UDC: 711.4:72.01(004.8)

INTEGRATION OF SMART-CITY AND SMART-BUILDING TECHNOLOGIES IN THE ARCHITECTURAL CONCEPT OF INTELLIGENT MULTIFUNCTIONAL BUILDINGS

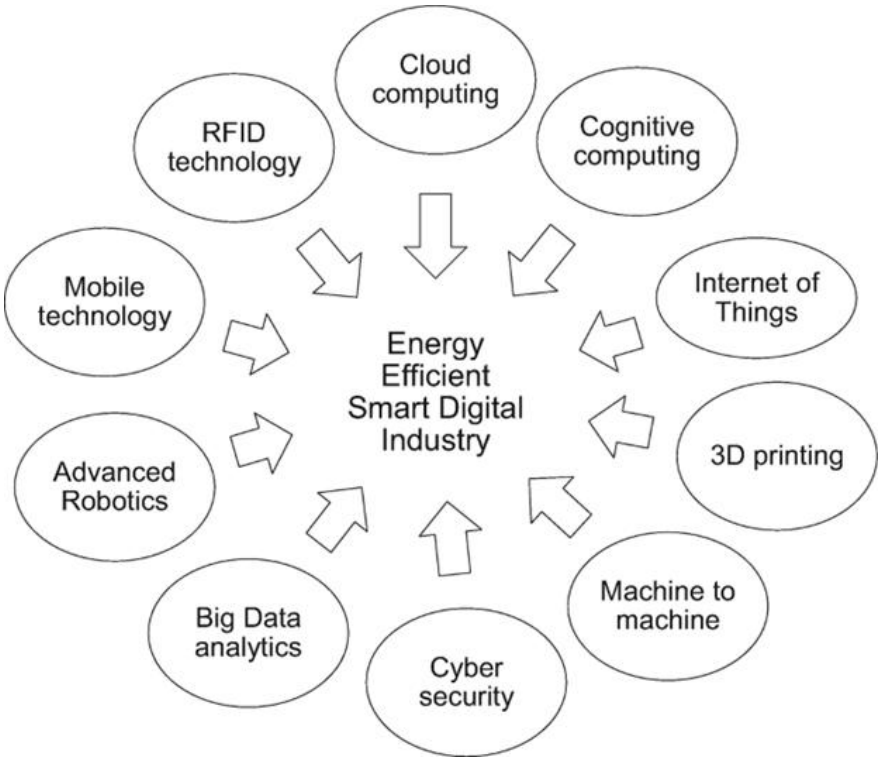
Yorqulov Farrux Isomiddinovich
Lecturer, Samarkand State of Architecture and Construction University

Abstract. Today, digital transformation processes are becoming the main driver of the development of modern architecture and urban planning. The increasing level of urbanization, resource scarcity, and the intensification of environmental problems require innovative approaches to urban management. In this context, the concepts of "smart city" and "smart building" have emerged as important tools for sustainable development. This article provides a scientific analysis of the integration of smart-city and smart-building technologies within the framework of intelligent architecture and examines their role in shaping multifunctional buildings.

Keywords: urban planning, smart city, smart building, architecture, infrastructure, integration, technology, urbanization.

Introduction.

In the 21st century, one of the key trends in urban development is the formation of intelligent infrastructure managed through digital technologies. In conditions of rapidly increasing urbanization, efficient management of urban resources, maintaining ecological balance, and creating a comfortable living environment for the population have become important scientific and practical challenges. In this process, the concept of "intelligent architecture" has emerged and is developing based on the integration of smart-city and smart-building technologies.



Digital technologies have become one of the main transformative factors in the development of modern urban planning and architecture. The rapid growth of the population, the need for efficient use of resources, and the intensification of environmental challenges have led to the widespread adoption of the “smart city” and “smart building” concepts on a global scale. These approaches are considered as complex systems aimed at digitalizing urban infrastructure, optimizing management systems, and creating a comfortable environment for people.

The European Commission defines the smart-city concept as an efficient system for managing urban infrastructure through digital technologies [2]. At the same time, according to the International Energy Agency, buildings account for approximately 30–40% of global energy consumption, which makes the implementation of smart-building technologies a necessity [1].

The concept of a smart city is closely related to the idea of a “smart planet,” which implies the management of urban systems through information and communication technologies. The European Commission defines a smart city as a sustainable urban model based on the integration of transport, energy, healthcare, and utility services [2]. At the same time, the concept of a smart building focuses on automated management at the individual building level, ensuring energy efficiency and user comfort (Figure 1).

Figure. 1. Digital technologies

https://link.springer.com/rwe/10.1007/978-981-19-6778-8_22

Main Part.

The integration of smart-city and smart-building technologies represents one of the most promising directions in the development of modern urban planning and architecture. In the context of rapid digital transformation, cities are increasingly evolving into complex socio-economic and ecological systems, where traditional management approaches are no longer sufficient. From this perspective, the smart-city concept emerges as a comprehensive approach aimed at digitalizing urban infrastructure, ensuring rational use of resources, and improving the quality of life of the population.

Smart-building technologies constitute a key structural component of this system, enabling intelligent control and automation at the building level. The concept of a smart building implies the centralized management of engineering systems within a building based on a unified digital platform. In such systems, heating, ventilation, air conditioning, lighting, energy supply, security, and information-communication networks operate in an integrated manner.

Through sensors and monitoring devices, data are collected and analyzed in real time, allowing for the optimization of energy consumption, reduction of operational costs, and creation of a comfortable and safe environment for users. These buildings are not merely automated structures; rather, they are considered active elements that are closely interconnected with the digital infrastructure of the city.

Within the smart-city framework, urban transport systems, engineering networks, environmental monitoring, public safety, and коммунal services are managed within a unified information environment. The integration of smart-building technologies into the smart-city system transforms buildings from passive consumers of infrastructure into active participants. For instance, the transmission of real-time energy consumption data to urban energy systems enables load balancing. In addition, data on traffic and pedestrian flows serve as valuable inputs for urban mobility planning and optimization.

In the integration process, information technologies play a particularly important role. Artificial intelligence, big data processing, and cloud technologies ensure effective communication between smart-city and smart-building systems. Data collected at the building level are analyzed at the city scale and applied in strategic management decision-making. Simultaneously, city-level forecasts and directives are transmitted back to building management systems, enhancing their adaptability. This process forms a new management model based on two-way information exchange between the city and individual buildings.

The integration of smart-city and smart-building technologies is closely linked to the principles of sustainable development. Energy efficiency, reduction of carbon emissions, and maintenance of ecological balance are key priorities of these systems. Intelligent buildings contribute to urban ecological sustainability by utilizing renewable energy sources and coordinating energy production and consumption. As a result, the efficiency of resource use in the urban environment increases, improving both public health and quality of life.

From a social perspective, integrated intelligent systems significantly enhance convenience and safety for urban residents. Smart buildings can create environments adapted for people with disabilities, the elderly, and children. When connected to smart-city platforms, they enable rapid response in emergencies, efficient organization of evacuation processes, and enhanced security. These capabilities align with the human-centered principles of urban development.

Studies on the integration of smart-city and smart-building technologies reveal that this integration operates as a multi-level system. It occurs at both macro (city) and micro (building) scales. At the macro level, intelligent transport, energy, and utility systems function, while at the micro level, internal building environments are controlled through automated management. The integration of these systems allows for more efficient use of resources. For instance, intelligent energy systems have been shown to reduce energy consumption in buildings by 20–30% [3].

In the concept of multifunctional buildings, these technologies are particularly effective. Such buildings operate as unified systems, integrating residential, office, commercial, and recreational functions. Studies indicate that these complexes reduce the load on urban infrastructure while increasing economic efficiency. The integration of intelligent technologies with architecture encompasses not only technical but also social and ecological factors. According to the World Economic Forum, smart-city technologies can reduce carbon emissions by 10–15% [3].

The integration of smart technologies addresses technical, social, and environmental dimensions simultaneously. World Economic Forum reports suggest that smart-city projects enhance urban infrastructure efficiency and contribute to a 10–15% reduction in carbon emissions, which is a significant factor in combating global climate change [3].

Another important aspect of the intelligent architecture concept is user adaptability. Using artificial intelligence and IoT technologies, buildings analyze user behavior and automatically adjust environmental parameters. For example, lighting levels, temperature, and ventilation systems are managed in real time based on occupants' needs.

However, challenges exist in integrating smart-city and smart-building systems. These include high investment requirements, the complexity of technical infrastructure, and information security issues. The European Commission emphasizes the need for standardization and regulatory frameworks to address these challenges [2]. Furthermore, the human factor is crucial in intelligent architecture. According to Jan Gehl's concept, all technological solutions should be convenient and adaptable for people; therefore, smart systems must be responsive to user needs [4].

In Uzbekistan, initial steps are being taken to implement smart-city and smart-building concepts. In particular, projects in Tashkent focus on developing digital infrastructure, improving energy

efficiency, and introducing modern construction technologies. These initiatives provide a foundation for adapting the intelligent architecture concept to national conditions in the future.

Conclusion.

The integration of smart-city and smart-building technologies represents one of the priority directions in contemporary architecture and urban planning. These systems play a crucial role in improving energy efficiency, ensuring ecological sustainability, and creating a comfortable living environment. Future research and practical applications will focus on further developing these technologies and adapting them to local conditions, making this an important area for both scientific and applied investigation.

References.

1. International Energy Agency. *Energy Efficiency in Buildings Report*, 2021.
2. European Commission. *Smart Cities and Communities Report*, 2020.
3. World Economic Forum. *Smart Cities Impact Report*, 2022.
4. IBM. *Smarter Planet Initiative Reports*.
5. Batty, M. *Smart Cities of the Future*. UCL Press, 2018.
6. Townsend, A. *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*, 2013.
7. Normative documents of the Republic of Uzbekistan concerning digital economy and construction.