Impact of Blockchain Technology for Modification of the Supply Chain Management in Energy Markets

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***Abstract*— Supply chain management played a critical role in the electric power industrial chain optimization. The paper notes that in order to increase transparency and efficiency of settlements for electric energy, the introduction of intelligent metering systems is necessary. In order to achieve efficiency, transparency, data security and reduce transaction costs abroad, blockchain technologies that have both positive and negative characteristics have begun to be actively introduced. Similar aspirations are realized in Russia, where smart metering devices are also installed everywhere for consumers of electric energy. At the same time, studies show that it is advisable to implement the implementation of blockchain technology only in conditions of decentralized electricity supply, since the principles of this technology are not compatible with management from a single center. In Russia, given the significant role of centralization in electricity supply chain and non-payment for energy, the presence of "non-disconnected" consumers and a very modest share of renewable energy, the possibilities for using blockchain technology are very limited. This necessitates the search for effective ways to use blockchain technology, taking into account the current circumstances.**

***Keywords*—** *supply chain, digitalization, blockchain technology, intelligent electricity (power) metering systems, non-payments, unified dispatch control, renewable energy sources.*

1. Introduction

Energy companies are increasingly rethinking their supply chains in order to maximize opportunities, reduce costs and achieve competitive advantage. Electric power industry is a complex technological and economic system. In Russia, it includes more than 800 power plants operating at different levels, over 1,500 network organizations of various levels of voltage, and millions of wholesale and retail buyers, individuals and legal entities that consume electricity. The functioning of this system requires the prompt collection and processing of a huge amount of information, the adoption of timely management decisions on the introduction of electric power operation modes, economic dispatching of the system, and payment of energy consumption. Solving these problems requires the introduction of digital technologies: Big Date, Blokchain, Smart, and others. In this regard, the question arises: how energy systems are ready to introduce new technologies?

A report by the UK Government [1] states that blockchains might have the capacity to '*reform our financial markets, supply chains, consumer and business-to-business services, and publicly-held registers*'. Blockchain is one of the modern technologies that can be successfully used to store and process personal data, and to identify users. The use of this technology makes calculations of payments for energy consumption transparent and operational and eliminates non-payments. However, this requires "smart" affordable metering devices that would remotely provide information on the measurement results, data on the amount of electricity consumed and other parameters, on the basis of which mandatory financial transactions will be formed. For electric utilities digitalisation offers an opportunity to improve network efficiency, billing processes, supply chain and enables exploration of new sources of innovation and novel business models [2, 3]. Solving the problems of adapting Blockchain technology to various operating conditions of energy companies is a demanded task.

2. Materials and Methods

Supply chain management is critical for managing sustainability at global and local levels. Whether the focus is on energy and environment initiatives, the largest and deepest influences are supply chain activities. Of all technological developments,

blockchain technology can have profound implications for supply chain sustainability, also known as distributed ledger technology. AlthSituational, structural and dynamic analyses were the leading methods that allowed us to study the possibilities of adapting blockchain technologies in energy markets, changes in time and space, in close connection with other phenomena. A systematic approach was used to assess the state of adaptation of blockchain technologies for supply chain in energy markets.

3. Results

For countries, energy security is particularly important for energy intensive economic activities that play a critical role in advanced manufacturing supply chains, for example aerospace and automotive, and account for 70% of industrial energy use. It has been established that despite the revolutionary development of information technology, energy companies only just start to develop the use of Blockchain. This is largely due to the fact that comprehensive conditions for digital technologies have not yet been created in the electric power system. It is shown that the production, transmission and marketing of electric energy are very specific and require serious adaptation to digitalization. It is proved that in solving this problem in such a large country as Russia, with its extensive network of energy systems over an extended territory, the participation of government bodies, energy companies and individual consumers, capable of joint efforts to create the necessary conditions for the adaptation of digital Blockchain technology in the energy system is necessary. State regulation of this process is necessary so that the adaptation of the Blockchain does not contradict the strategic intentions of accounting and control over the use of energy resources of the industry.

4. Discussion

Sustainable, and especially green, supply chains can benefit from blockchain technology, but there are also caveats. There are different opinions regarding the prospects for the development of blockchain platforms, but an analysis of foreign solutions in the electric power industry has shown that about 12 blockchain projects are currently at the development and at the implementation stages. In Europe, the majority of projects focus on renewable energy sources (RES). The production of own natural energy resources in the EU is steadily decreasing, as is the production of electricity from them, but the production of renewable energy sources is growing, their share in some countries already exceeds 50% [4-10].

Today, Germany leads European countries in terms of the number of smart grid and metering projects, followed by Denmark. Nevertheless, from the point of view of digitalization, the most interesting is Estonia being a small Baltic state with a population of 1.3 million people. Despite the small number of citizens and the modest area, Estonia is 100% equipped with smart meters, and its government is actively using digital technologies. [11-14]

Currently, the Estonian energy market is tokenized using the blockchain. The European company WePower, in cooperation with the Estonian transmission system operator (TSO) Elering, is engaged in tokenization of the entire Estonian energy system based on the blockchain. As part of the first phase of the project, data on electricity production and consumption in Estonia for the year (24 TWh of electricity) are transferred to Ethereum, which at least proved the technical feasibility of transferring such a volume of real data to the blockchain. As a result, this data was converted into 38,973,240,000 Smart Energy Tokens, where each token represents a digital contract for the sale of 1 kWh of electricity. They can be traded, as well as they can be cashed in the local electricity market, which is achieved by linking digital contracts to the energy system data via the blockchain [15].

At present, Russia is lagging behind in equipping smart meters of electricity and deploying renewable energy sources from Western countries. However, in our country, work in the application of blockchain for settlements with consumers in the retail electricity and capacity market is already underway.

The government has identified steps to introduce smart energy in Russia and approved a roadmap to improve legislation and remove administrative barriers to settlements using blockchain technology and smart contracts [16, 17].

A prerequisite for the application of Blokchain technology is 100% equipping consumers with “smart” metering devices integrated in the IoT / M2M system (the Internet of things and machine-to-machine communications) [18]. The research of the Russian market of IoT / M2M conducted by Jason & Partners Consulting LLC showed that as of 2018 the number of IoT / M2M devices connected to WAN (Wide Area Network), simply put, to the

Internet network exceeded 23 million units. The prospective forecast of Jason & Partners Consulting LLC implies an increase in the number of connected devices to 42 million units by 2023. [19]. At the same time, it is obvious that the Russian market of IoT / M2M does not take into account the need for smart metering devices for electric energy ("smart" meters) like Internet devices.

A certain dynamics and structure of electricity meters consumption has developed and, within the framework of the basic development scenario, a forecast of their increase to 2025 has been made [20]. As the energy environment changes and low cost, stable and sustainable energy inputs are not guaranteed, the interdependency of energy and the performance of production systems, and the firms within it, needs to be incorporated into supply chain management.

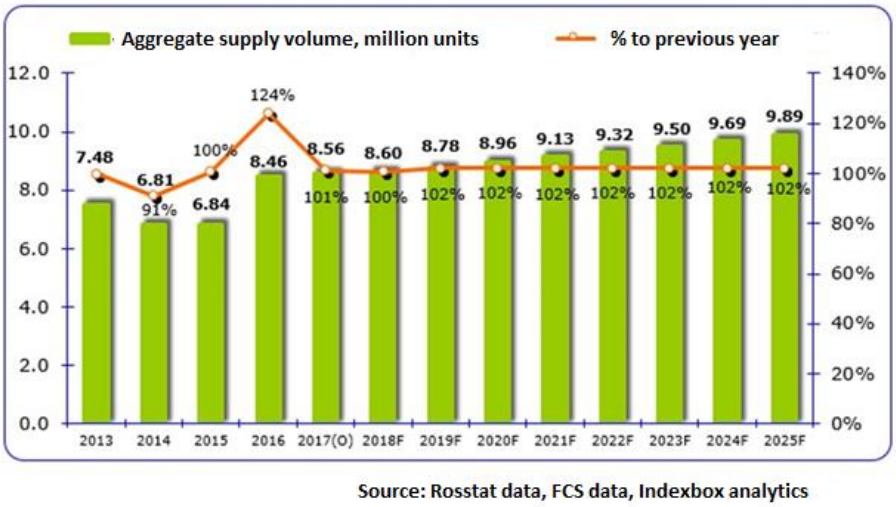

Fig. 2. The volume of production of meters and the forecast for their demand until 2025 (million units) under the basic development scenario [12]

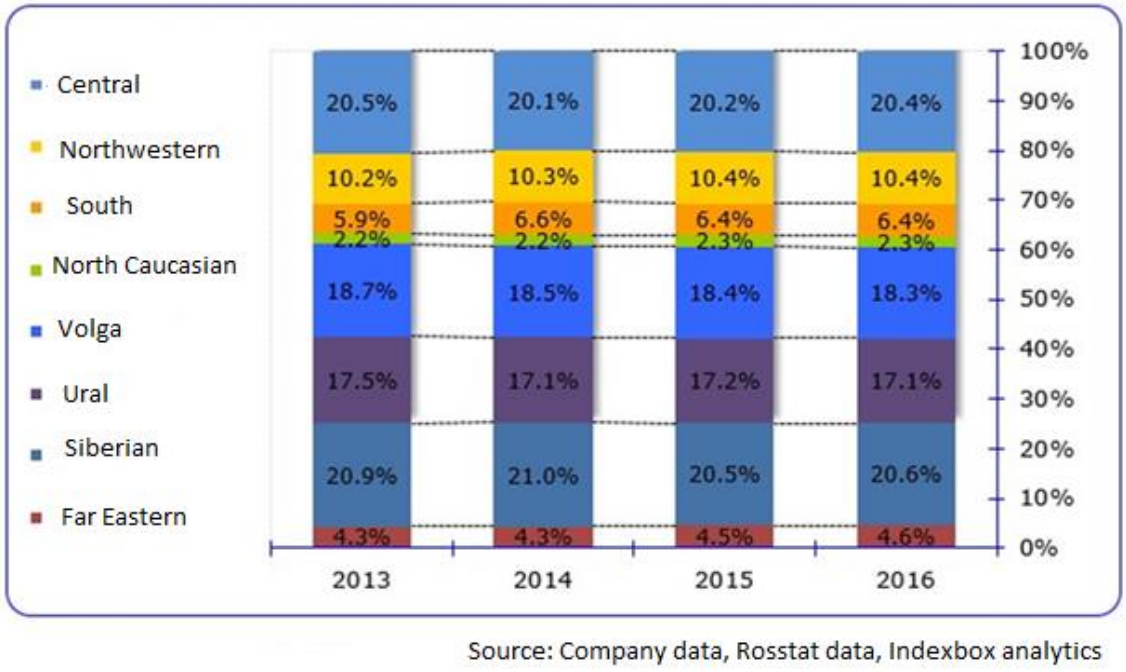

Fig. 3. Dynamics, structure of consumption of electricity meters in Russia, by regions, and forecast for them until 2025, mln. pcs.

As can be seen from fig. 3, the leaders in the replacement and installation of meters in Russia were the Central and Siberian regions, outsiders are the Southern and Far Eastern regions. In 2018, Federal Law No. 522-FZ "On Amending Certain Legislative Acts of the Russian Federation in Connection with the Development of Electric Energy (Power) Metering Systems in the Russian Federation" (hereinafter referred to as the Federal Law) introduced an intelligent electric energy metering system [21-23]. In addition, it established that "subjects of the electric power industry, consumers of electric energy (power) and other owners of electric energy metering devices are obliged to carry out information exchange of data obtained in the course of ensuring its commercial accounting [24].

Energy use in production chains has been thought of in terms of logistics rather than a strategic concern for the performance of the supply chain [2-9], as production systems have been constructed on the assumption of affordable and available energy inputs. Thus, the norms of the law are aimed at unification of various requirements for the presentation of a huge array of information, the standard minimum set of functions of an intelligent electricity metering system, as well as metering devices themselves, so that they can adapt to internal and external conditions; network companies must choose and install electricity metering devices themselves and determine a minimum set of functions of intelligent electric energy metering systems; in case of failure to provide access to the minimum set of functions provided by smart systems of accounting for electric energy, a subject of electric power industry or a consumer of electric energy has the right to demand the payment of a fine [23].

The fulfillment of these requirements should ensure that intelligent electric energy metering systems will cover the majority of consumers with their services and allow the expansion of telemetry and telecontrol systems. In addition, by 2023, the total number of IoT / M2M smart devices connected to the network will be 80 million units.

Another problem on the way of introducing blockchain technology is financial calculations, which can become more efficient using the Blockchain system.

Blockchain in general is a database in the form of a registry that is distributed between various participants in the retail market connected to the blockchain network. Records in a distributed database are formed in the form of a sequential chain of transactions, with each subsequent transaction containing a control hash (file integrity marker) of the previous one into which information is written. This principle provides a key function of the blockchain - eliminating the possibility of changing or deleting information. The invariability of data, transparency and resistance to manipulation are very important today for the retail electricity market.

It was decided to launch. In 2020, the launch of a number of pilot billing projects began [13]. The experiment started in Yekaterinburg and Kaliningrad. Now the financial model of pilot projects is being calculated. The final amount of payment for the consumer will be reduced by reducing costs. In these projects, it is supposed to implement the following areas of changes implemented on the basis of blockchain technology in the electric power industry and get the following advantages:

- Decentralization through elimination of a single control center or storage location; all network participants are directly involved in maintaining the system's operability;
- Data safety when duplication of data among participants guarantees the safety and immutability of information entered into the blockchain;
- Transaction transparency when each network member has access to the entire transaction history, right up to the very first transaction [3];
- High transaction speed due to that transactions occur directly between users, regardless of their location and without the participation of intermediaries;
- Reduction of transaction costs because in order to conduct a transaction, it is not necessary to resort to the services of intermediaries [5, 6].

It should be noted that the Unified Energy System of Russia (hereinafter referred to as the UES) covering more than a third of the country's territory, with more than 130 million people, mainly consists of a small number of large participants and, in fact, is built on principles that are the exact opposite to blockchain principles. Strong technological links already exist between major participants, and the existence of state regulation makes the system inert and inflexible.

At the same time, in Russia there are regions with isolated power supply systems, for example, the territories of the Far North and the Far East, or

regions intensified by developing decentralized sources of energy supply. The use of blockchain technologies is very promising here.

5. Conclusion

Demand side supply chains are changing; they are demand responsive, complex and interrelated and as such require flexibility in purchasing inputs and adjustments to product costings. The study showed that the variety of conditions for the implementation of Blockchain and other digital technologies requires the management of the processes of energy companies' adaptation to changes in the internal and external environment. An important factor in the success of their application is the regulatory functions of the state on the basis of the adoption of new laws and amendments to existing legislation. An important role is played by the programs for the production and installation of modern meters for accounting the expenditure of electric energy consumed by both legal entities and individuals. This problem can be dealt with using market-based mechanisms for creating competitive production with the help of government programs focused on certain volumes of new electricity meters and the organization of digital control over its implementation. It is also possible to use the foreign experience of adaptation accumulated by foreign partners and applicable in Russian conditions.

Conflict of interests

The authors confirm that the materials presented do not contain a conflict of interest.

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