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BLOCKCHAIN TECHNOLOGY APPLICATION FEATURES FOR SOLVING FEC-RELATED PROBLEMS

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Abstract

Blockchain technology applicability for solving problems of fuel and energy complex (FEC) is investigated in the article. The purpose of the article is a study of blockchain application features in technological cycle management process for a large-scale production in FEC at the nuclear waste burial stage. The following study methods were applied: projection, analysis, information consolidation and systematization, methodological tool set of Scrum, Customer journey map. This article specifies a range of questions and answers to them will help to come up with a solution of the defined problem – confirmation of theoretical feasibility of blockchain technology application to the problem of FEC waste burial; detection of challenges related to blockchain technology application for solving the defined problem; application of blockchain technology to FEC waste burial problem with assurance of information security, simplification of its processing and possibility of “clear” and unhampered control over the quality of transaction or financial operations. Detailed process flow diagram from extraction of raw materials to waste burial was drawn out; electricity generation stages and sub-processes were identified and described; advantages of blockchain technology for FEC were specified; the defined problem solution scheme was drawn out; cyber threats and protection measures for blockchain technology application for nuclear waste burial problem were specified. Achievable effects of blockchain technology adoption at the nuclear waste receiving stage: provision of transactioning security, its transparency; elimination of risks related to management of news by mass media; raise of investor interest, raise of environmental responsibility; rise in stock value of the company.

Keywords: Production cycle, technological processes, blockchain technology.

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1. Introduction

Timeliness of the topic comes from the fact that fuel and energy complex and power system of Russia under study is extensive, complex, far-flung and interconnected at the same time. Therefore, data management in such a system is extremely complicated. Since the development of this sector has potential, workable technologies are topical for it:

- application of blockchain technology in all state information systems is expected;
- FEC industry incrementally moves towards digitalization;
- many major companies have started to actively work on blockchain technology;
- blockchain can significantly increase management level, performance and security of data;
- several pilot programs involving blockchain technology were launched in oil and gas industry in the latter half of 2018 (Bovkun, 2019; Koniukhov & Oparina, 2019).

2. Problem Statement

Based on the analysis of literature sources and results of enterprise practices, one may determine that problems arise quite often at every stage and they are related to a variety of implementation process disadvantages (Andreeva & Nechaev, 2014; Granberg, Alekseev, Amosenok, Babenko, Bazhanov 2008; Petrov & Pavlenko, 2015; Shamarova, Krupenev, & Rogov, 2018; Shchadov, Koniukhov, Chemezov, & Beliaevskaia, 2015).

For the initial data analysis, we assumed that application of blockchain is expected in all state information systems; FEC industry incrementally moves towards digitalization. Many major companies have started to actively work on blockchain technology (Bolshedvorskii & Starkov 2017; Dziuba & Trofimovich, 2019; Gavrikova & Bunkovskii, 2019; Starkov & Shekhter, 2018).

The field of nuclear power industry and electricity as the product of a nuclear power plant (NPP) operation were selected for the study. It is one of our advanced industries with extensive structure that includes not only uranium mining but also nuclear icebreaking fleet, nuclear and radiation safety and much more (Baiaskalanova & Ruposov, 2018; Baiaskalanova, Naumova, & Osipova, 2018).

Its advantages are:

- huge energy intensity: 1 kilogram of uranium enriched up to 4 %, releases energy equivalent to combustion of 100 tons of bituminous coal or 60 tons of oil;
- uranium recycling: fissile material (uranium-235) in nuclear fuel does not burn out entirely and can be reused after recovery (unlike ash and slag from fossil fuel);
- reduction of “greenhouse effect”: every year operating NPPs in Russia prevent discharge of around 210 million tons of carbon dioxide to the atmosphere;
- economic development: one employment position during construction of NPP creates more than 10 employment positions in related sectors.

Raw-material base of this industry is uranium ore used for fuel element fabrication. Then fuel elements are used for fabrication of fuel assemblies – nuclear reactor fuel cells. The main uranium mining region in Russia is the Transbaikal krai. According to official data of Rosatom Company, uranium resource in Russia was 523.9 thousand tons as of 2017. As is evident from the specified data, Russia has a

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lot of uranium. Consequently, product composition, as a result of nuclear power industry, depends on electricity generation life cycle stage.

The following is incidental to the selected industry and product:

- most of NPPs are situated in European part of Russia and gross installed capacity of all power units is 30.25 GW;
- all NPPs operate in the Unified Energy System, 30% of power consumption in Russia is covered by electric-power generation of NPPs;
- it is impossible to name specific nuclear power consumers in the Unified Energy System.

Process flow diagram includes uranium ore mining, uranium enrichment, fuel manufacturing, electricity generation and delivery to the consumer, spent fuel decay in the pools and its reprocessing, nuclear waste burial.

Life cycle stages: designing, engineering, construction of NPP, electricity generation at NPP, service and maintenance of equipment at NPP.

Let us focus on “Nuclear waste burial” stage and define a problem that recently was raised by several mass media and environmental organizations again: delivery of spent nuclear fuel to Russia. The Russian Federation reprocesses 5 million tons of radioactive waste every year; three of them are being buried in repositories (Dykusova & Kravets, 2017; Koniukhov & Kaimonova, 2017; Koniukhov, Galiaudinov, & Bugushkinova, 2019; Kuklina & Galtaeva, 2018). The problem is as follows:

- delivery of uranium enrichment rejects to Russia raises questions concerning material safety, integrity of waste package and area of further storage;
- Russian branch of Greenpeace had stated that import of uranium tailings to Russia is illegal and that eventually the costs associated with this import may be shoved onto Russian taxpayers;
- annual business reports of Rostechnadzor (as of 2004, 2006–2011) mention risks of package seal failure when uranium tailings are stored outdoor at enterprises in Angarsk, Seversk, Novouralsk and Zelenogorsk;
- these factors can damage reputation of a company and decrease stock value, scare away new investors and disappoint old ones.

The abovementioned factors can damage reputation of a company and decrease stock value, scare away new investors and disappoint old ones.

3. Research Questions

- Can we confirm theoretical applicability of blockchain technology to waste burial problem of Fuel and Energy Complex?
- Can we identify challenges associated with blockchain technology application for the solution of the defined problem?
- Can the application of blockchain technology to waste burial problem of FEC ensure information security, simplify its processing and allow for “clear” and unhampered control over the quality of transaction or financial operations?

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4. Purpose of the Study

The purpose of this article is a study of blockchain application features in technological cycle management process for a large-scale production in FEC.

In order to achieve the purpose in hand, the following objectives were set and addressed in this article:

- definition of applicability of blockchain technology as part of FEC project technological process management;
- statement of a problem associated with application of this technology;
- setting a purpose of the study and objectives;
- description of applied study methods and methodological tool set;
- description of obtained results of the study through the example of waste burial problem in FEC;
- concluding observations on blockchain technology application for solving problems of FEC.

5. Research Methods

The following study methods were applied: projection, analysis, information consolidation and systematization, methodological tool set of Scrum, Customer journey map.

Projection method was useful for the study of steady-state phenomena and processes developed in the past and arising in the present as well as their projection on the future.

Analysis method made it possible to divide capabilities of FEC technological process management systems, and identify their advantages and disadvantages.

Consolidation method is based on selection and registration of invariable technological process management system features. As a result of consolidation, the most important blockchain technology features were selected from the authors' point of view. The selection was based on the requirements of a large-scale production to technological process management.

Systematization method is based on development of a unified system of blockchain technology features.

Scrum method provided a development framework that can be used for resolution of emerging problems.

Customer journey map tool set allowed to conduct data analysis and ensured visualization.

6. Findings

In order to answer the raised question, a detailed process flow diagram was drawn out – from extraction of raw materials to waste burial. We distinguish six milestones (uranium ore mining; uranium enrichment; fuel manufacturing; electricity generation; spent fuel decay; nuclear waste burial), one inch stone (service and maintenance of NPP equipment) and two derived stages (electric power transmission and sale). As part of the study, electricity generation stages and sub-processes were identified and described.

First stage – uranium ore mining. Underground ore mining: leaching runs through ore deposit and then uranium-bearing solution is pumped to the surface, uranium is decontaminated and converted. Sub-

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processes: leaching pumping over; pumping of uranium-bearing solution to the surface; decontamination; uranium conversion; figures: 1 kg of uranium 235 = 2,900 tons of coal; 1.5 thousand of uranium concentrate per year is a reserve for 50 years.

Second stage – uranium enrichment. Enrichment technology – gas centrifuge. Sub-processes: gas centrifuge enrichment; extraction of enriched and depleted uranium from centrifuge; mixing operation: plutonium dioxide; plutonium and uranium carbide; various metal alloys.

Third stage – fuel manufacturing. Gas centrifuge manufacturing, fuel fabrication. Sub-processes: fuel fabrication; fuel assembly fabrication; production of components for fuel assemblies.

Fourth stage – electricity generation. 10 operating NPPs in Russia. Technology based on the operation of fast-neutron reactors, light water-cooled and moderated reactors, uranium-graphite channel-type reactors. Sub-processes: fission reaction, heat generation; conversion of coolant into steam; steam supply to turbine blades; rotation of turbine; rotation of power generator; electric current production.

Fifth stage - spent fuel decay in the pools and its reprocessing. High technology process aimed at minimization of spent nuclear fuel radiation hazard, recovery of unused components, extraction of useful materials and their further use.

Sixth stage – nuclear waste burial. Shallow disposal technology. Sub-processes: pretreatment; conditioning, treatment: separation of non-conform waste; burial.

Seventh stage – electric power transmission. Three-phase alternating current with a frequency of 50Hz is used for electric power transmission and distribution, distant electric power transmission is provided by power transmission lines under high voltage (up to 500 kV and higher).

Eighth stage – electricity sale at the Wholesale Electricity Market (WEM). All electricity generated at NPP is sold at the WEM. Ultimate customer – sales organizations

Ninth stage – service and maintenance of NPP equipment. Startup and commissioning, commissioning tests for new nuclear power plant units and training of operating personnel for operating nuclear power units and units under construction in Russia and abroad.

Blockchain technology advantages for FEC are defined as follows:

- Distributed storage. Any information on a network is stored on a server. In other words, any financial data, rights to property and personal information are in a certain place. A malevolent person may edit the data by expending some efforts.
- Direct dealings. Safe financial transfer via blockchain is possible without the involvement of banks and notarization of documents is not required.
- Security. When it comes to blockchain, the data are stored on a network of interconnected devices dotted around the world. Therefore, if a third party wants to obtain the data, it will have to hack into all devices in the network.
- Publicity. Public access to the entire base. It may be viewed by any network user.

Therefore, it is assumed that application of this technology may significantly increase management level, efficiency and ensure data security.

Solution procedure for the defined problem is further described. The backbone of the solution is formation of a smart contract between a waste supplier (e.g. Urenco) and Rosatom with the involvement of Greenpeace, Rostechnadzor and other organizations in it, then climate campaigners and the general

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public will be able to receive trustworthy information and publish it. That will increase the company's credibility and improve its image.

Then cyber threats to application of blockchain technology for spent nuclear fuel burial problem were identified. Blockchain leaves a little space for separate data storage inside encrypted transactions in the log. The Analyst of Kaspersky Laboratory, Vitalii Kamliuk, and his colleagues from Interpol have found that this feature creates a number of problems. For example, a malicious user may embed a malicious code into a constant record in blockchain, whereas methods of malicious code removal from a blockchain record are unknown.

Potential attack parties: competitive companies in the field of peaceful nuclear development, climate campaigners trying to put a stop to nuclear power industry. Potential consequences of the attack: decrease in value of the company's shares; financial and information leaks and big losses as a result. Potential attack surfaces: Sybil attack and DoS attack. Sybil attack is an attack wherein a malicious user creates a large number of network nodes under its control in a network and tries to "besiege" the victim's node, i.e. to take over all adjacent network nodes. DoS attack is an attack wherein a malicious user hacks into a large number of computers and creates a base for "denial of service" type of distributed network attacks.

Finally, cyber security measures against the abovementioned cyber threats were defined in the study. Thus, the main way of protection against Sybil attack is to make the attack more expensive. The number of full nodes under control of the malicious users depends on actual number of full nodes in the network, which means that in order to make the attack more expensive it is required to increase the number of full nodes. There are two ways of increasing the number of full nodes: to create a direct financial interest of full node deployment for the users and to organize full node deployment by efforts of organizations. Countermeasures against DoS attacks can be passive and active as well as preventive and reactionary.

7. Conclusion

The key idea of available solution comes from the defined problem and its unique character will show itself in the achieved effects: adoption of blockchain technology (conclusion of smart contracts) at the stage of nuclear waste receipt will ensure transactioning security and its transparency. Consequently, it will be possible to eliminate risks associated with management of news by mass media, to increase interest of investors, to increase the extent of environmental accountability, and the company's stock value will increase as a result.

But in order to achieve these effects, problems associated with blockchain technology application should be resolved:

- need for creation of hybrid blockchains;
- regulatory and process constraints;
- professional competence of blockchain developers;

- blockchain technology application should be limited to the industry life cycle.

As a result, the answers to the questions defined above were obtained in this study:

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- theoretical applicability of blockchain technology to waste burial problem of Fuel and Energy Complex was confirmed;
- the challenges associated with blockchain technology application were identified, including in particular imposition of regulatory and process constraints, influence of professional competence of blockchain developers on the quality of problem solving;
- it was confirmed that the application of blockchain technology to waste burial problem of FEC ensures information security, simplification of its processing and "clear" and unhampered control over the quality of transaction or financial operations.

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