Operational services management in the context of sustainable development of intelligent technologies

Anna Romanova, Evgeniya Ilina

Kazan State University of Architecture and Engineering, Kazan, 420043, Russia
E-mail: ilina19091982@mail.ru

Abstract. The article discusses the conditions for the functioning of a sustainable economy. The operation of an apartment building is considered for this stage of economic development not as an object of luxury, but as a basic need to live comfortably. The object of the study is the level of depreciation and technical "under-equiping" of apartment buildings. In the conditions of sustainable development of intelligent technologies, theoretical understanding of economic efficiency from the introduction of innovative technologies in the field of housing and communal services, as well as improving indicators affecting the quality of services provided by industry enterprises, which is directly related to the livelihoods of the population, is no less relevant. The article discusses the experience of practical application of innovative solutions in the field of operational services of an apartment building. The purpose of the study is to analyze innovative technologies in the field of housing and communal services and an objective review of specific examples of the introduction of innovations in the industry.

Keywords: sustainable development, intelligent technology, operational services, apartment building, quality of life.

1 Introduction

Currently, it is becoming the norm to take into account the installation of smart meters and the use of intelligent technologies in the design and construction of a new building, but it is much more difficult to manage the building during a long production cycle. But it’s even more difficult to upgrade an existing multi-apartment building to the level of a “smart home”: to integrate new technological equipment into existing engineering systems. The problem boils down not only to how to technically solve these problems, but also where to find funds for modernization and bringing the house to the level of its own “intelligence”.

The management of smart cities and intellectual infrastructure for sustainable development are the subject of numerous works by foreign and domestic scientists. The main areas of research in the field of management systems of smart cities and houses are identified by the works of scientists Meijer, A., Bolívar, M. P. R. [1], Caragliu, A., Del Bo, C., Nijkamp, P. [2], who evaluated the intellectual infrastructure for sustainable urban development. Smart buildings are monitored by Oluwole S., Kin W. M. S. et al [3], Bolchini C., Geronazzo A., Quintarelli E. [4]. Problems and achievements in creating engineering and intelligent applications are disclosed in the works of Zhun J.Y., Fariborz H., Benjamin CM. Fung [5]. Energy-efficient smart home systems are studied quite extensively by Filho G.P.R., Villas, et al [6]. Models of changes in owners’ behavior and energy consumption in residential premises are shown in the works of Karatasou S., Laskari M., Santamouris M. [7], and Jo H., Yoon Y.I. proposed a concept and an intelligent model of energy efficiency of a smart home using an artificial mechanism [8]. The developmental approach to intelligent buildings developed by Taktak E., Abdennadher I., Rodriguez I. B. [9] is of high interest.

Researchers such as Doca S., Corgnati S.P., Buso T. [10], Fischer C. [11] dealt with energy conservation and determination of resource consumption efficiency. Mogles N., Walker I., Ramallo-Gonzalez A.P., Lee JH., Natarajan S., Padget J., et al [12] studied smart meters and how smart they can be. The development and implementation of sensors for creating reusable building applications and smart home applications are offered by Balaji B., Verma Ch. [13], and Alaa M., Zaidan A. et al
The relationship between energy-saving consumer behavior and the environment was investigated by Buchanan K., Russo R., Anderson B. [15], Cotton D., Miller W. et al [16]. Information modeling of the capital construction market and the impact of residents on energy performance is the subject of research by Bakhareva O.V., Romanova A.I.et al [17], Gilani S., O'Brien W., Gurney H. B. [18]. Problems and prospects for the development of the operational cycle of real estate based on energy saving were considered in the works of Romanova A.I., Burkeev D.O., Ilina E.V., Safina R.S., Egorov D.A. [19], Mingaleev G.F., Shinkevich M.V, Misbakhova Ch.A., Bystrov A.V., Romanova A.I. and Bulkin V.A. [20].

However, despite the availability of an extensive theoretical and methodological data set and practical solutions, there is a lack of practical examples that demonstrate the effectiveness of modern solutions to the problem of optimizing the operational services of an apartment building and increasing the level of smart management. The purpose of such measures is the technical improvement of the facility, as well as accounting for the consumption of resources (as one of the main conditions for a sustainable economy), as a result of which monetary savings are revealed.

2 Methods

For the purpose of calculating the economic efficiency of smart technology in the operational services of an apartment building, the following methods were used: analysis of statistics of the housing and communal services committee, analysis of specialized websites of the branch ministry, surveys of residents; conducting a “focus group” with the leaders of the houses. Extensive analytics made it possible to offer users of operational services the installation of a meter with a pulsating output (a device that uses a circuit diagram to establish a clear size of the flow of cold and heated water). The pulse output makes it possible to subsequently connect the counters to a common node in order to read data in the current period. The main difference between a pulsating water meter and an ordinary pulse counter is that it is equipped with a weak magnet and a hermetic contact (reed switch); it becomes closed taking into account the influence of a magnetic field. During the period of taking readings, the contact gives a galvanic push, which automatically reads the readings and serves it in the control panel. It is noteworthy that a pulsed water meter does not require an additional power source: the reed switch itself generates an electromagnetic pulse and causes a short circuit of low-current electronics.

Among the advantages of using pulse water meters are:

- accurate accounting of the quantity and quality of the consumed resource;
- ease of use and full automation of devices;
- the ability to choose the best model for any budget.

The main disadvantage of a water meter with a pulse output is the tight contact. It is quite fragile and cannot be repaired. It is necessary to monitor its serviceability, integrity, service life; another minus is the mandatory connection to a radio or digital type of signal. The information collected by the counter can only be transmitted using a modem or antenna; counters with a pulse output are designated as “anti-magnetic”. The practical application of these devices gives different results. An invisible magnet stops the rotation of the impeller by 100%. Due to the magnetic field, the reed switch fails.

At least one pair of cold and hot water meters CHVA-15 and CGVA-15 is installed in each apartment; meters are connected directly via RF868 LPWAN to the BS-1.2 base station.

Instrument connection technique:
1) the common house water meter must be replaced with a meter with a pulse output;
2) a common water meter is connected to a pulse counter wireless RF868-LPWAN 4-channel; 4-channel wireless RF868-LPWAN pulse counter is connected via RF868 radio channel to the RF868 LPWAN BS-1 base station;
3) the base station RF868 LPWAN "BS-1" must be connected to the Internet;
4) the customer (HOA) must organize the server; you can use the dispatcher’s personal computer as a server, provided that it works smoothly.
It can be assumed that, ceteris paribus, theoretically, the operation of the house using this method of taking readings will be more profitable. Such monitoring with increased measurement accuracy can be used by apartment building and government authorities to control resources, while developing appropriate decisions in the field of sustainable development of territories.

3 Results

As an example of the implementation of smart technologies of a sustainable economy in the management of real estate, we will carry out a technical and commercial calculation for the installation of pulse meters for water in an apartment building. The house has 4 entrances, 9 floors each, a total of 144 apartments. The residential building is managed by the Homeowners Partnership (HOA), the meeting of tenants decided to install such an innovation as pulse water meters. Residents were offered the supply of equipment of an automated system for the integrated metering of energy consumption at the SAKLAU ASKUPE with data transmission via the LPWAN radio channel (Table 1, 2).

Table 1. Equipment Specification: Equipping the facility with metering devices with the possibility of remote reading.

| Name | Type, brand | Price, rub. | Quantity | Amount, rub. |
|------|-------------|-------------|----------|-------------|
| The counter of cold water with non-return valve and radio channel | CHVA-15 with PK LPWANOK | 2394 | 296 | 708 624 |
| Household electronic hot water meter with check valve and radio channel | CGVA-15 with PK LPWANOK | 2394 | 296 | 708 624 |
| Household cold water meter with pulse output | CVMT-50D | 9580 | 1 | 9 580 |
| TOTAL metering devices | | | | 1426828 |

Table 2. Equipment of the facility with system components.

| Name | Price, rub. |
|------|-------------|
| RF868 LPWAN BS-1.2 base station (Ethernet; power over Ethernet, PoE power supply included; Linux OS and pre-installed Packetforwarder software; IP65; beam / mast mount; N-Type female connector for connecting the RF868 antenna, not included) | 24700 |
| Vertical antenna for the “Antenna 868-01” base station (operating frequency range 864-876 MHz; gain 6 dBi; SMA connector; mount for mounting on a beam / mast is supplied) | 2900 |
| Wireless RF868-LPWAN pulse counter 4-channel “Vega SI-11” (class A device; 4 counting channels, 2 of which can be emergency; autonomous power supply; internal antenna; IP65) | 2500 |
| The IOTVegaPulse client application (a tool for simple and convenient collection and display of meter readings. The application can be used to protect buildings and premises by displaying alarms online from security sensors connected to SI series of pulse meters. Current meter readings and reports on utilities and alarms can be exported in Word \ Excel) | Free |

The cost of implementing the system is calculated without taking into account the cost of installation and commissioning (cost = 1100 rubles). On average, expenses per apartment will amount to 11,217.56 rubles, taking into account installation and commissioning. The cost of installing intelligent equipment is expensive for owners, and, for example, three-room apartments must install (according to design decisions) 6 meters with a pulse output. However, within the framework of an innovative management solution, two possible options can be used that will not burden the owners in terms of charging fees for installing ASKUPE throughout the house.

The first option: carrying out work to modernize the water supply system and automatically take meter readings from capital repairs in agreement with all apartment owners in the MKD. According to article 166 of the Housing Code of the Russian Federation (section 9, “Organization of the overhaul of common property in apartment buildings”), it is allowed to carry out modernization of the house’s water supply system from a special overhaul account.
The second option (if available): the use of funds from the reserve fund, which accumulated funds from income for several previous periods in an apartment building (for example: income from advertising in an elevator, renting out common areas to providers or other advertisers). Currently, such a need has matured.

4 Conclusions
As a result of the study of the economic efficiency of operational services when introducing an innovative meter reading device for an apartment building, it is possible to formulate practical results of the project:
1) the installation of pulse metering devices for water is connected with the issue of transparency of individual water consumption. The fact is that in the process of consuming hot and cold water, a big difference began to appear between the readings of individual meters and common house meters. This difference could arise due to the difference in the meter reading by the apartment owners, with a spread from the 15th to the 22nd day of the month. The readings in this version of the water consumption meters were assigned to the owner, and the “human factor” was triggered, which led to fluctuations in the values, and, ultimately, this difference between CMD (common metering devices) and IPU (individual metering devices) was thrown off in CHN (common house needs). So, on the example of the considered MKD, about 1800 cubic meters were spent on household water needs on an annualized basis. Given the cost of 1 cubic meter of water, equal to 19.64 rubles in the city of Kazan, only under the CHN. CHN spent about 35,000 rubles a year from the funds of homeowners.
2) the cost of operational services will be reduced, due to the exclusion of errors in the measurement of resource consumption. In the passport of water meters of the previous generation, a possible error was established experimentally when taking readings, about 10 – 15% of consumption. The installation of ASKUPE “SAKLAU” with the transmission of data via a radio channel will not completely solve the problem and will not eliminate the difference between the common house water consumption meter and individual metering devices, since the CHN indicators at the end of the year “sit” the costs of flushing the heating systems and using water to maintain the common house property and watering plants. But we believe that at least half of the costs of 1800 cubic meters of water per year will decrease. The intentionally distorted registration of water consumption by apartment owners will be reduced. In addition, a program that automatically reads readings will quickly show those who do not have meters. This, on the one hand, will facilitate the work of the plumber, and on the other hand, it will not allow regular errors on the readings of meters.

The results of the study can be used in developing priorities in optimizing the operational services of an apartment building, which will have a positive impact on the implementation of a national project to create comfortable living conditions for the population in a sustainable economy of the region.

5 Discussions
The mechanism for the implementation of smart technologies is impossible without attracting additional financing and including budgets of different levels in the process; implementation of energy service contracts; public-private partnerships; special programs of banks; special funds to promote energy efficiency or reform housing systems. All this may be the topic of further research on the issue of the intellectualization of apartment buildings in a sustainable economy.

References
[1] Meijer A, Bolivar M P R 2016 Governing the smart city: A review of the literature on smart urban governance International Review of Administrative Sciences 82(2) pp 392–408 DOI: 10.1177/0020852314564308
[2] Caragliu A, Del Bo C and Nijkamp P 2011 Smart cities in Europe Journal of Urban Technology 18(2) pp 65–82 DOI: 10.1080/10630732.2011.601117
[3] Oluwole S, Kin W M S, Lawanson T and Adeniji O 2016 Assessing smart infrastructure for sustainable urban development in the Lagos metropolis *Journal of Urban Management* 5 pp 52–64 DOI: 10.1016/j.jum.2017.01.001

[4] Bolchini C, Geronazzo A and Quintarelli E 2017 Smart buildings A monitoring and data analysis methodological framework *Building and Environment* 121 pp 93-105 DOI: 10.1016/j.buildenv.2017.05.014

[5] Zhun J Y, Fariborz H and Benjamin C M Fung 2016 Advances and challenges in building engineering and data mining applications for energy-efficient communities *Sustain. Cities Soc.* 25 pp 33-38 DOI: 10.1016/j.scs.2015.12.001

[6] Filho G P R, Villas L A, Gonçalves V P, Pessin G, Loureiro A A F and Ueyama J 2019 Energy-ancient smart home systems. Infrastructure and decision-making process *Internet of Things* 5 pp 153–167

[7] Karatasou S, Laskari M and Santamouris M 2014 Models of behavior change and residential energy use a review of research directions and findings for behavior-based energy efficiency *Adv. Build. Energy Res.* 8(2) pp 137-147

[8] Jo H and Yoon Y I 2018 Intelligent smart home energy efficiency model using artificial tensorflow engine *Human-centric Comput. Inf. Sci.* 8(1) pp 9-17 DOI 10.1186/s13673-018-0132-y

[9] Tatak E, Abdennadher I and Rodriguez I B 2016 An adaptation approach for smart buildings *Proceedings of the IEEE Eighteenth International Conference on High Performance Computing and Communications; IEEE Fortieth International Conference on Smart City; IEEE Second International Conference on Data Science and Systems* pp. 1107–1114 DOI 10.1109/HPCC-SmartCity-DSS.2016.0156

[10] Doca S, Corgnati S P and Buso T. 2014 Smart meters and energysavings in Italy determining the effectiveness of persuasive communication in dwellings *Energy Res. Soc. Sci.* 3 pp 131-142

[11] Fischer C 2008 Feedback on household electricity consumption a tool for saving energy *Energy Effic.* 1(1) pp 79-104 DOI: 10.1007/s12053-008-9009-7

[12] Mogles N, Walker I, Ramallo-Gonzalez A P, Lee J H, Natarajan S, Padget J, Gabe-Thomas E, Lovett T, Ren G, Hyniewska S, O'Neill E, Hourizi R and Coley D 2017 How smart do smart meters need to be? *Building and Environment* 125 pp 439-450 DOI: 10.1016/j.buildenv.2017.09.008

[13] Balaji B, Verma Ch, Narayanaswamy B, Agarwal Y. Zodiac 2015 Organizing Large Deployment of Sensors to Create Reusable Applications for Buildings *Proc. ACM Int. Conf. Embedded Systems for Energy-Efficient Built Environments* pp 13-22 DOI: 10.1145/2821650.2821674

[14] Alaa M, Zaidan A, Zaidan B, Talal M and Kiah M 2017 A review of smart home applications based on internet of things *J. Netw. Comput. Appl.* 97 pp 48–65 (2017). DOI 10.1016/j.jnca.2017.08.017

[15] Buchanan K, Russo R and Anderson B 2014 Feeding back about eco-feedback how do consumers use and respond to energy monitor? *Energy Policy* 73 pp 138-146 DOI: 10.1016/j.enpol.2014.05.008

[16] Cotton D, Miller W, Winter J, Bailey I and Sterling S 2015 Knowledge, agency and collective action as barriers to energysaving behaviour *Local Environ.* pp 1-15 DOI: 10.1080/13549839.2015.1038986

[17] Bakhareva O V, Romanova A I, Talipova L F, Fedorova S F and Shindina T A 2016 On the building information modeling of capital construction projects market development *Journal of Internet Banking and Commerce* 21(3)

[18] Gilani S, O'Brien W and Gunay H B 2018 Simulating occupant’s impact on building energy performance at deferent spatial scales *Building and Environment* 132 pp 327–337 DOI: 10.1016/j.buildenv.2018.01.040
[19] Romanova A I, Burkeev D O, Berval A V, Ilina E V, Safina R S and Egorov D A 2019 Evaluation of savings on operational services from innovative energy-saving materials IOP Publishing 786 012029 DOI: 10.1088/1757-899X/786/1/012029

[20] Mingaleev Gaziz F, Shinkevich Marina V, Misbakhova Chulpan A, Bystrov Andrey V, Romanova Anna I and Bulkin Vadim A 2019 Formation of Innovative Programms Sub-Goals in Energy Saving Asian Exercise and Sport Science Association 8 pp 208-215