

# The impact of innovative technologies on consumers in the power supply market

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**Abstract.** Service of supplying electricity to consumers in the Russian Federation (RF) is carried out based on power supply contract. Utilization of innovative technologies will allow to change the power supply service in the power-supply market. There is an opportunity to create unique power-supplying market approach. With implementation of “Smart meters” technology and Blockchains with “Smart Contract” functionality. The article describes innovative technologies and examines examples of their successful implementation in foreign countries. Article will also talk about tools that are required to replace old service with a new power supply system, based on innovative technologies that include small-scale renewable energy generation.

## 1 Introduction

Currently, providing power to consumers in the Russian Federation is only possible based on a power supply contract. According to Art. 539 of the Civil Code of the Russian Federation, part 2, power supply contract is an agreement according to which power supply organization takes the responsibility to supply energy (power) to the subscriber (consumer) through the electric grid, and the subscriber takes the responsibility to pay for the received (used) power. Consumer is also required to follow the consumption rate stipulated by the agreement, to ensure the safe operation of the energy networks under its jurisdiction and the serviceability of the used instruments and equipment that consume energy [1].

Countries around the globe lean towards implementing innovative technologies to use in the energy(power-supply) sector. The development of such innovations began with the strategic initiative SmartGrid, announced by US President George W. Bush Senior, and is followed by integration of innovative technologies such as “Blockchain” or distributed registry technology, “Smart Contract”, cryptocurrency (Bitcoin, Ethereum, Litecoin, etc.), multi-agent systems.

In this article we are going to discover how innovative technologies are going to influence Russian power supply market for the consumers.

## 2 Materials and methods

Based on the international experience [2-10] and synthesis of different instruments the extrapolation modelling of electrical energy generation and selling with the help of innovative technologies was done. The analysis of the current technologies and best practices allowed to find the optimal way to implement innovative

technologies in the power supply market in Russian Federation.

## 3 Results

### 3.1 Innovative technologies and their successful implementation

#### 3.1.1 «Blockchain»

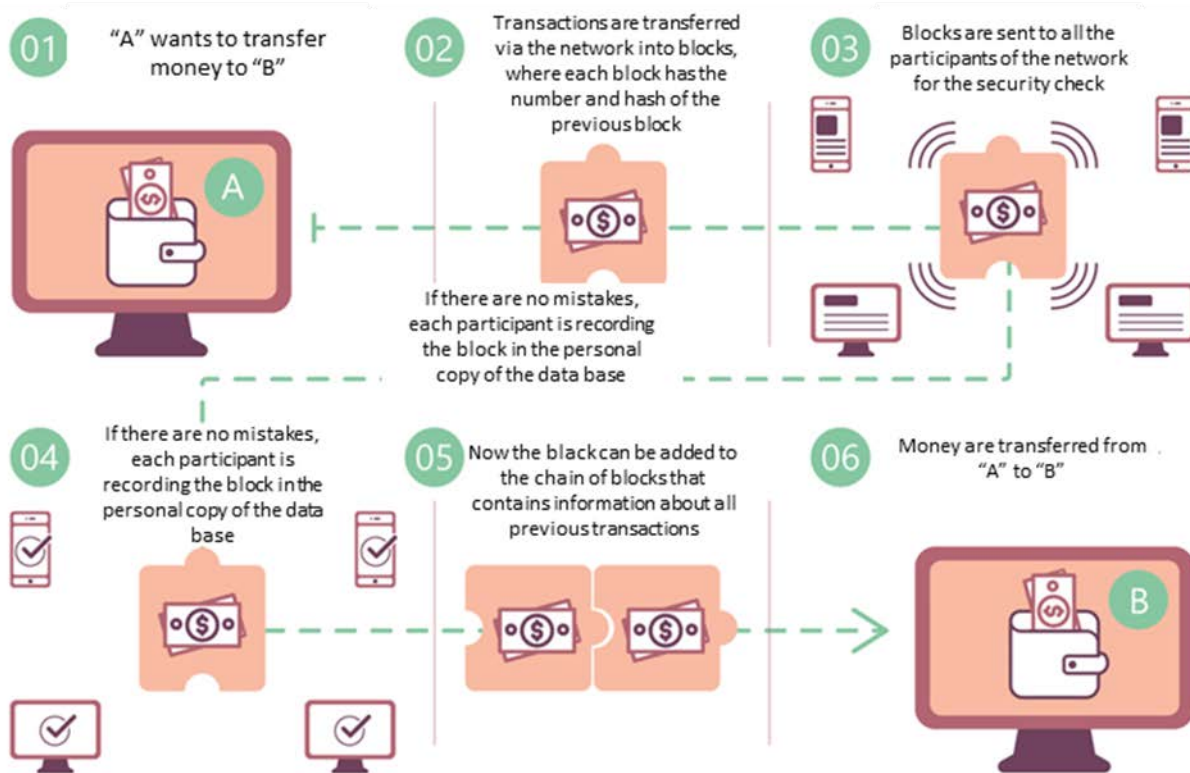
«Blockchain» or the distributed registry technology is the distributed and automounts database that allows storing data about all transactions in non-centralized way.

Blockchain – is a type of database that allows user (in Peer-to-Peer network) to connect with another user without using 3<sup>rd</sup> party and middleware. It also allows said user to charge another user for any services (ex. Power-supply). Connections (transactions) are various actions dealing with transferring money from one account to another. Information about these transactions is stored in the decentralized global network. This network connects devices of transactional sender, receiver and other users of the network.

In Blockchain, there is no need in middleman - banks or power-supplying company are no longer required, this is due to fact that every member of the chain acts as the link between the user and the provider, they verify the transaction and store information about it locally on their computers; metadata about the transaction is stored in the decentralized global network. When initiating the transactions, the involved parties determine variables such as receiver, sender and the amount.

Fig. 1 Displays example of Blockchain technology and interact money transfers.

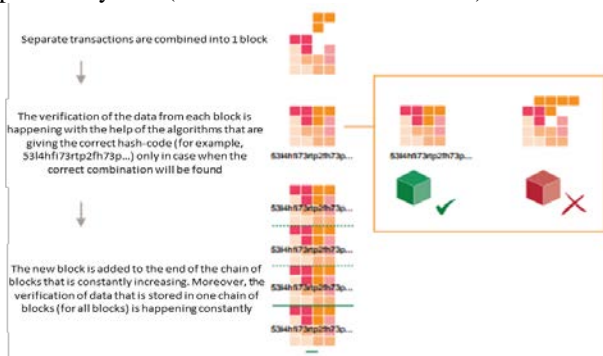
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**Fig. 1.** Blockchain example [11].

Pros of Blockchain technology [12]:

1. any change in the registry is automatically reflected in a few minutes or even seconds in a distributed registry;
2. information cannot be deleted, copied or somehow used by others, making the technology safe and reliable;
3. reliability and security of data stored in the registry is carried out on the basis of verification of the transaction by all network participants (users). In fig. 2 [13] the verification process is described in details.
4. there is no admin or superuser who controls the database, everyone involved has equal rights
5. there is no 'hard limit' to the database size, it can store unlimited number of transactions
6. storing and using the information is practically free (no additional costs involved).



**Fig. 2.** Transaction verification process [13].

### 3.1.2 Cryptocurrency

Cryptocurrency – is a digital asset designed to work as a medium of exchange in the Blockchain technology. Market is full of various cryptocurrencies, most well known are Bitcoin, Ethereum and Litecoin. The best example of the application of the Blockchain technology is Bitcoin, a cryptocurrency launched in 2009 by Satoshi Nakamoto. It is based on the Blockchain technology and protocol that the Bitcoin cryptocurrency was developed.

Cryptocurrency has the following advantages [14]:

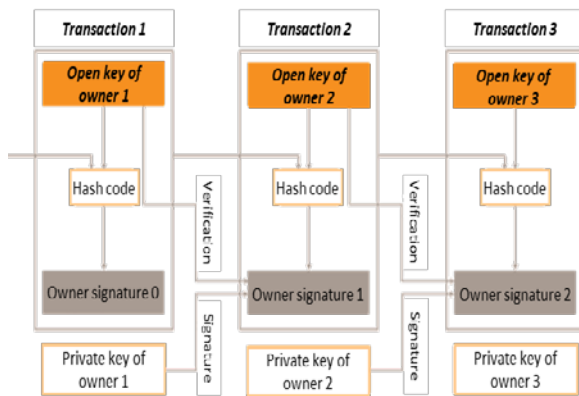
1. Can be stored on any computer, smartphone or online wallet.
2. No intermediaries while making payments.
3. No centralized (overseeing) organization that determines the exchange rate – based on market of supply and demand.
4. Can be liquidated for 'real' money.
5. Can be acquired (purchased) using real money, products or services
6. Possibility of earning as rewards for mining - users provide their computing resources to verify addresses and record transactions in the registry
7. User-based login (not anonymous) to send, receive and record Bitcoin transactions, bitcoin addresses are used - alphanumeric strings 27–32 characters long, no personal identification information required.

### 3.1.3 Completing a transaction

Fig. 3 shows a transaction example between two parties in a peer-to-peer network, note that no intermediary is

required. As mentioned above, this transaction requires a bitcoin address to be completed. Blockchain technology uses a blockchain address. The blockchain address consists of a public and private key. The public key is used to view the user's transactional history, where private key is used to access the account and to complete the transaction.

As you can see on Fig. 3, User 1 is sending one bitcoin to the second user using the digital signature through the hash code of the previous transaction and the public key of the next recipient (digital signature). After, the transaction is added to the Blockchain. The receiving end (be that information or payment) – second user, can verify the chain of users by checking the digital signatures with the open key of the first user, that key is stored in the chain of 'blocks' and has open access. They, however, can't check if this bitcoin was already used by the previous owner before the current transaction (double usage). Double usage can be checked by using the verification process [13].



**Fig. 3.** Transaction between peer-to-peer network [13].

### 3.1.4 "Smart Contract"

Smart Contract allows to create and maintain commercial contracts in blockchain infrastructure. "Smart Contract" was developed using blockchain technology and allows transactions to be automated using predetermined conditions, as well as selecting potential counterparties to complete the transaction.

"Smart Contract" has the following advantages [15]:

1. Independent – binding contract is created without intermediary.
2. Secure – Contracts and their details are stored in the decentralized network.
3. Reliable – Contracts have duplicates in the blockchain.
4. Economy – no intermediary fee.
5. Accuracy – no need to fill out the documents/contracts by hand.

### 3.1.5 Multiagent systems

Old programming methods and approaches often turn out to be ineffective when it comes to complex systems that must quickly adapt to change and be able to find the

optimal solution taking into account a variety of factors. If traditional approaches do not work, intelligent system solutions based on multi-agent technologies (multi-agent systems) come to the rescue.

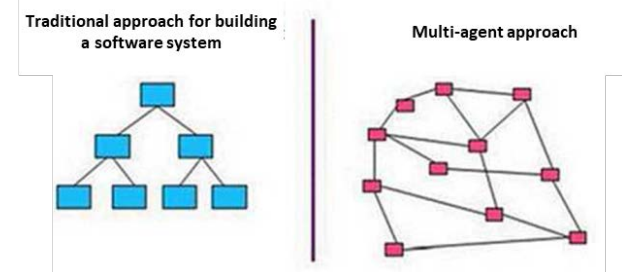
Multi-agent technology is a tool used to perform various tasks and allows you to coordinate various independent processes.

Multi-agent technologies can solve problems that are characterized by frequent and unpredictable changes; complex dependencies between elements. Unlike traditional systems in which the solution is found using centralized, sequential, and deterministic algorithms, in multi-agent systems, the solution is achieved as a result of the distributed interaction of many agents — stand-alone software objects aiming to find the optimal and most relevant solution for every moment of time [16]. The agent acts in such a way that it is possible to achieve the best result or, in the face of uncertainty, the best expected (predictable) result.

You can't call (invoke) an agent, you can only ask it to perform a task, it can refuse or accept your 'task', this is due to the fact that it might have other obligations to other software, another person or user; thus in these conditions, in order to complete your task, it must renegotiate with other agents. The transition from centralized, hierarchically sequential programs to a community of small programs: autonomous, capable of perceiving information, making decisions, communicating with their own kind, will create a self-organizing system for any type of activity.

Thus, firstly, services use pre-determined algorithms, unlike agents that work in conditions of incomplete information and therefore use 'intuition'. Secondly, there is a managing entity for the services that coordinates their work, but there is no such thing for agents - they operate completely independently. Thirdly, each service has a clear purpose, which is untrue for the agent simply because it can perform any tasks, utilizing its' self-organization and self-training [16].

Fig. 4 shows the difference between the traditional approach for building a software system and the multi-agent approach.



**Fig. 4.** difference between the traditional approach for building a software system and the multi-agent approach. [17].

### 3.1.6 An example of successful implementation of innovative technologies

The very first country to test innovative technologies in the energy (power) sector is considered to be the United States. Their project is called Brooklyn Microgrid.

The goal of the project is to test how the Blockchain technology can be used to conduct sales of electricity from solar panels directly (no intermediary) between neighbors.

This project is currently being implemented in the USA by TransActiveGrid. This RES-based microgrid is equipped with an energy storage system that uses rechargeable batteries. It allows 130 households, both using and not using photovoltaic(solar) panels, to trade electricity with their neighbors

The first transactions at Brooklyn Microgrid were carried out in April 2016. A similar prototype of a decentralized system was launched in the Netherlands by Oneup (formerly BigDataCompany).

Fig. 5 shows how the project looks like in reality. Solar Renewable Producers - produce electricity through solar energy, and Potential Neighbor Consumers - potential consumers of electricity.



Fig. 5. Brooklyn Microgrid [18].

### 3.2 Issues within the power industry of the Russian Federation and their solutions using innovative technologies

The implementation of innovative technologies will provide a solution to problems in the power supply industry [19]. In table 1, there are several addressed problems in the power industry and how innovative technologies will solve them.

Table 1. Problems in the power supply industry

Issue / Problem	Definition	Solution
1. Lack of alternative methods of power supply	Power supply is possible only on the basis of a power supply contract	The consumer will be able to conclude a contract for the purchase of electricity with any member of the network that can act a producer/provider of electricity
2. Consumers are limited in their choice of electricity supplier (power supplier)	It is only possible to sign power supply contract with a power-supplying company (organization)	
3. Workload of power-supplying organizations (wait time)	Excessive time required for processing an application for power supply (30 days)	Network participants (users) will independently conclude their contract and establish the terms (price, quantity, etc.)
4. The fragmentation of the electricity rates	Each of the 85 regions in the Russian Federation has its	

	own electricity charge rate.	
5. Inability to provide power to remote and sparsely populated areas	The territories are isolated from centralized power supply network and have weak transport links with energy hubs.	Providing power utilizing renewable energy sources (RES) and microgrids

### 3.3 The idea of implementing a new power supply system and the required for it tools

Authors came up with the idea of implementing a new power supply system where electricity will be produced at small, distributed generation facilities (usually based on renewable energy sources - RES). RES includes such energy sources as solar energy, wind energy, etc. Electricity produced at small distributed generation facilities will be supplied to consumers via microgrids. This RES-based microgrid is equipped with an energy storage system using rechargeable batteries.

The consumer can also establish his own renewable energy sources in his house and act as a producer of electricity, thus being able to sell it to his neighbors through the "Blockchain".

When using RES the very important element of the electric system is the express control [20]. This allows to reduce the negative effects on the environment.

Of course, the fact that RES will be introduced in such a large number does not necessary mean that the traditional power industry (TPPs, nuclear power plants, etc.) will be taken out of operation. They will also be able to produce electricity and sell it directly to consumers through Blockchain.

The contract for the purchase and sale of electricity will be concluded with the use of innovative technologies. In order for the system to work, the simultaneous use of the Smart Meters technology and the installation of the Blockchain software with the integrated Smart Contracts technology are required.

Each building (apartment) will be equipped with "smart meter", which will be connected to a computer. Smart meters will record the amount of electricity produced and consumed.

This computer will be configured with a "smart contract", which will check whether the consumer will be able to sell electricity to another consumer (if he is willing to act as a producer of electricity) in the required volume or whether he himself needs electricity. If the consumer does not have enough electricity, he will be offered a list of possible suppliers. A "smart contract" will provide an automated contracting mode for transactions (contracts) and a decentralized distribution of energy. A "smart contract" will automatically record the amount of electricity consumed and each consumer will be able to track the amount of electricity consumed by them (for example, 0.5 hours). They will also allow consumers to independently set the price, quantity, quality of provided electricity and other parameters that are desirable for them. "Smart contracts" will conduct

and reflect transactions (contracts) in an automatic and secure mode. All data on concluded transactions (contracts) will be stored in the “Blockchain”.

The transition to a decentralized distribution of energy will allow the consumer to purchase electricity from a supplier directly without an intermediary - power supplying organization.

It will be possible to pay for electricity using both real currency and cryptocurrencies

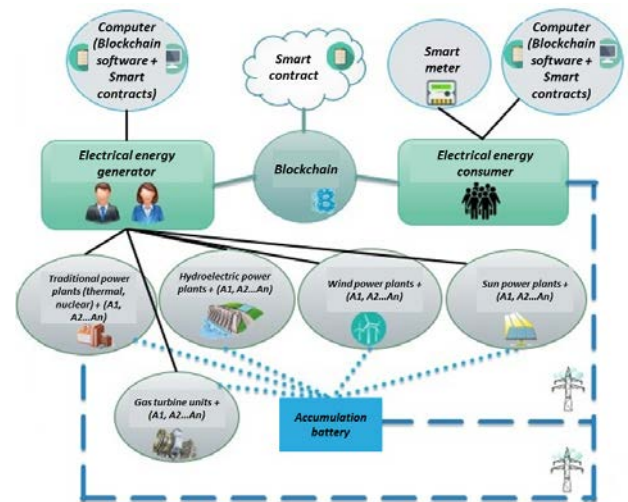
Multi-agent technologies will control the conditions of electricity consumption. Currently all power plants are controlled by a human. But a single human cannot operate with thousands of factors in the face of uncertainty, while ensuring that the schedules for power supply are met and met at minimal cost; not only that, but to be able to make the right decision in a given situation (for example, in case of an accident at the plant) . In these cases, one should not make the optimal (predetermined) decision, but to come up with the best decision at the given moment, taking into account all risk factors. After all, the main goal for any and all power supplying organizations is to maximize their profits.

Multi-agent technologies will allow to quickly adapt to changing situations and find the optimal solution, taking into account a variety of factors. The system will become self-organizing, able to perceive information, make decisions and communicate with other agents in the system. Agents will interact with each other and resolve emerging conflicts. If a problem or some kind of conflict arises between the agents, it will be resolved not by the standard method of enumerating the options, but by resolving the conflicts between the individual programs (nodes). Each program will work on the basis of the rules laid down in advance.

Agents will be used both in traditional energy production and for renewable energy sources. They will be used for production and supply of electricity, to help account for losses, they will monitor the state of microgrids and equipment depreciation and so much more. They will constantly exchange information with each other and will work in parallel. Agents will aim to maximize profits from the production of electricity, while using the best way to achieve the main goal. Agents are able to take part on the operational activities of any site and are able to solve any situation by choosing the best solution to the situation within a few seconds, as well as negotiate with other agents autonomously without human intervention.

This system will allow consumers of the electricity to become more active and independently optimize their own schedule for loading their capacities in order to minimize the cost of electricity and to generate income from the sales of energy.

Fig. 6 Shows a way of implementing a power supply system for consumers using innovative technologies.



**Fig. 6.** Production and potential sale of electricity after market transformation using innovative technologies.

## 4 Discussion

Successful implementation of innovative technologies will allow:

1. The system becomes flexible, transparent and secure;
2. Reduce the loss of electrical energy in networks;
3. To conduct the sale of electricity directly (no intermediary);
4. To provide energy supply to remote and sparsely populated territories (for example, the territory of the Far North);
5. Reduce electricity bills;
6. Increase the number of suppliers (providers) of electric energy;
7. Create an alternative to the energy supply agreement (contract);
8. Reduce the difficulty of concluding an energy supply agreement;
9. Improve energy efficiency and network security;
10. Increase the reliability of energy infrastructure;
11. Change the structure of the labor market increasing the payout for labor;
12. Open doors for innovation in power supply industry and/or others.

The introduction of innovative technologies will undoubtedly transform the electricity (power supply) market both inside and out. Innovative technologies are attracting more attention, so their usage in the energy sector, as practice shows in foreign countries, is real and effective. Since 2018, the first steps have been taken in the Russian Federation to transform the electricity market [21]. And this first step was the replacement of old electricity meters with smart electricity meters (“smart meters”). This step is proving that the transformation of the electricity market is already

happening. So, it's only the question of time when innovative technologies will be applied in the isolated energy systems with small distributed generation facilities on the RES basis in the Russian Federation.

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