергетичному сектору, але це потребуватиме відповідних регуляторних змін.

Key words and phrases: blockchain in energy sector, regulatory politics, energy markets, Web 3.0.

Ключові слова: блокчейн в енергетичному секторі, регуляторна політика, енергетичні ринки, Веб 3.0.

The future has arrived – it's just not evenly distributed yet

Introduction

Web 3.0 with its “less trust more truth” [1] decentralised conception is on the way to replace “free-of-charge” centralised and GAFAM monopolised Web 2.0 – is this just a trendy hype? Or we are witnessing some more fundamental structural transformation of High-Tech Sector and its influence on the Global Economy in general and the Energy Sector in particular? What are these Web 3.0 promised brand new points of growth – which soon can compensate us the lack of security we've been experiencing till now, help to decrease transaction costs and uprise the industry performance? Blockchain and smart contracts are among them in first row.

Literature review

Blockchain based solutions in energy sector is rather new topic of research that have been in focus since 2018. The list of recently published research works includes the following, but is not limited to them:

“Blockchain in Energy Sector” by Nai Fovino I., Andreadou, N., Geneiatakis, D., European Commission's Joint Research Centre,

“Oil, Natural Gas and Blockchain” by Mohamed El-Masri, Blockchain Research Institute,

“Blockchain in Oil and Gas Industry: Applications, Challenges, and Future Trends” by Raja Wasim Ahmad, Khaled Salah, Raja Jayaraman, Ibrar Yaqoob, Mohammed Omar.

“Blockchain-Based Energy Applications: The DSO Perspective” by Ahmet Yagmur, Beyhan Adanur Dedetürk, Ahmet Soran, Jaesung Jung and Ahmet Onen.

Purpose of the article

The purpose of the article is to propose blockchain-based solutions in energy sector, consider EU best practices and Ukraine's perspective in legislative and regulatory aspects.

Results

Blockchain – brief retrospective. Blockchain was designed as a tailor-made technology for peer-to-peer transaction platforms that uses decentralized storage to record all transaction data. Originally developed in the financial sector to serve as the basis for the Bitcoin cryptocurrency, in past decade it's been used as a core in the emerging crypto industry.

The initial idea of the blockchain technology was to grant anonymous but public access to the data ledger without ability of further intrusion and amending it. So, the public platform is a native and most common type of blockchain implementation, but not the only possible. Ongoing transformation of the technology caused by market demands made possible developing of private and hybrid blockchain platforms which are applied most widely in non-financial sector.

The public blockchain platforms are open networks of connected nodes that allow users to have full control on their transactions and data. The users of the public blockchain platforms can access, view, update, and write data on the blockchain ledger without involving any third party.

The private blockchain users follow an invitation-only model to access the platform. Private blockchain platforms are controlled and managed by a single entity. Permission is required from the designated entity by the users to join the network or access, view, and write data and transactions on the blockchain. In hybrid platforms, public platforms host private networks to control access to the blockchain platform. Through hybrid platforms, restricted access is granted to only a limited number of users.

A consensus protocol as a core brick of blockchain architecture assures that the most recently added block to the existing ledger is approved by the majority of verifier nodes within the blockchain network. There are three basic types of consensus algorithms that are followed by numerous blockchain platforms – Proof-of-Work (PoW), Proof-of-Stake (PoS), and Proof-of-Authority (PoA). PoW consensus algorithm requires users to solve satisfactorily a mathematical puzzle to form a block and claim the reward. The PoS selects a distinguish node to create a

block based on several factors such as the total stake of the particular user or age. The PoA consensus algorithm counts the reputation score of the user to select an appropriate node for mining a block. PoA is a highly fault-tolerant and computationally fast protocol.

Blockchain itself as upgraded transaction ledger is probably senseless in non-financial sectors currently. The bridge to connect the Web 3.0 technology with real demands of consumers and businesses is a smart-contract. A smart contract, as a blockchain derivative technology, represents a digital protocol that automatically executes predefined processes of a transaction without requiring the involvement of a third party (e.g. a bank). It would be possible, for example, to create a fully automated smart contract between a gas supplier and a consumer that autonomously and securely regulates both supply and payment.

A blockchain platform is a shared, immutable ledger that facilitates recording transactions and tracking assets in a business network. In general, there are two types of platforms – relied whether on cryptocurrency or on enterprise-grade solution.

The first ones were originally designed for cryptocurrency deployment and have been possessed some inherent features to support various use cases related to DeFi, cryptocurrency exchanges, wallets, NFTs, and governance. Ethereum and its universe is the most popular blockchain network for Web 3.0 and decentralized apps (dApps).

Early attempts to fit the benefits of blockchain for non-financial sector caused to foundation of enterprise-grade solution blockchain platforms, such as Hyperledger. These are based on a quite different approach featuring permissioned network, confidential transactions, and programmable smart contracts.

Up-to-date blockchain deployment in non-financial sectors. Despite continuous downturn the crypto industry has been suffering for a while 2022, a widely-spread practice of blockchain technology implementation in non-financial sectors is a new reality we can't ignore anymore. So, how do they fit within each other?

Having experienced a decade of development and pilot implementation of blockchain based projects in Energy Sector worldwide and in EU in particular, one

can conclude we are currently entering a new stage – of maturity and sustainable deployment.

A list of blockchain based cases consists of wide range of industries – upstream to downstream in fossil fuels to balancing and trading platforms in electricity. These include:

- Wholesale Energy Trading;
- Electric mobility/EV charging application;
- Pipeline Monitoring and Leak Detection;
- Automation of Oil and Gas Exploration and Production;
- Simplifying Billing and Payments;
- Regulation of Compliance and Accountability;
- Disposal and Recycling of Oil and Gas industry Waste;
- Interoperable solutions connecting smart homes;
- TSO-DSO-Consumer interface architecture solution;
- Platform for operation of distribution network.

Onwards we'll consider closer actual emerging projects focusing EU energy sector.

The INTERRFACE (www.interrface.eu) project aims to support greater coordination between TSOs and DSOs facing common challenges around the procurement of distributed flexibility. The coordinated procurement of balancing, congestion management, and other ancillary services at both the transmission level and the distribution level will enable more efficient and effective network management and will increase the level of demand response and capacity for renewable generation.

Blockchain-based TSO-DSO Flexibility Integration of an intelligent platform with blockchain-based technology, allowing the trading of flexibility services among prosumers at the TSO and DSO levels enabling TSOs, DSOs, prosumers, BRPs, and suppliers to trade flexibility services in a transparent and cost-effective way. Its distinctive features are blockchain-enabled procurement process allowing greater visibility into all market parties and the validation of assets' metadata and the settling

of associated financial operations. State-of-the-art digital tools based on blockchains and big data management will provide new opportunities for electricity market participation and thus will engage consumers in INTERRFACE's proposed market structures designed to exploit Distributed Energy Resources.

The Platone (www.platone-h2020.eu) project aims to develop an architecture for testing and implementing a data acquisitions system based on a two-layer approach, an access layer, and a service layer to allow greater stakeholder involvement and enable efficient and smart network management. The tools used for this purpose will be based on platforms able to receive data from different sources, such as weather forecasting systems and distributed smart devices spread across an urban area. These platforms, by talking to each other and exchanging data, will enable the collection and elaboration of information that is useful for distribution-system operators (DSOs), transmission-system operators (TSOs), customers, aggregators, and other stakeholders, such as market operators, energy traders, and balance-responsible parties. In particular, the DSO will invest in open and non-discriminating standard economic dispute-settlement blockchain-based infrastructure to give both customers and the aggregator the possibility to become flexibility market players easily. This solution will see the DSO evolve into a new form – a market enabler for end users and a smarter observer of the distribution network.

The PermianChain (www.permianchain.com) is a permissioned blockchain platform-as-a-service (BPaaS). It solves the funding challenge by simplifying how exploration and production (E&P) companies and registered exempt market dealers (EMDs) work together. It solves the market challenge by allowing E&P companies to sell field-generated electricity digitally to data center operators for powering on-site remote data mining farms. The BPaaS uses Hyperledger Fabric blockchain integration to allow E&P companies to catalog, manage, and create value from their proven oil and gas reserves.

All transactions, once executed, are immutable and recorded in the distributed ledger and reflected on the token register of the platform. The data registered on the BPaaS are updated by authorized verifiers and users on the platform. When E&P

companies must upload or update oil and gas reserve reports and company valuations, authorized petroleum consultants must verify them on the platform before these data are pushed to Hyperledger Explorer.

Oil and gas data reports are uploaded and accessible to accredited investors in a private virtual data room. Accredited investors must first be admitted to PermianChain's primary digital securities issuance platform to subscribe for NASTs by their registered EMD. Key data from these reports (e.g., proven reserves, barrels of oil equivalent, valuations, etc.) appear on the investor dashboard so that investors have key indicators relevant to the value of their holdings.

Legislative and regulatory aspects of blockchain based solutions implementation in Ukraine's energy sector. State regulation and law adoption are the most necessary steps in further development and implementation of blockchain based solutions in Energy Sector.

EU has been passing huge efforts adopting its legislation to the upcoming changes, in some cases encouraging them. As one of the key steps was establishment of European Blockchain Partnership [2] in 2018, pursuing several core principles to implement blockchain technology:

- Full legislation compliance;
- Avoiding fragmented approaches;
- Exemption of blockchain-based solutions from existing legislation rules of security market regulation.

In the field of standardization activity, The IEEE Standards Association (SA) P2418.5 Blockchain in Energy Standards Working Group (WG) was established in 2018 [3].

The IEEE SA P2418.5 Blockchain in Energy Standards WG aims to propose, develop and communicate a set of open, common and interoperable standardization procedures as well as a reference framework model to create holistic and vendor agnostic blockchain related guidelines applicable to the energy industry by covering the following objectives:

- Serve as a guideline for blockchain use cases in the electrical power industry and the oil and gas value chain;
- Propose, design and develop an open, interoperable, safe and implementable reference standardization framework that is based on a wide consensus between seasoned industrial and academic members (WG members), comprehensive desktop surveys and the solid reference architecture framework for the energy sector (mainly the power industry, and partially the oil and gas industry);
- Create a technological map of the conceptualized initial reference architecture framework with the selected energy use cases where blockchain can be applied, providing additional value;
- Evaluate and provide guidelines on scalability, performance, security and interoperability through the evaluation of consensus algorithms, smart contracts and type of blockchain implementation for the energy sector.

The common practice of early stage state support worldwide has become launching of blockchain regulatory sandboxes – controlled environments where companies can test their products and services while engaging with relevant regulators. As an example, it is a recent launch of European Regulatory Sandbox for Blockchain. By implementing the initiative, European Commission pursues providing legal certainty for decentralized technology solutions including blockchain by identifying obstacles to their deployment from a legal and regulatory perspective and providing legal advice, regulatory experience and guidance in a safe and confidential environment. The Sandbox will host 20 projects annually till 2026.

Nowadays Ukraine is just at the beginning of the way – there is a blind spot in its legislation body considering regulation of digital assets. The respective draft law [3] is currently under development. After implemented, further steps to harmonize industry codes will be necessary.

The regulatory aspects of blockchain implementation in the energy sector of Ukraine are complex and evolving, as the technology continues to gain traction in the region. While there is no specific legal framework for blockchain technology in the

Ukrainian energy sector, there are several regulations and guidelines that are relevant to its use.

One of the primary concerns related to the use of blockchain in the energy sector is data privacy and security. The General Data Protection Regulation (GDPR) and the Ukrainian Law on Personal Data Protection regulate the collection, processing, and storage of personal data, which is crucial for blockchain-based solutions. It is essential to ensure that personal data is protected and that the necessary permissions have been obtained before any blockchain-based solution is implemented.

Another key issue is the legal status of smart contracts, which are an essential component of blockchain-based solutions. Ukrainian law does not recognize smart contracts as a legal entity, but there are efforts to amend the Civil Code to include provisions for smart contracts. Additionally, the Ministry of Justice has released guidelines on the use of smart contracts, which provide some clarity on their legal status.

The Ukrainian energy sector is highly regulated, and any blockchain-based solution must comply with the relevant regulations. The National Commission for State Regulation of Energy and Public Utilities is responsible for overseeing the energy sector in Ukraine, and any blockchain-based solution must obtain regulatory approval before implementation.

One of the significant advantages of blockchain technology is its ability to facilitate peer-to-peer energy trading, which is not allowed in Ukraine at present. The current regulations only allow energy trading through centralized marketplaces. The adoption of blockchain technology could enable decentralized energy trading, which would require a significant regulatory shift.

Meanwhile there are two possible approaches in state influence on blockchain implementation in Ukraine – the liberal and conservative ones.

The liberal approach involves only a framework legislative regulation, for which it is enough to implement the above-mentioned legislative acts. In this case Ukraine's energy sector should return to the track of liberalization and deregulation it

left in 2021. State intervention in the energy sector might be minimized, as well as government energy price cap control. State and regulation authority influence on blockchain implementation processes would be neglected to zero in that case – industry players shall act on their own response considering competitive motivation and accepting upcoming risks.

The conservative approach is closer to EU practices and is based on a concept of deeper involvement of regulation authorities in adoption and implementation of sectoral standards and secondary legislation.

Nevertheless, it's obvious to begin this process as soon as possible endeavoring not just being in trend, but realizing a wide range of new opportunities the technology assures.

Conclusions

Although the current legislation does not prohibit directly the use of blockchain technologies in the economic relations of legal entities, the shortage of trust and security, as well as the lack of practices for settling possible disputes, make their full use rather limited at present.

The only acceptable option for the further development of technology in Ukraine and its wide use in energy sector is the formation of a legislative and regulatory environment based on European experience. A consumer-oriented energy market will do the rest.

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Стаття надійшла до редакції 20.04.2023 р.