World practice and Russian experience of housing and utilities sector digitization

Irina Drozdova[1*], and *Aleksandr* Petrov[1]

[1] Saint Petersburg State University of Architecture and Civil Engineering, Faculty of economics and management, 190005 2-ya Krasnoarmeiskaya st. 4, Russian Federation

Abstract. The housing and utilities infrastructure is a socially significant branch of economy for life support of population and satisfactory of their demands for adequate housing and utilities services. Implementation of digital technologies in the housing and utilities infrastructure is justified under the program "Digital economy of the Russian Federation" and the concept "Russian smart cities". It was found out that using the technology of Internet of Things in the housing and utilities infrastructure allows to increase efficiency of business-process, reduce costs for maintenance and operation of housing facilities, and to optimize the payment system of the housing and utilities services. It is established that the driver for development of housing and utilities infrastructure digitization shall be implementation of intelligent devices for metering all types of resources and power consumption in dwelling houses which will be gradually unified in the intelligence system of settlement for recourses consumption based on SIM-cards.

1 Introduction

In conditions of globalization of international economics and social transformation of population which provide for transfer to the forth industrial revolution (Industry 4.0), paradigm shift of its economic development based on digitization of economy and society, blockchain technology, Internet of Things (IoT) market development become actual for Russia.

In terms of technology, the digital economy is defined by four trends: mobile technologies, business analytics, cloud computing and social media; globally – social networks.

According to the McKinsey's report "Digital Russia: new reality" in terms of a number of Internet users, in 2016 Russia took the first place in Europe and the sixth one in the world (87 million people). According to data of Rosstat, in the period from 2010 to 2016, a number of households in Russia with access to the Internet increased from 48.4% to 74.8% [1]. In this case, Russia takes second place by the lowest prices for the Internet and mobile communications in the world. According to the World Bank, an increase in a number of high-speed Internet users by 10% increases the annual GDP growth from 0.4 to 1.4% [1].

* Corresponding author: drozdova@lan.spbgasu.ru

Currently, a share of the digital economy in the GDP of economically developed countries averages 7% (the highest indicator in Great Britain is 12%), in Russia – 2.8% [1].

According to forecasts, 65-70% of the world population (about 6.4 billion people) will live in cities by 2045. Mass migration to cities will have a significant impact on city transport systems, food and water supply, energy infrastructure, sanitation and public safety.

Information and communication technologies promote the growth of "smart cities" using digital technologies to improve the efficiency and sustainability of urban centers.

2 Current state of the sector

Housing and utilities infrastructure (HUI) is one of the largest fields of Russian economics which establish an economy development and social well-being of country population. The main purpose of the housing and utilities infrastructure is stable and qualitative provision of population with housing and utilities services required for life activity of each citizen. The share of the domestic housing and utilities complex is about 6% of GDP, more than 30 thousand enterprises operate in the industry, a total number of personnel exceeds 2 million people [2].

Housing and utilities infrastructure is one of the most important areas where, according to experts, the digital transformation of the Russian economy is to begin.

The process of housing and utilities infrastructure digitalization began with the creation and implementation of the state information system (GIS GKH) in 2016 as information storage on all housing and utilities enterprises within the Russian Federation. Its activities are regulated by the Federal Law No. 209-FZ dated July 21, 2014 "On the state information system of housing and utilities infrastructure". The system contains the information on public utility services, performed works, communication systems, housing facilities stock, etc. The service providers shall publish the reports on their activities in the SIS of the housing and utilities infrastructure, data on tariffs for residential rental payment, list of debtors for public utility services, etc. Consumers of housing and utilities services can monitor the quality and scope of performed operations and provided services, monitor the costs of their Condominium Partnerships, send complaints and appeals to housing supervisors, resource providers, homeowners' association, Condominium Partnership, and hold residents' meeting in electronic form on a real-time basis.

Thus, SIS of housing and utilities infrastructure is a strategic infrastructure project that allows optimizing the interaction between authorities, citizens and organizations providing housing and utilities services.

Currently, 74 thousand organizations of the housing and utilities infrastructure are registered in the system including 75% of Condominium Partnerships (TSZh), 88% of utility providers, 100% of homeowners' association and state housing inspectorates, the information on 0.5 billion payment for housing and utilities services, 33 million personal accounts of citizens, 10.8 million homes have published. 1945 IT systems are integrated with the SIS of housing and utilities infrastructure including more than 500 banking solutions to make on-line payments [1].

Automation of business processes in housing and utilities infrastructure is based on the use of Internet technologies, in particular, a comprehensive billing system is developed for the housing and utilities infrastructure and cloud computing SaaS-platform energy. Utilities providers, homeowners' association of housing and utilities infrastructure, and united information-computing center use the system "On-line Billing". The platform is based on a comprehensive functionality for charging housing and utilities infrastructure for individuals and legal entities, recalculations taking into account the communal consumption, distribution of payments for services and suppliers. The SIS of the housing and utilities

infrastructure and services "Subscriber Profile" are integrated with the billing system, which allow monitoring tariffs and rates, looking through calculations for rent, controlling own utility payments, keeping records of meter readings, printing copies of receipts for payment of housing and utilities services, making payments for services using a bank card (Internet-acquiring).

One of the smart technologies used in the housing and utilities infrastructure based on the modern IT solutions is the blockchain [3, 4, 5]. This is a database built based on complex mathematical calculations with cryptographic protection of the information transmitted in the chain. In this case, the blockchain technology can ensure full transparency of payments in the housing and utilities infrastructure featuring low payment discipline and a chain of intermediaries between the population and resource providers. Blockchain technology implementation allows the resource provider to track payment for the utility service of each consumer at any time. This will exclude the possibility for concealment and misuse of collected funds by an unscrupulous intermediary.

The transition to intellectual commercial accounting with the use of the blockchain technology also limits the losses of electric and heat energy in the networks, which are 30% according to the Ministry of Energy of the Russian Federation. The blockchain technology will allow managing the energy system, entering into smart contracts and conducting financial calculations, however, the technology itself is only functional if there are smart revenue metering devices (SRM) integrated via the Internet and allowing the use of real-time information. According to the iKS-Consulting study, in early 2017 the total number of apartments in Russia was 65.2 million, and the number of houses – 3.7 million. The total indicator of households' probability with conventional hour meters in Russia is about 99%. The total potential of the smart meters market within Russia in the segment of private utility power and water consumption is more than 206 million smart meters according to the analysts' estimation data. According to the estimates of the Ministry of Energy, installation of smart hour meters throughout the Russian Federation will cost about 400 billion rubles [1].

It should be noted that the blockchain technology has only just begun to spread in the electric power industry of the economically developed countries. Currently, there are two scenarios for the blockchain technology in the electric power industry. The first allows small power producers, utilities and users themselves to sell electricity surplus. The second scenario involves the use of tokens for electricity payment. Smart contracts also provide new opportunities for all market participants. Thanks to the blockchain technology an "Electricity Internet" is formed that helps to save and changes the approach to power production.

The Russian venture company together with the scientists of the Ural Federal University (UFU) developed the startup accelerator GenerationS as a blockchain-platform. The platform records data by volumes of power production and consumption and provides automatic invoices. Using this technology, consumers will be able to make automatic payment for electricity that will avoid filling up paper receipts and on-line forms manually. In addition, the need for payment service providers will be excluded.

Currently, the technologies based on the Internet of things (IoT) are actively introduced in the housing and utilities infrastructure. This is commercial accounting with remote data collection from individual meters, and electronic schemes for waste handling, etc. One of the most popular and actual fields of the Internet of things ("smart house"), directly relates to buildings erection and operation. An important aspect is the prospect of integrating SIS of housing utilities infrastructure with existing IoT technologies.

The Internet of things is popular among breakthrough technologies that can change the business model of companies and entire industries, and advances, for example, artificial intelligence, robotics, virtual and augmented reality, blockchain. The Internet of things has

a number of important advantages including readiness for direct implementation and scale of application.

The Internet of things represents a system of integrated computer networks and connected physical objects with built-in sensors and software for data collection and exchange with the possibility of remote control and control without human participation. According to various estimates, a number of connected meters will be within the range of 20 to 50 billion by 2020 [6, 7].

The successful examples of the Internet of things introduction based on the initiative of both the state and business are known in the foreign practice. In the EU countries, South Korea, China and India, the smart city technologies are introduced that improve the management of power consumption and transport flows. The UK and the USA have implemented the large-scale programs to introduce "smart meters" for remote monitoring of power consumption in households [3].

The concept for development of 50 smart cities of Russia is implemented in Russia based on the integration of information and communication technologies and the Internet of things, the priority fields of which are transport, housing and utilities infrastructure, energy, industry and E-government.

The technologies based on the Internet of things are already beginning to be massively implemented in the Russian megacities (Moscow, Saint Petersburg), improving the management of the transport system, urban infrastructure and housing and utilities infrastructure facilities.

Streetlights equipment with motion sensors allows to automatically turning on and off lighting of streets and local areas. The dimming technology allows you to adjust lighting brightness depending on the day time and weather conditions. "Smart lighting" is also used in the entrance halls. The street lighting management has already been centralized in Moscow, but motion sensors and dimming technologies are implemented in the framework of isolated projects. In addition, the integrated information and control system of outdoor lighting (IICSOL) provides automation of the entire life cycle of outdoor lighting facilities. The system is designed to store information about accidents, work plans, repairs, maintenance and planned construction. The controlled lighting in the entrance halls is implemented in accordance with the initiative of citizens.

The monitoring of garbage cans filling capacity allows optimizing the graphs of garbage disposal: the garbage truck approaches when the containers are filled. As well as the technologies have been developed which allow delivering garbage from containers to garbage disposal points by pneumatic pipes. To dispose garbage, two technologies have been developed: cans filling capacity tracking and disposal after they are filled and analyzing the data by the weight of the garbage disposed in vehicles to provide subsequent building a model that optimizes the export schedules.

The sensors installed on the communal engineering, with which the streets are cleaned, allow real-time monitoring of movement route and speed, fuel consumption and operation mode, ensuring control over task performance by drivers.

Monitoring for the condition of electric networks and water pipes allows to avoid emergency situations and to pass to the maintenance according to the condition.

Pilot projects in the field of housing and utilities infrastructure are being implemented in Moscow. In particular, in the area of Lublino 16 mixed-use buildings are selected to create a "smart quarter", where the technology of "smart city": lighting, garbage collection, automated access to entrance halls and yard, smoke control, etc. will be tested.

The automated resources usage system (ARUS) in Moscow includes pressure gages which monitor the condition of pipes and help to avoid emergencies. Pilot installation of water leakage sensors in apartments and common areas (basement and apparatus floor) is planned to monitor leaks in water supply networks, as well as installation of CO2, CH4,

temperature, humidity sensors in apartments and common areas. It is expected that this will reduce the risk of fire, gas leakage and increased relative humidity as a result of roof leakage, water breakthrough in water supply or heating systems.

The Department of Information Technologies of Moscow implements the IoT technologies in the housing and utilities infrastructure, in particular, IICSOL and ARUS systems.

Since 2018, mass adoption of "smart meters" in Moscow households is planned that will allow energy suppliers to introduce flexible tariffs, for example, for peak and night hours.

All utility equipment in Moscow is equipped with devices that allow monitoring speed, route, fuel consumption and operation mode (for example, asphalt cleaning or not). As a result, fuel economy reached 4%.

3 Main world trends

Currently, the following smart systems are used for the cities management in the world and Russian practice [8].

Smart Metering. The smart metering technology of energy consumption (electricity, gas, water, heat), in addition to installing smart metering devices, involves the creation of information networks for data transmission. This solution is one of the types of intercomputer communication M2M and, therefore, blends with the IoT concept. The effect from the implementing the smart meters and their data collection networks according to experts will reduce the required amount of new power capacity by 20%. Due to the intellectualization of maintenance and technological operations, it is possible to connect more consumers to the already available facilities, to reduce losses from energy theft by 95%, and technical losses by 50%, to reduce consumer debt by 50-70% [4]. Each of these parameters is critically important for the Russian energy supply market.

Smart Home This is one of the most relevant solutions of IoT as residents have access to integrated management of the home or apartment life support systems. This smart home management allows coordinating the operation of heating and ventilation systems, security and fire alarms, video surveillance, communications and telephone, lighting, power supply, etc. It is possible to remotely control the home premises situation that prevents or significantly reduces the risk of accidents caused by water or gas leakage, electric devices connected to the mains, etc. However, the main advantage of IoT solutions in the smart home is the ability to reduce the power and heat costs. The smart home management system with gages, sensors, meters and household appliances connected to the single IoT network automatically maintains the optimal mode of power and heat consumption in the premises, informs about the left lighting, opens windows and selects the appropriate mode for switching on electrical devices based on time of day and current tariffs.

Smart Grid The energy industry is a typical example of new technologies could solve many problems of urban economy, in this case, the problems of transportation and consumption of energy resources. The Smart Grid provides on-line monitoring and managing the energy networks, as well as it implements communications between consumers and energy suppliers. Thus, it means not just smart meters and network devices – the Internet of things will connect electric car, home batteries, solar panels, thermostats and consumer electronics devices, such as TVs and air conditioners, to the Smart Grid. Constant on-line monitoring of energy consumption provides, if necessary, to direct energy flow in the opposite direction, from the consumer to the grid, and include it into accounts with the consumer. This will help to plan the power supply and consumption and to simplify the process of customer service. In the future, the principles of Smart Grid can be distributed to the networks of heat, gas and water supply, water disposal and sewerage.

Smart City The citizen needs grow: one day there was enough food, shelter and relative safety, but now, in order to make the city attractive and comfortable for people, it shall satisfy much more serious and complex requirements. The focus in urban management shifts to the good transport and utilities infrastructure, normal environmental conditions, effective security system, competent facilities operation, etc. The Internet of things makes it possible to improve the life quality. Thus, the IoT technologies will provide economical and ecological use of city systems of life support and utilities infrastructure (water supply, heating, electric power supply, lifting mechanisms, communications, etc.) by combining city services and organizations into smart distributed applications. This will allow them to interact quickly based on the modern IT both in daily work and in emergency situation.

Thus, the use of Internet of things technologies allows managing business processes in the housing and utilities infrastructure in a comprehensive, efficient and high-quality manner.

4 New vectors of development

With the implementation of the Internet of things technology in the sphere of housing and utilities infrastructure, new participants – service providers, operators of information network and systems appear which provide the necessary infrastructure support. The network or platform provider functions can be performed by the communication network operators using their infrastructure and network capabilities (data centers, call centers, communication channels and lines, access networks, etc.). This approach maintains qualitatively new requirements for automated and information systems in the housing and utilities infrastructure. The gage or sensor itself is, in fact, only a registrar of certain changes with the ability to transmit the collected information. The problem is that these data shall be correctly transmitted and meaningfully interpreted. Therefore, the mass implementation of smart meters initiates appearing new information systems with enhanced capabilities for information collecting, transmitting, processing, ensuring information security, billing and analytics of collected data. As a result, large integral systems appear in the housing and utilities sector, which provide a complete information life cycle – from the initial registration of a certain parameter change to its meaningful interpretation and making decision on the management of appliances, facility or the housing and utilities sector as a whole.

The Smart Metering subsystem is responsible for collecting, processing and storing information received from meters. It allows arranging the management of utility network elements in order to control the energy resources consumption and the dispatch services organization. The subsystem of personal services includes a set of applications implementing a number of services together with the smart metering subsystem that provide comfortable and safe living (control of smoke, leakage, unauthorized access to home, etc.).

The billing subsystem provides a full cycle of settlements for housing and utilities services including consumers accounting, energy consumption data processing, services invoicing, receipt of payments monitoring, work with debtors, etc.

Calculation of energy balances for homeowners' associations, executors, energy providers, resource providers is performed by the balance calculation subsystem that controls over unauthorized use of energy resources, losses accounting at various sections of utility networks. The monitoring and control subsystem interacts with SCADA/APCS systems of resource providers.

The subsystem of citizens' registration is used to register citizens permanently or temporarily residing within the municipal formation territory. Consumer affairs subsystem CRM performs the functions of information and reference services, registration and

processing of applications of housing and utilities services' consumers. The analytical subsystem allows to perform multi-dimensional analysis of data related to the population, housing stock and energy consumption, and to present these data in a convenient graphical form for statistical and analytical reports.

The information portal provides the consumers access to the regulatory reference and calculation information and to energy consumption statistics, receipt of invoices, energy saving expert advice, filing requests, complaints and claims, other information services related to housing and utilities infrastructure through the personal profiles. As well as other subjects of the housing and communal services sector has the access to the Internet portal for disclosing information via the Internet in accordance with the current standards and rules.

The databases are ordered set of registries, log books and regulatory and reference information about suppliers and consumers of housing and utilities services, information on the housing stock status, service agreements, services tariffs, benefits and subsidies, regulations for interaction of organizations during services rendering, The information system of public utilities is the most important functional component and source of information for SIS of the housing and utilities infrastructure.

The use of the Internet of things technologies contributes to saving resources. The foreign experience shows that water resources and power consumption can be reduced by 15-30% [3]. In Russia, the first experiments in this direction are just launched, and one example is the implementation of the Smart Grid project in Tyumen. The system measures pressure, temperature, flow and leakage in the surrounding areas of the heating network, provides dynamically to monitor failures. The system based on a comprehensive monitoring, accounting and control of data allows reducing the network operating costs and improving the operating efficiency in case of emergency. It should be noted that the project is implemented based on the domestic software developments and equipment, and is fully adapted to the conditions and standards of the Russian housing and utilities infrastructure complex. The equipment allows to quickly monitoring all changes in the heat network. This is required to eliminate leaks, problems with thermal insulation, to perform network balancing ensuring uniform heat supply to consumers that significantly saves funds of the energy providers. Currently, over 200 control points have been installed in Tyumen, information from which enters the information system. Their number will subsequently increase. It is planned to establish 4.5 thousand points to account dwelling consumption.

One of the ultimate goals of implementing such systems is differential pricing: in the course of time, each person will be able to manage his expenses for housing and utilities infrastructure, knowing where he can save. At the first stage about 30 million rubles were invested in the system, which were required to organize communication channels and purchase server equipment. The next steps may be already more expensive, but all investments in the Smart Grid system should pay off within a year.

The transition to Internet of things technologies in the housing and utilities infrastructure enters into new opportunities based on formation of the single information space of the industry, allows creating IT systems to inform customers and process their data, implementing mobile and cloud solutions including large data analytics.

However, according to data of Rosstat, the level of information and communication solutions penetration in the housing and utilities infrastructure is still low. For example, only 65% of resource providers used basic information technologies in 2016 including local networks, electronic document management systems, and other similar solutions – no more than 5% [2].

Resource providers do not strive to the widespread use of digital technologies, partly due to a lack of funds, partly due to the desire to receive more favorable payment for them based on the rates. As well as homeowners' associations, for which increase in the level of

automation and transparency could bring quite certain benefits, do not interest in improving the infrastructure against the talks about the possible direct interaction of resources providers and consumers.

Thus, the main driver for the development of housing and utilities infrastructure in the near future will be the active implementation of smart meters for all types of resource and energy consumption in dwellings, which will gradually be combined into a smart metering system, digital system of mutual settlements for resources consumption based on SIM cards using the Internet of things technologies that will allow to lower expenses on payment of housing and utilities infrastructure, expenses of resource and energy providers, and to increase efficiency and quality of these services.

References

1. Digital Russia: new reality [online], Available at: https://www.mckinsey.com/~/media/McKinsey/Locations/Europe%20and%20Middle%20East/Russia/Our%20Insights/Digital%20Russia/Digital-Russia-report.ashx (2018)
2. A. Parshkov, Technologies. Engineering, **1 (7)** (2018)
3. World experience and prospect of development of industrial Internet of things in Russia [online], Available at: https://www.crn.ru/news/detail.php?ID=113441 (2016)
4. M. Samsonov, A. Roslyakov, S. Vanyashin, A. Grebenkov, *Internet of things in a smart city* (Asgard, Samara, 2016).
5. N. Kemaykin, Society: Politics, Economics, Law, **11** (2017)
6. B. Panshin, Science and innovation, **3 (157)** (2016)
7. Internet of Things (IoT) in Russia. Currently available future technology [online], Available at: https://www.pwc.ru/ru/publications/iot/IoT-inRussia-research_rus.pdf (2016)
8. A. Pidzhukov, Tele-satellite, **4 (258)** (2017)
9. A. Petrov, I. Drozdova, World Applied Sciences Journal, **23** (2013)
10. L. Primak, L. Chernyshov, *Energy saving in the housing and utilities infrastructure* (Akademicheskij proekt, Moscow, 2011)
11. K. Gulin, V. Uskov, Problems of territory development, **4 (90)** (2017)
12. P. Nielsen, Energy Efficiency in the Public Sector: Lessons Learnt, Presentation given at the meeting of the Working Group on Energy Efficiency and Related Environmental Aspects [online], Available at: https://energycharter.org/fileadmin/DocumentsMedia/Thematic/Public_Sector_EE_2008_en.pdf (2008)
13. J.M.L. Prado, I.M.G. Sanchez, Journal of Productivity Analysis, **27 (3)** (2007)
14. V. Komkov, N. Timakhova, *Energy saving in the housing and utilities infrastructure* (INFRA-M, Moscow, 2010)
15. J. Magyar, Energy Efficiency in the Public Sector (Slovak Republic), Presentation given at the meeting of the Working Group on Energy Efficiency and Related Environmental Aspects [online], Available at: https://www.edgebuildings.com/wp-content/uploads/2017/10/EBRD.pdf (2007)