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THE SMART HOUSE PROJECT AS PART OF URBAN DIGITALISATION IN THE ARCTIC

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Abstract

The article identifies negative factors affecting the economic state and development of electricity industry in Murmansk Oblast cities and towns and provides a rationale for smart systems of energy consumption management based on digitalization of the metering process. In particular, the high demand for and the scarcity and inefficient use of energy in the Arctic have laid the groundwork for the Smart House Project within the National Projects for Housing and Urban Environment and Digital Economy. Key results of the project include a reduction in consumer debt for energy, reduced costs of reading and processing data from electricity meters, increased efficiency of enforcing energy consumption restrictions, increased economic efficiency of the sector, and safety for people living in residential houses. That is the reason why digitalisation of the energy consumption management process in the existing market economy is a priority goal of the management system as a whole. Using technical means, databases, and software for timely and efficient information processing will also help make energy accounting more accurate and less time-consuming.

Keywords: Digitalisation, national project, energy saving, smart house, smart systems

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1. Introduction

There are several reasons why the study is relevant. First, the energy resources required for power supply and heating of residential houses are limited. Secondly, the cost of power generation is high. Thirdly, the heating season in the Arctic is long, approximately nine months a year from September to early June. Fourthly, energy is used by the people in a wasteful and inefficient way. Fifthly, there are no reliable consumption metering systems. Sixthly, the consumer debt for using energy resources is large.

2. Problem Statement

Implementation of the Smart House Project raises a number of theoretical and practical question. Practical questions. The Russian authors Bodrunov et al. (2018) believe that "the Government measures to regulate and stimulate digitalization should be expanded with an industrial section, which, on the one hand, should be orientated at more incentives for industrial use of digital technologies, on the other hand, at their development specifically by Russian companies" (p. 43). The developed "model of intersectoral support infrastructure for innovation in industrial technologies" (Charykova & Markova, 2019, p. 409) proves the need for using digital technologies for "forming prospective regional clusters". Based on the "Conceptual model for a multi-level economic transition to a digital scenario", Frolov and Lavrentyeva (2019) agreed on the need to "delineate the digital and digitalized sectors encompassing the sectors directly and indirectly connected with digital technologies and products" (p. 33). In digitalization of economic processes, "a correct interpretation of determinants influencing human resource efficiency will help choose the right management tools for HR as a factor of economic growth" (Kelchevskaya & Shirinkina, 2019, p. 465). The expedience of digitalization in managing territorial processes was demonstrated in an experiment of software development for identifying structural constituents of an economic potential in Russian regions (Skotarenko et al., 2019).

An analysis of papers on digitalization issues in the Russian economy has shown an assessment of the influence of digitalization on industrialized economies (Budzinski & Stöhr, 2019; Kooshki & Ismail, 2011), company-based digitalization of economic processes (Pasandideh et al., 2013; Willems & Kamau, 2019), and studies dedicated to the changes in European and international legislation in a digital economy (Ting & Gray, 2019; Trenta, 2019). It shows that digitalization of electricity consumption in residential houses in macroregions has not been studied in detail and therefore is a promising area for future studies. In particular, we can observe inefficient energy use in Russian macroregions.

3. Research Questions

The study raises the following questions:

- What factors laid the groundwork for the Smart Home Project?
- What is the Smart Home Project?
- What are the projected results of the Smart Home Project?

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4. Purpose of the Study

We suppose that answers to the questions will help provide a rationale for digitalisation of electricity metering in cities and towns in the Russian Arctic as a way to cut costs and make the Smart House Project profitable.

5. Research Methods

The study is carried out using the comprehensive, programme-goal, and process-based methodological approaches as well as analysis and synthesis.

6. Findings

Since 1 February 2015, the Atomenergosbyt Corporation has been the default supplier of electricity in Murmansk and Murmansk Oblast, where a reliable state-of-the-art infrastructure for individuals and companies of the Russian Arctic is present: Branch of KolAtomEnergoSbyt (hereinafter referred to as "KAES"). Its main activities are buying electricity on wholesale and retail markets in order to sell it to customer markets and managing and dispatching power supply to customers in cooperation with relevant organizations within natural monopolies.

Further development of the branch is, however, impeded by a significant amount of debt on the consumer market, i.e. residents of private houses and flats.

The debt factors can be divided into groups. The first group is connected with electricity metering problems experienced by some consumers in private houses and flats. The first factor is the absence of individual meters, which leads to standardized consumption bills quoting an estimate that does not reflect the actual consumption. The second factor is the presence of outdated meters or meters with accuracy class 2 that no longer comply with the applicable law. Consequently, the consumed resource is partially unaccounted for and therefore effectively misappropriated.

The second group includes factors of legal and regulatory nature, such as the absence of a general legal mechanism for settlement of underpayments for consumed energy, the absence of administrative and criminal articles penalizing defaulting consumers for deliberate failure to pay for the energy consumed, the binding rule for default suppliers of electricity to enter into a contract with any consumer (On functioning of retail electricity markets and full and (or) partial restriction of power consumption, 2012); energy suppliers having no right to hold a preliminary solvency test of a potential customer thereby excluding client debt accumulation, and energy suppliers having no right to terminate an effective contract because of customer debt for the resource consumed.

The third group is connected with the absence of a full-scale and timely monitoring system. First, is it the shortage of inspectors for connecting to and disconnecting from utility networks, which hinders complete and timely tracking of misappropriation, unauthorized connections to internal networks in residential houses, and tampering with meters in order to rewind or slow them down. Secondly, unscrupulous consumers have no difficulty reconnecting illegally and restoring the power supply after the inspectors have partially disconnected it. Offenders are not stopped even by the threat of financial penalties.

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Thirdly, the default supplier for Murmansk and Murmansk Oblast is understaffed with inspectors, which makes it impossible to carry out monthly checks of each flat to find out about offenders, non-payment and underpayment for or faulty metering of energy consumption.

Those factors laid the groundwork for development and implementation of the Smart Home Project that started in 2017 and will continue in 2021. The debt of the general population market increased in 2020 because of a spike in the number of new high-tech and power-consuming devices (powerful computers, air conditioning, washing machines, dishwashers, and dryers) as well as their intensive use during the lockdown and remote work and study.

A "smart home" can be understood as automated power consumption management system for residential houses. It includes three sets of devices: sensors or meters reading and recording the input power consumption data, a hub or a central controller processing the input data and generating output data as commands, and slave modules performing the commands generated by the hub.

The Smart Home Project is expected to bring the following results: lower consumer debt for the energy supplied for shared needs of residential houses, lower costs of reading, obtaining, and processing of metering data, increased efficiency of imposing consumption restrictions, and safety of the public in the respective area. Federal Law No 522-FZ of 27 December 2018 "On amendments in Russian Federation legal acts due to development of electricity (power) metering systems in the Russian Federation" changed the relations between consumers and default providers and introduced new concepts, such as "smart electricity (power) metering system", "default suppliers and network companies", and "types of commercial metering" (On amendments in Russian Federation legal acts due to development of electricity (power) metering systems in the Russian Federation, 2018).

In accordance with the law, starting from 1 July 2020, default suppliers shall be in charge of accounting for electricity in residential houses (including shared areas in blocks of flats), and network companies shall be responsible for the same at all other power facilities of their respective networks on wholesale markets. From 1 July 2020, any commissioned blocks of flats shall be equipped with individual and general electricity meters capable of being connected to smart metering systems. From 1 January 2022, all meters accepted for use shall be smart.

The implementation stages for the law are shown in Figure 1. As the default supplier of electricity in Murmansk Oblast, the KAES Branch has to install smart electricity meters as part of the Smart Home and Smart City projects. Experience has proven that a smart meter with a specialized controller is an efficient way to improve consumer discipline in payments by means of full or partial remote disconnection of defaulting consumers. Smart meters are connected in smart metering systems (SMS). The KAES Branch is currently installing two SMS: "Merkuriy" and "Fobos".

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<table>
<tr><th>2020
1 July</th><th>2021
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<tr><td rowspan="8">Network/supply companies become responsible for servicing and installation of meters</td><td></td><td></td><td></td></tr>
<tr><td rowspan="7">All new buildings shall be equipped with remote-access meters (with a data transmission channel)</td><td></td><td></td></tr>
<tr><td rowspan="6">All commissioned meters shall comply with requirement to minimum functionality</td><td></td></tr>
<tr><td></td></tr>
<tr><td rowspan="3">Consumers without access to their metering data may demand penalties from the network/supply companies</td></tr>
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Figure 1. Implementation stages of Federal Law No 522-FZ of 27.12.2018

The Branch has already installed 1,043 SMS in Murmansk Oblast, with the number of serviced accounts being 9,900 companies and 342,200 individuals. The number of SMS may reach 300,000 by 1 January 2022.

SMS operate as follows: the default supplier installs/replaces an individual meter containing the meter itself and a controller transmitting the data. The controller transmits the input data every morning and evening to a specialised hub device or a central controller installed by the default supplier at the facility. The hub then processes the data from the whole block of flats and generates respective commands. The hub transmits the data to the server of the facility. The server processes the data and sends it to the default supplier. The data is then used for billing the residents for the electricity.

The Smart Home Project is integrated into the Safe City Programme of the Smart City Project approved and implemented by the Russian Ministry of Construction, Housing, and Utilities as part of the National Projects for Housing and Urban Environment and Digital Economy (National Project Data Sheet: Housing and Urban Environment, 2018; National Project Data Sheet: National Programme for a Digital Economy in the Russian Federation, 2019). Installing a video surveillance system and video door phones in a smart home will improve the safety and quality of life of the residents by preventing misconduct, maintaining cleanliness and order, creating a comfortable environment, and protecting the shared property of the block of flats. The residents will be able to control the access into the house and monitor the surrounding area. The project will help solve energy, economic, and environmental issues by integrating state-of-the-art digital and engineering solutions into urban utilities and environment.

The Smart City Project is aimed at developing urban infrastructures. It ensures high performance and creates a safe and comfortable environment for urban residents. At its core, it is people-orientated, technology-based, aimed at improved municipal resource management, prioritizing economic efficiency of a city, including its service sector.

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The project includes an action plan harmonized with a different pilot project for development of a digital infrastructure and economic sectors in the town of Polyarnye Zori from 2019 to 2024. Murmansk has joined the pilot project as well.

The SMS in the Smart Home Project are based on automated commercial electricity metering systems (ACEMS) and a united data collection and transmission system (UDCTS).

The main purposes of the ACEMS is automated data collection from electricity meters, data storage in a database, multi-rate metering, elimination of incomplete metering, remote disconnection of defaulting consumers, data collection, storage, and processing, monitoring electric grids, and customized reporting.

The ACEMS can solve the following problems: lack of or delays in data receipt from individual meters, incomplete metering, inefficient energy use for shared needs of a block of flats, unauthorized connection, tampering with meters, and high energy consumption for shared needs of a block of flats.

Tablet devices, TV sets, and the accompanying equipment makes in convenient for flat owners to use the Atomenergosbyt mobile app to view their energy consumption, CCTV camera video, notifications, and announcements.

The united data collection and transmission system (UDCTS) is meant to enable the KAES Branch to collect metering data directly on its own without third parties collecting, storing, and processing both the metering data and personal data of the consumers.

A feasibility study has been carried out for the base project in order to select and approve such projects for implementation in houses under construction.

Let us analyses the payback period of the Smart Home Project along the base models in Murmansk and Polyarnye Zori. Equipment costs for smart metering systems, video surveillance, accessories, and software at two facilities are shown in Table 1.

Table 1. Cost of equipment, accessories, and software for the Smart Home Project

Equipment	Number of units	Price per unit, RUB	Cost, RUB	Number of units	Price per unit, RUB	Cost, RUB
	Murmansk			Polyarnye Zori		
Smart metering						
Three-phase meter	1	5.236	5.236	1	5.236	5.236
Single-phase meter	24	2.356	56.545	0	0	0
Data collection and transmission device	1	44.129	44.129	1	44.129	44.129
Wires and cables	1	8.227	8.227	1	8.227	8.227
Consumables	1	2.992	2.992	1	2.992	2.992
Video surveillance						
Camera	14	4.488	62.827	28	4.488	125.654
Video recorder	1	3.740	3.740	1	3.740	3.740
Monitor	1	5.236	5.236	1	5.236	5.236
Wires and cables	1	14.959	14.959	1	26.178	26.178
Consumables	1	4.488	4.488	1	4.488	4.488
Subtotal:			208377	Subtotal:		225.879
Software						
cEnergo	1	50000	50000	1	50000	50000
Total:			258.377		Total:	275.879

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For installation and operation of all Smart Home components, installation, testing, and commissioning has to be carried out, the costs shown in Table 2.

Table 2. Cost of contractor work for the Smart Home Project

Type of work	Cost, RUB.	
	Murmansk	Polyarnye Zori
	Smart metering	
Installation	100.000	90.000
Testing and commissioning	15.000	15.000
Subtotal:	115.000	105.000
	Video surveillance	
Installation	200.000	300.000
Testing and commissioning	10.000	10.000
Subtotal:	210.000	310.000
Total:	325.000	415.000

Tables 1 and 2 show that implementing the project requires 583,377 RUB in Murmansk and 690,879 RUB in Polyarnye Zori.

A cost effectiveness analysis for the Smart Home Project shows that the cost is reduced along the following lines: payroll costs for inspector reading electricity meters, (excessive) shared-needs energy consumption in block of flats, and payroll costs for electricians connecting/disconnecting consumers to and from electric grids (Table 3).

Table 3. Cost saving in the Smart Home Project

Cost item	Cost, RUB	
	Murmansk	Polyarnye Zori
Taking readings	1 129	4 233
General building needs	18 023	67 586
Disconnect / Connect	987	3 700
Total	20 139	75 519

The profitability of the Smart Home Project under consumption monitoring contracts with utility management companies, calculated at 70 RUB per flat per month, and the payback period of the project in Murmansk and Polyarnye Zori are shown in Table 4.

Table 4. Smart Home payback period for two facilities

Base model including contractor work	Costs, RUB	Cost saving for cost items, RUB/year	Profit, RUB/year	Payback period, years
Murmansk	583.377	20.139	20.160	14.5
Polyarnye Zori	690.879	75.519	75.600	4.5

As seen from Table 4, the payback period of the project implementation is 14.5 years in Murmansk and 4.5 years in Polyarnye Zori. The difference is due to the fact that the house in Polyarnye Zori has 3.75 times more flats than in Murmansk.

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The strengths of the project include the following: reduced debt for the energy supplied to consumers and for shared energy needs in blocks of flats, reduced costs of collection, receipt, and processing of meter data, increased efficiency of imposing restrictions, and using video surveillance to ensure safety in the area. Positive feedback from residents will help promote commercial digital projects as an additional activity and improve the reputation of the Branch and the corporation as a whole.

The project weaknesses are the long payback period, large amounts of required investment, the need for approval of the branch's activities with a number of authorities, including the Murmansk Oblast Committee for Tariff Regulation, and limited viability of installing smart metering systems in Murmansk Oblast at the stage of construction given the small number of new houses. The project will be primarily implemented in old houses, and the software will have to be customised for each smart metering system since every meter has its own principle of recording and transmitting data.

The Branch therefore has to cooperate with various data processing centres, which leads to additional costs and entering into contracts with multiple parties in order to consolidate the resource consumption data.

7. Conclusion

The findings show that the Smart Home Project implemented by other branches of AO Atomenergosbyt in Tver, Kursk, and Smolensk is connected with the opportunity to use innovative and efficient solutions for installing solar panels with energy storage options in order to power the external and internal lighting. The Murmansk Branch is an exception because it is not feasible to install solar panels in the region.

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