Smart Home Concept at the Design Stage of Engineering Systems in the Construction of Economy Class Apartment Buildings

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Abstract. At present, the construction market of apartment buildings in the Moscow region is in an active transformation phase. The use of modern technologies has increased the volume of housing construction and reduced the time of commissioning new facilities. With the growing number of proposals in the real estate market, the demand for new buildings remains high. At the same time, buyers' requirements for the quality of housing have changed significantly. Today's potential apartment buyer pays attention not only to its basic characteristics and price per one square meter. One of the modern selection criteria is the availability of modern engineering systems, high-tech equipment in residential complexes, allowing to make living in such houses more comfortable and safe, as well as save energy when forming utility bills. The author conducted a study of the complex equipment of apartment buildings with "smart home" (SH) system, showed the main advantages of using various subsystems of SH, formulated proposals that can make more affordable SH technology for ordinary residents. These activities will also allow developers to adjust the approaches to the planning and implementation of their projects for the next 5-7 years to meet modern market requirements.

1. Introduction

One of the most pressing issues in any big city is the construction of apartment buildings. Despite the difficult financial situation in Russia, under conditions of sanctions pressure, the volume of apartment buildings construction continues to grow in the Moscow region. According to the development strategy of the Complex of urban planning policy and construction of Moscow, it is planned to build 6.32 million square meters of housing in the framework of one program “Dwelling” in the period 2019-2020. From the beginning of 2018 to the middle of 2019, 11.7 million square meters of housing were put into operation in the Moscow region.

In the recent past, apartment buyers focused mainly on the basic characteristics of housing, such as location, type of apartment building, apartment area, number of rooms and ancillary facilities, layout, interior decoration, availability of parking [1].

Currently, due to the high competition for customers, the projects win when developers pay special attention to architecture, design of public areas, landscaping, as well as the use of innovative technologies in the management of various engineering systems [2]. Today the greatest preference is given to such residential complexes. The statement that the "target audience "standard" and "comfort" class is interested only in the price" is gradually losing importance.
Today's trend is high-tech housing with the use of IT-systems within the living space. These issues are actively discussed in the scientific community, such as the concept of creating universal machines for intelligent power systems and critical infrastructure, taking into account the requirements of the digital economy [3], optimal energy management for residential buildings [4], creating advanced neural network models for energy awareness of smart home residents about how they can improve daily habits while reducing energy consumption and, consequently, costs [5], intelligent hybrid energy management system for smart home, taking into account the bidirectional flow of energy and different methods of charging devices [6], the creation of a single platform to ensure the compatibility of various intelligent devices [7], the recognition of human activity in the living space using various sensors [8].

In this article we will focus on the system "smart home" in terms of its importance and the need for implementation at the design stage in the construction of apartment buildings. On the one hand, the presence of SH, allows you to make the apartment warm and bright with less energy [9], significantly increases the level of comfort and safety, on the other hand, it leads to additional costs for the installation and maintenance of many devices, while managing all this engineering becomes a difficult task.

In the last decade, technologies have been rapidly developing, almost everyone has a smartphone and other devices with the Internet access, machine learning technologies, augmented reality and much more other technologies have appeared. At the same time, all the same engineering systems are used in the design of apartment buildings as at the beginning of the century.

The relevance of this article is due to the fact that there are a number of problems associated with the mass implementation of the SH system, with all its many benefits. The author gives practical recommendations for solving the identified problems.

The scientific significance of the article is to improve the construction process of apartment building investment projects through the proposed set of measures. This will allow the mass introduction of SH systems, making them more popular for ordinary residents. The availability of SH technology will create a comfort of living in such houses to be much higher than in ordinary apartments, it will significantly save on utility bills, and will also open many additional services for residents which were available only to owners of luxury apartments and suburban real estate [10].

2. Research
"Smart home" is a living space organized for comfortable living and saving resources through the installation of a variety of high-tech devices [11].

For the first time the concept of SH was formulated by the Institute of intelligent building in Washington in the 1970s. It assumed a new form in the organization and management of living space due to the built-in complex of software and hardware, which significantly increased the efficiency of functioning of all engineering systems, while ensuring the reliability and simplicity of controlling actuators. For almost sixty years, SH technology has evolved significantly.

Modern SH systems impress for its capabilities. The list of their capabilities includes not only control and management of various engineering systems using a smartphone, tablet or computer [12]. The use of machine learning technologies has made the management process of some systems autonomous, the SH system itself has learned to recognize specific situations occurring in the living space, and to respond accordingly to them, implementing various scenarios, adapting to the lifestyle of the inhabitants of the housing [13].

As a result of the analysis of proposals from leading companies in the field of professional automation systems, the main subsystems of SH and their functionality were identified from the variety of provided services (table). According to the author, these indicators should form the basis of typical solutions in the design of apartment building.

The functionality of the dedicated SH subsystems presented in the table can be expanded depending on the customer's needs.
Table 1. Main subsystems included in smart home.

| Subsystem name                        | Functional                                                                 |
|---------------------------------------|-----------------------------------------------------------------------------|
| **Lighting and electrical loads**     | 1. Automatic lighting control according to the indications of various sensors of the people presence in the rooms (motion sensors, infrared sensors, etc.). |
|                                       | 2. Disconnection of all electricity consumers with one button during the absence of residents or at night (except refrigerator, washing machine and dishwasher). |
|                                       | 3. Maintenance optimal lighting brightness depending on the time of day and natural light. |
|                                       | 4. Combined switching on of electrical appliances (e.g. indoor lighting and TV). |
|                                       | 5. Remote control of electricity consumption. |
|                                       | 6. Management of lighting, sockets, electrical appliances (curtains, blinds), the creation of scenarios. |
| **Climate control (heating, ventilation, air conditioning, humidification)** | 1. Individual climate environment in each room. |
|                                       | 2. Synchronization of heating, ventilation and air conditioning systems (for example, elimination of conflicts from simultaneous switching on of heating and air conditioning, disconnection of air conditioning when windows are opened, etc.). |
|                                       | 3. Installation of different temperature scenarios in each room (for example, minimum heating, switching off ventilation and air conditioning in rooms where there are no people). |
|                                       | 4. Optimal ventilation supported by a threshold level of indoor humidity and an acceptable level of CO₂ in the air. |
|                                       | 5. Automatic exit from the economy mode and warming up rooms for the arrival of residents. |
| **Water supply**                      | 1. Control of leaks in rooms with high humidity (bathroom, kitchen). |
|                                       | 2. Automatic shut-off of water supply in case of emergency, notification to the control device. |
| **Fire safety**                       | 1. Fire extinguishing system. |
|                                       | 2. Fire alarm. |
|                                       | 3. The system of notifications coming to the control device and informing the emergency services. |
| **Video surveillance and security systems** | 1. Indoor video control. Fixation of penetrations into the rooms. |
|                                       | 2. Event recording, archiving, transferring photo/video files to control devices. Call security. |
|                                       | 3. Separation of access to different rooms using combination locks or fingerprint readers. |
| **Entertainment system**              | 1. Audio and video system installed in different rooms and having a single control with content management capabilities (multiroom). |
|                                       | 2. Seamless Wi-Fi network. Uninterrupted, high-speed Internet access in any room. |

According to estimates by the world's leading analytical agency, Business Insider Intelligence, in the period from 2014 to 2019, a compound annual rate of SH devices is 67%, and it will reach 2 billion units worldwide in 2019. Sales of smart home devices will be $ 490 billion in 2019 (figure 1) [15].
Modern SH devices include not only security systems, sensors connected to the Internet, monitors, cameras, alarm systems and energy equipment, but also intelligent home appliances (washing machines, dryers, refrigerators, audio and video systems [16], etc.). The category of devices related to the concept of SH is about 25% of the wider category “Internet of things”. It is expected that this year this figure will also grow.

Energy equipment and safety systems, including devices such as connected thermostats and smoke detectors, will become popular in the first place, leading to consumer growth (figure 2) [15].

Today, unified concept of smart home - smart street - smart city is being created. In the future, according to the author, the main reason for the use of SH in apartment building equipping will be not only increasing the comfort of living, but also the desire to save on utilities and automation of housing and communal services. By using the SH it is achieved savings on heating and electricity, and the presence of smart meters [17] simplifies the process of transferring readings to management companies [18].
With the obvious advantages of SH, today there are a number of difficulties that prevent the mass introduction of this technology. The key problems are listed below and the ways to solve them are proposed.

1. State requirements for engineering infrastructure and guidance documents of the Ministry of communications of the Russian Federation do not impose obligations on the developer for the arrangement of SH systems in the construction of apartment buildings. In this regard, many developers comply the minimum technical specifications for saving money. In such buildings there are no cable channels for the cable infrastructure and any space for the installation of devices and SH sensors. There is also no special place for the active equipment.

2. A variety of disparate non-integrated systems and devices from different manufacturers and service providers. As a result, there is a difficulty in SH managing and the need to install many applications that have different architecture and usage logic.

3. High cost of installation and maintenance of SH systems after the commissioning of the apartment building. This requires highly qualified employees of the integrator company. These costs eliminate energy savings from the use of SH [19].

The author proposes to develop a number of typical SH projects with the main subsystems and their functionality presented in the table, focusing on the installation of the most promising of them – power equipment and security systems. Thus, this will be the next engineering step from the standard placement of communications in the apartment building to the development of basic apartment automation for the end user with the ability to scale the SH systems.

These technical solutions should be laid at the architectural and construction design level in order to avoid repeated construction and installation work on wall changing the configuration of existing engineering systems after commissioning. A positive factor in the design of such apartments will be to increase value and competitiveness in the housing market for the developer.

The introduction of standard SH solutions will also contribute to the creation of a single ecosystem, a single point of entry for the consumer. This will stimulate the development of system integration in terms of combining a variety of devices with different protocols, as well as professional automation systems [20] into a single platform, so that the end user has the opportunity to use one application [21]. Such tasks are solved much more effectively at the implementation level of the SH in the residential complex than an individual installation in each apartment.

3. Conclusion
Confirmation of the above is that in recent years more and more developers are aware of the need to change the concept of apartment building construction. Gradually, “smart homes” begin to appear in Russia. In Moscow, the residential complex "Tetris" and the residential complex "City" are the most famous projects. There is also growing interest among management companies that seek to manage entire clusters of such houses.

Additional support for such projects will be an approved action plan of the Ministry of digital development, telecommunications and mass communications of the Russian Federation for the period 2019-2024, affecting the digitization of the housing and utilities sector.

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