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THE USE OF BLOCKCHAIN TECHNOLOGIES IN THE ENERGY INDUSTRY

ANNOTATION

This article examines the problem of increasing the efficiency of the energy industry using blockchain technology. The main purpose of the work is to determine the directions of implementation of blockchain technology in the oil and gas sector and the electric power industry. The article also outlines the conditions for the effective implementation of blockchain projects, analyzes the directions of blockchain implementation in the oil and gas industry and the electric power industry, and determines the expected results of the implementation of blockchain technology in the energy sector and possible related problems. Blockchain technology turns out to be fundamental for automatic monitoring, tracking, and recording of information, namely, an asset, which is electricity. Opportunities are opening up for managing the processes of electricity consumption and production through the economics of the relationship of technologies. Along with traditional generation, alternative opportunities arise for the local purchase of energy when it is cheap, its subsequent sale at a higher price at the peak of consumption, or a decrease in consumption during periods of price increases. In addition, blockchain can contribute to the development of decentralized energy by allowing small home or commercial energy producers to sell their excess energy to other users. This can create new opportunities for the development of renewable energy sources and reduce dependence on traditional energy suppliers.

Key words: *blockchain technologies, energy saving, local energy market, distrubeded energy, GRID+*

Introduction. Blockchain technologies, since the advent of bitcoin, have significantly expanded their horizons and found application in various business areas. One of the most promising areas is their use in the energy industry. The revolutionary capabilities of the distributed blockchain registry help optimize processes in the energy system by creating efficient and reliable management systems.

One of the key challenges in the energy sector is tracking the origin and transactions of energy resources. Blockchain technologies allow you to create traceable energy supply chains, starting from production and ending with its consumption. Due to the fact that the blockchain is a public and genuine registry, it is possible to verify and confirm the origin of energy, as well as control over its distribution [1].

Blockchain also helps to improve the energy efficiency of systems. Blockchain network nodes can receive information about electricity production and consumption in real time, which allows you to more accurately predict the load and optimize the distribution of energy resources. This reduces energy losses, increases reliability and reduces the cost of maintaining the power system [2-10].

Blockchain in the energy sector is the concept of using blockchain technology to optimize and improve performance in the energy industry. It can be applied in various aspects of energy, including:

1. Electricity management and trading: Blockchain allows you to create a decentralized platform for electricity trading, where producers and consumers can interact directly, without intermediaries. This makes it possible to improve the efficiency and transparency of trading processes.

2. Network and Data Management: Blockchain can be used to create a secure and reliable power grid management network. It allows you to monitor and control power consumption and data transmission, providing more efficient management and faster response to changes in the network.

3. Distributed Energy sources: Blockchain can be used to manage distributed energy sources such as solar panels or wind turbines. It allows you to monitor and manage the process of energy production and distribution, as well as distribute it between different consumers.

4. Accounting and certification of green energy production: The blockchain can be used to account for and certify the production of green energy, such as energy obtained from renewable sources. This helps to verify the authenticity and origin of such energy, as well as to ensure transparency for consumers.

5. Energy Smart Contract Management: Blockchain allows you to create and manage energy smart contracts that are automatically executed when certain conditions are met. This simplifies and automates the management and calculation processes in the energy industry.

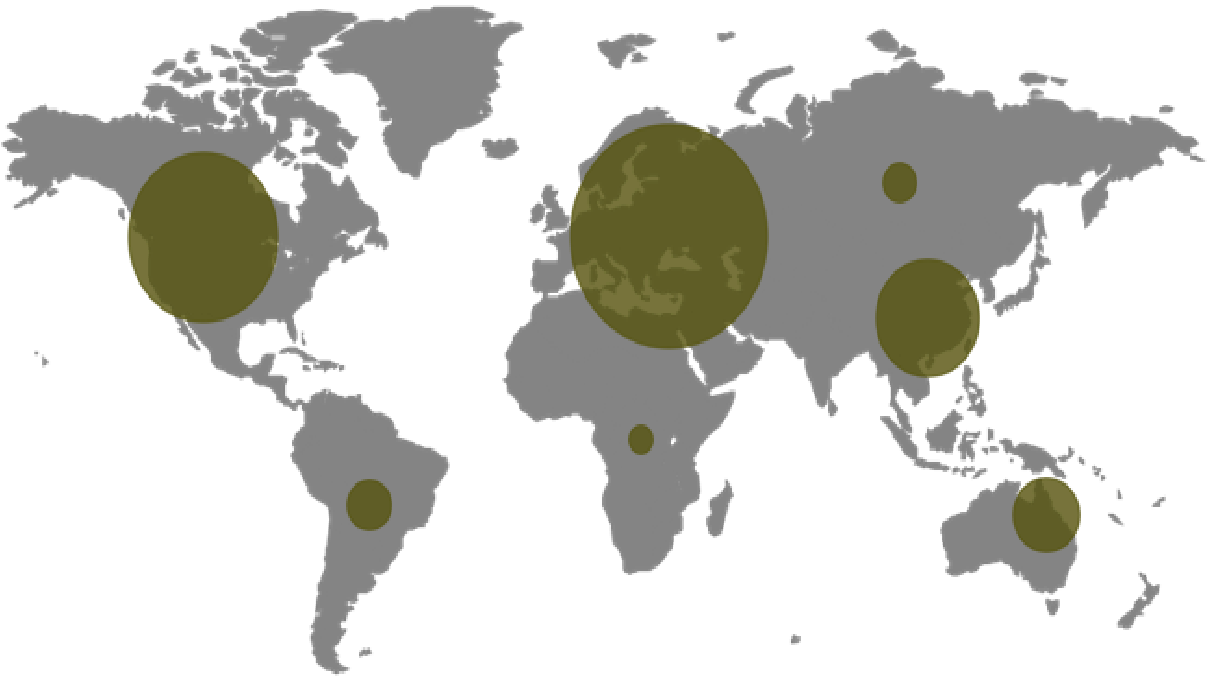


Figure 1 – Global technology demand (the share of projects in the world of the total number)

Objects and methods of research. One of the top priorities is to promote the possibility of horizontal energy trade. Providing this opportunity involves the direct exchange of excess energy between individuals and businesses that produce it and other members of their local community. If a household equipped with solar panels produces excess electricity, it can realize its energy resources by selling them to neighboring residential buildings or industrial enterprises. This allows consumers to become prosumers (producers-consumers), namely, to turn into producers and consumers of electricity at the same time. Ultimately, such interaction contributes to a more efficient and localized energy distribution system.

For successful integration of renewable energy sources into everyday life, it is necessary to automate the system using innovative equipment. This task puts before us the requirement of an energy system built on the basis of blockchain technology, in which each component plays its important role. Only such a system will be able to effectively manage and distribute energy, providing reliable energy supply for our daily lives [11-17].

The introduction of blockchain technology can be a revolutionary step for energy companies that seek to adapt to changing market demands. An example of such a necessary transformation is the situation in Japan, where allowing retailers to sell excess green energy has led to a 15% decrease in the number of customers of the Tokyo Electric Power energy company. In response to these challenges, the leading supplier decided to invest in the Electron blockchain project, which has long been noted for its advantages in modernizing the infrastructure of the energy industry, allowing efficient power distribution and cost reduction.

One of the main factors that renewable energy companies are currently facing is the need to combine millions of assets into energy networks at the transmission and distribution level. To solve this problem, market participants need to create a reliable common infrastructure capable of identifying and registering the properties of these assets. This aspect is relevant to achieve flexibility and efficiency of the energy network.

Electron enterprise, using the Ethereum blockchain platform, has developed a demo system that simulates data from 53 million energy metering points in individual homes serviced by 60 different energy suppliers. And, importantly, it has been proven that switching an energy supplier can occur 20 times faster than current switching speeds. This is a huge achievement in the field of energy exchange and confirms the potential of blockchain technology in the energy sector.

Research results. The global energy consumption annually reaches approximately 580 million terajoules, which is equivalent to 580 million trillion joules, requiring 13,865 million tons of oil equivalents. Furthermore, energy consumption has experienced a significant increase of one third since 2000, with projections suggesting a further 30% rise to 740 million terajoules by 2040. Unfortunately, more than 80% of our energy comes from fossil fuels, posing a risk of substantial greenhouse gas emissions that contribute to the exacerbation of global warming.

Table 1 – Transition to a new energy sector

The current (dominant) energy paradigm	A new energy paradigm
Fuel (hydrocarbon) sources of renewable energy	Renewable energy sources
High concentration of generating capacities	Deep decentralization of energy production
Hierarchical electric networks with radial topology, centralized management of operation and development	Smart Grids and Smart Energy systems, decentralized multi-agent management
Unidirectionality of e/e flows from the generator to the consumer	Prosumers, bidirectionality of e/e flows
The simultaneity of the processes of production and consumption of e/e	Energy storage technologies, energy as a "storable" commodity
Widespread use of fuels in industry and transport	Deepening the electrification of industry and transport

It is imperative that we shift our energy supply mix towards renewable sources to mitigate these risks. As custodians of our planet, we bear a shared responsibility to protect our environment, ensuring the preservation of natural resources and maintaining an ecological balance that fosters our long-term coexistence as a society [18-20].

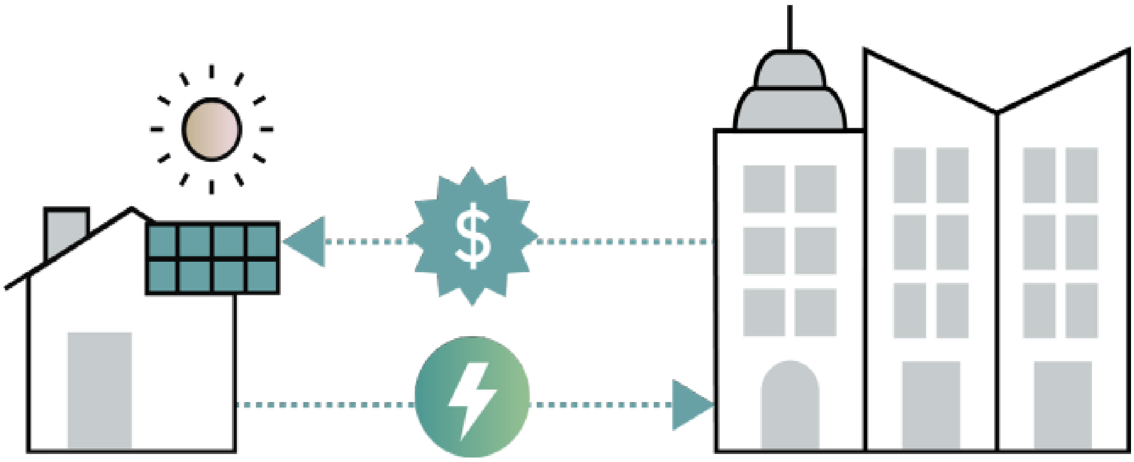


Figure 2 – Customer A trading excess energy to the energy retailer in exchange for crypto or fiat currency

In the current model as shown in the diagram above, individuals consume energy directly from power sources. In a decentralized model, individuals can consume energy, as well as produce energy, by owning fractional amounts of energy producing assets such as solar panels, becoming “prosumers” – that is, producers and consumers. They can sell their excess energy to other individuals for a profit, and even back to the grid. This flexibility and monetary incentives would attract the individual energy consumers operating on a traditional centralized model to take part in a decentralized model. At scale, peer-to-peer energy trading, which can incorporate features like dynamic pricing, preferential trading, and gifting/donating, empowers consumers to manage their excess energy in a manner that would not have been possible without blockchain applications. This new role that consumers can take on becomes a market-driven incentive to accelerate the deployment of distributed energy resources, in ways that can save communities around the world from the need to rely on other financial incentives and government subsidies to support renewable energies (e.g., feed-in tariffs or net metering to achieve deployment targets). Ultimately, while both blockchain and crypto can provide significant benefits to peer-to-peer trading, collaboration with energy retailers to become key stakeholders as part of the process illustrated above is key to foster adoption [20].

A local energy market (LEM) is largely a network of human beings growing a sub-marketplace of strength for every other. It may want to entail any vicinity or district wherein strength is traded among players, permitting power customers to barter and determine on power portions and charges for every transaction. This flexibility enables smooth power integration through supporting to control the shortages and surpluses of an strength marketplace after they occur. Much like seasonal vegetables, wherein charges alter to their deliver in the course of the year, power charges at a nearby stage additionally alter to seasonal modifications in deliver which might be herbal for renewables. In any LEM, the deliver of smooth power is matched with power call for at the proper rate through adopting superior optimization strategies and constraint management. Any mismatch may be traded with the electricity grid as according to business-as-usual (BAU), i.e., surplus nearby power is fed lower back into the electricity grid on the feed-in-tariff (FiT) rate, at the same time as unmet call for is bought on the timeof-use (ToU) charges.

Distributed power fashions with underlying blockchain generation for information records, in place of centralized power fashions, are great desirable to control power distribution and underlying transactions. Typically centralized power reassets are steady, in place of decentralized power reassets which might be intermittent, as proven withinside the figures below.

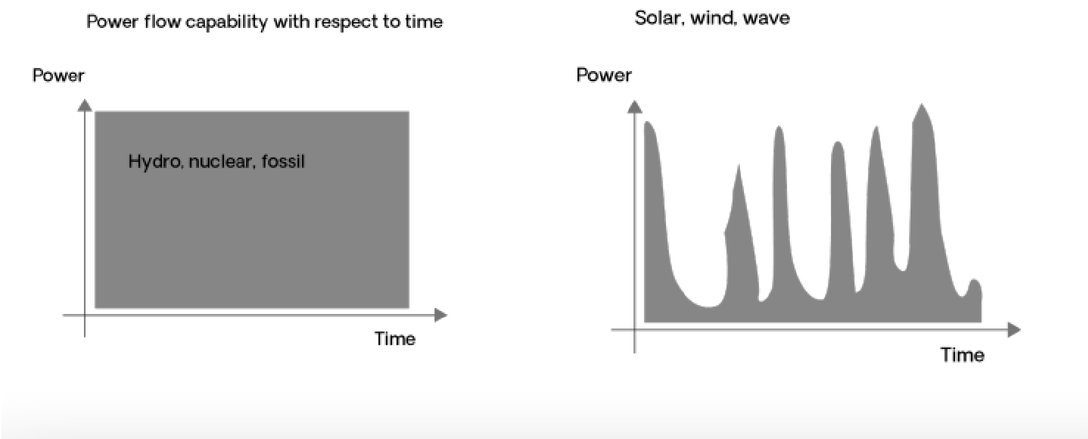


Figure 3 – Centralized energy (left): Steady power capability supports a centralized structure and fixed pricing. Distributed Energy (DE) (right): Intermittent energy works well with a local energy market and dynamic, agile pricing.

Many experiments have been conducted in the field of energy and blockchain, but not all projects have reached significant proportions, and many more problems remain to be solved. The main problem is the lack of regulatory clarity in blockchain technology. Currently, there are not enough recommendations for the implementation of blockchain projects, especially in the field of p2p energy trading, although this technology can empower consumers and promote environmentally friendly energy consumption - which is the goal of many legal and regulatory initiatives in the industry.

In addition, it is important to ensure scalability, speed and security in the energy sector, one of the critical industries. At the moment, most publicly available blockchains are forced to sacrifice in one of these aspects, since each of them is a major obstacle to the widespread use of existing solutions. Although a private blockchain can help mitigate some of these problems, the development of blockchain solutions is costly, and uncertainty about success may constrain efforts in this area [15].

Finally, the existing system, which includes infrastructure, technology and regulation, is deeply rooted and represents a significant barrier to the development of blockchain in any industry.

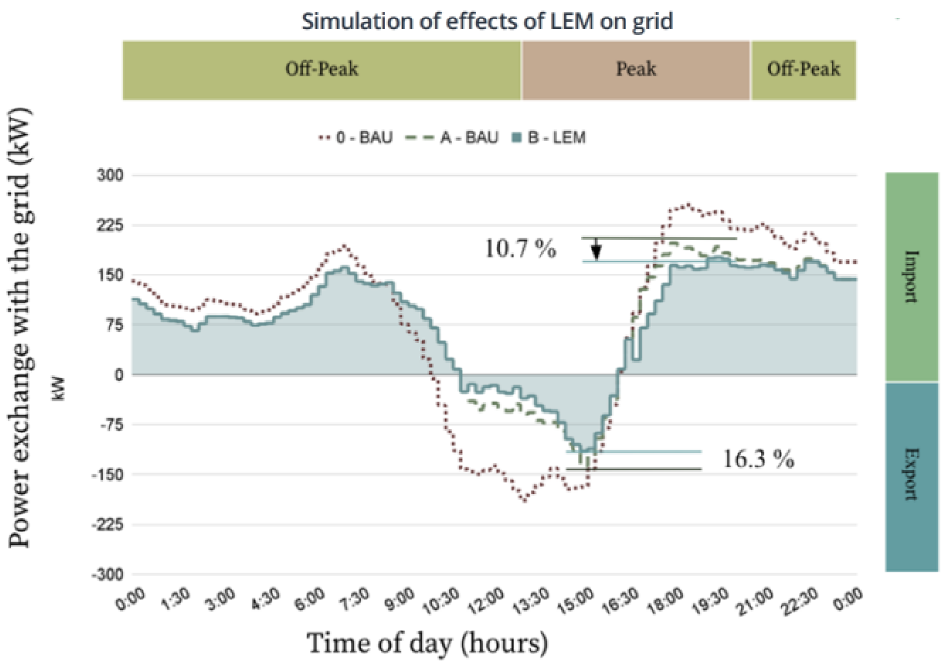
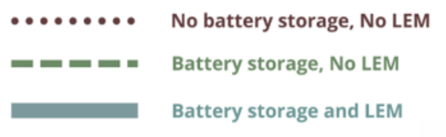


Figure 4 – Simulation of effects of LEM on grid

Assumptions
• Minimizing the electricity bill cost for 300 participants.
• Minimizing the grid import and export peaks of whole LEM trading trading group
• Analysis is based on AusGrid data of 180 consumers, 60 prosumers with solar PV and 60 prosumers with solar PV and BESS.
• ToU: Peak hours 3pm to 9pm, off-peak hours 9pm to 3pm.
• P2P_selling_price: >5.3 c/kWh and 12.6 c/kWh and



For example, the GRID+ company A distinctive feature of the American company Grid+ is its positioning as an electricity supplier (REP), unlike firms engaged in creating a software platform for all market participants. The team from Austin (Texas, USA) began its research activities in 2015 and successfully attracted $29 million in investments at the token presale last year. The company is also registered in its home state as a guaranteeing electricity supplier. Now let's look at the market entry plan that the company has chosen for itself [16].

The first step is related to the development of a specialized software platform for customers. It is assumed that registered users will be able to make payments at the proposed tariffs automatically using smart contract technology and prepaid tokens. It will be possible to pay and replenish the deposit both in dollars and in major cryptocurrencies. The consumer will be able to set up and choose the frequency of payment of electricity bills, as well as gain advantages when integrating their drives into the network. The architecture of the retail platform database (billing system) is a database of events that records the balances of all consumers, and includes a payment module and a module that debits funds from accounts.

At the next stage, the company connects the customers of the system by registering them and installing special electronic agents that are connected to electricity metering devices. This electronic device will analyze electricity consumption and plot consumption forecasts. Based on the forecast data, the device will purchase electricity the day before actual consumption. At the same time, the electronic agent is essentially a user's hardware wallet that stores a private key. Calculations are planned to be carried out using ETH or BOLT cryptocurrencies (equivalent to $1) in real time with preset intervals.

It is assumed that the device will be able to predict power consumption with high accuracy.

Figure 5– Type of hardware agent prototype

The following advantages are noted in comparison with the usual consumption model:
• payments in cryptocurrency;
• low cost of electricity;
• the ability to connect drives to the network;

• special tariffs for the purchase and sale of electricity based on forecasting consumption and demand;

• Support for and access to electric vehicle chargers.

At this stage, not only the device itself is being developed, but also top-level software for connecting to the calculation platform, as well as forecasting algorithms themselves for efficient consumption and sale of electricity.

The connection of private generation and energy storage systems is the next step in building a system where integration with the software platform and agent takes place using special protocols and software. It is assumed that the purchase and accumulation of cheaper electricity on the market — as well as the sale of electricity — will be available automatically.

At the final stage, the company with connected users will begin to fully carry out its activities as a registered electricity supplier based on an information billing platform with the possibility of purchasing electricity directly on the wholesale market or on the private generation market, where peer-to-peer transactions are possible.

The first token, BOLT, is basic and stable, with a fixed price of $1 per unit. It is used to make transactions for electricity on the platform. The funding of "agent" type devices takes place precisely in BOLT tokens at the expense of funds placed on customer deposits. The number of BOLT tokens is limited only by the amount of money on deposit: if you deposit one dollar, one BOLT is created; as soon as you have consumed electricity for this very one BOLT, it is destroyed. Thus, the risk of double calculations is eliminated. And the token itself is a double of the dollar on the network.

The second token on the platform is the GRID token. One such token gives the right to redeem 500 kWh on the wholesale market at any time. The authors of the project declare it as a kind of "coupon" that gives you the right to buy back power at wholesale prices. The project plans to issue about 300 million such tokens. For GRID, the situation is somewhat more complicated in terms of determining economic efficiency: the tokens themselves are traded on exchanges and purchased at the current market price, however, regardless of the price of the token, you can purchase exactly 500 kWh for it. At the same time, the price of electricity in the wholesale market also changes, and for the same 500 kWh you can, accordingly, pay more or less. It turns out that if the price on the wholesale market rises, and the price of the GRID token falls, then for GRID+ this may mean working at a loss [14-19].

Therefore, the price of the GRID token will vary from market to market at the regional level and should be lower than the average price for electricity in the US wholesale market, taking into account approximately 30% of the operating costs of the company itself. Note that the average price in the US wholesale market hovers around the $30 mark for 1 MWh, or 6 cents per 1 kWh. A simple calculation (500 kWh × 0.06 cents/kWh × 0.3) gives $9 per token — this is the real market price. At the same time, the token itself is now valued by the market at 55 cents.

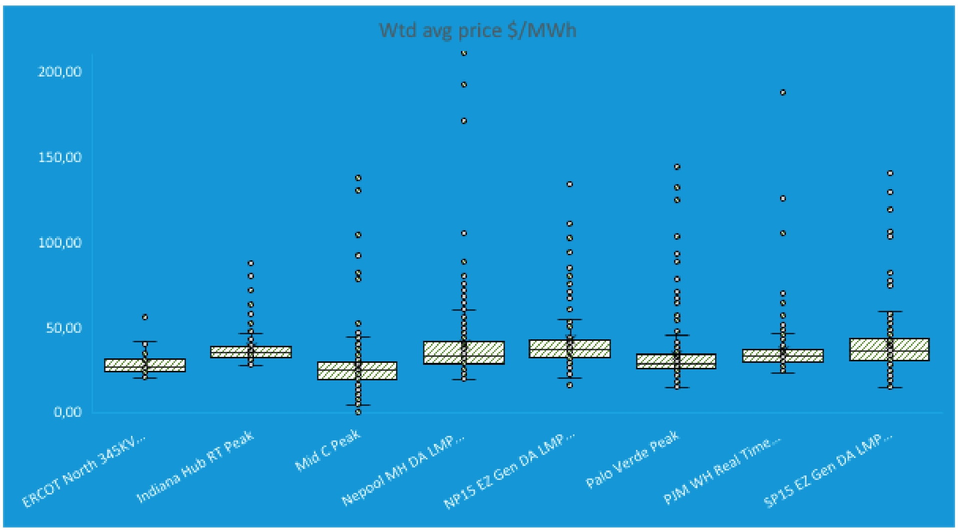


Figure 6 – The average cost of 1 MWh of electricity in the wholesale market

Conclusion. There are different approaches to the implementation of such projects in the world, which have some common features. The key factors contributing to the emergence of such projects are the liberalization of the energy sector, especially the significant development of private renewable generation with the requirement of programmatic coordination between market participants, as well as the widespread use of automatic electricity metering systems and the Internet.Blockchain technology plays a fundamental role in the automatic monitoring, tracking and recording of information about electricity, which is an asset. Thanks to this technology, new opportunities are opening up for managing the processes of electricity consumption and production using the economics of high technologies. In addition to traditional energy generation, alternative options arise for the local purchase of electricity during periods when it is cheap, and then its subsequent sale at a higher price during periods of increased demand or reduced consumption during periods of price increases.

The transition to green energy benefits from a predictable source of clean energy that can be calculated transparently and is easy to maintain. This platform is critical to operating the grid safely and efficiently. Direct data from IoT sensors on devices such as solar panels are recorded on the blockchain and fed into artificial intelligence algorithms for prediction and smart decision-making, which can change the current energy model to a sustainable one that meets user needs. model. Looking ahead, an interesting issue that arises in energy-related financial models is the responsibility of individuals to protect themselves. If a central bank customer loses a credit card, the bank can reissue it upon request. If unauthorized activity is detected on a customer's balance, a bank employee with authorized privileges can be contacted to make amends.

Finally, blockchain technology can also help scale up and integrate smaller projects to achieve the scale needed to attract large-scale energy investment. This reduces opportunities for the business community to participate in project financing and other renewable energy purchase options. Electricity systems help generate electricity costs for cities, villages and communities. This is possible for grid transformers, remote areas, low-income areas and developing countries. New financial networks can update these new networks, enabling new financial systems that rely on reliable and transparent networks.

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ТҮЙІН

Бұл мақалада Блокчейн технологиясын қолдана отырып, энергетика саласының тиімділігін арттыру мәселесі қарастырылады. Жұмыстың негізгі мақсаты мұнай-газ секторында және электр энергетикасында блокчейн технологиясын енгізу бағыттарын анықтау болып табылады. Сондай-ақ мақалада блокчейн жобаларын тиімді іске асыру шарттары белгіленеді, мұнай-газ және электр энергетикасында блокчейнді енгізу бағыттарына талдау жүргізіледі, энергетикада блокчейн технологиясын енгізудің күтілетін нәтижелері және ықтимал ілеспе проблемалар айқындалады.

Блокчейн технологиясы ақпаратты, атап айтқанда электр энергиясы болып табылатын активті автоматты түрде бақылау, қадағалау, жазу үшін іргелі болып табылады. Технологиялардың өзара қарым-қатынасы экономикасы арқылы электр энергиясын тұтыну және өндіру процестерін басқару мүмкіндіктері ашылады. Дәстүрлі генерациямен қатар энергияны арзан болған кезде жергілікті сатып алудың, кейін оны тұтынудың ең жоғары бағасы кезінде жоғары бағамен сатудың немесе бағаның көтерілу кезеңінде тұтынуды азайтудың баламалы мүмкіндіктері туындайды.

Сонымен қатар блокчейн шағын үй немесе коммерциялық энергия өндірушілерге артық энергияны басқа пайдаланушыларға сатуға мүмкіндік беру арқылы орталықтандырылмаған энергияны дамыта алады. Бұл жаңартылатын энергия көздерін дамытудың жаңа мүмкіндіктерін тудыруы және дәстүрлі энергия жеткізушілеріне тәуелділікті төмендетуі мүмкін.

РЕЗЮМЕ

В данной статье исследуется проблема повышения эффективности отрасли энергетики с использованием технологии блокчейн. Основной целью работы является определение направлений внедрения блокчейн-технологии в нефтегазовом секторе и электроэнергетике. Также в статье обозначаются условия эффективной реализации проектов на блокчейн, производится анализ направлений внедрения блокчейн в нефтегазовой отрасли и электроэнергетике, а также определяются ожидаемые результаты внедрения блокчейн-технологии в энергетике и возможные сопутствующие проблемы.

Технология блокчейн оказывается фундаментальной для автоматического мониторинга, отслеживания, записи информации, а именно — актива, которым является электроэнергия. Открываются возможности управления процессами потребления и производства электроэнергии через экономику взаимоотношения технологий. Наряду с традиционной генерацией возникают альтернативные возможности для локальной покупки энергии тогда, когда она дешева, ее последующей продажи по более высокой цене в пике потребления либо снижение потребления в периоды повышения цен. Кроме того, блокчейн может способствовать развитию децентрализованной энергетики, позволяя малым домашним или коммерческим производителям энергии продавать свой избыток энергии другим пользователям. Это может создать новые возможности для развития возобновляемых источников энергии и снизить зависимость от традиционных энергетических поставщиков.

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