TECHNOLOGY, CREATIVITY, IMPLEMENTATION

ENERGY EFFICIENT AND ENVIRONMENTAL FOCUS OF SMART CITIES

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Summary
The idea of creating "green" or "sustainable" cities is aimed at improving and optimizing urban "metabolism" and involves the use of energy-efficient design solutions, "green" materials, and new approaches to urban urbanism.

Some scientific sources give different interpretations of the definition of "smart city", which gives an idea of a more accurate understanding of such innovative settlements. As a rule, the differences in definitions are tied to the diversity of countries. Examples of smart cities are given, which are both successful and unsuccessful examples. In this article, an analysis was carried out using the method of questioning the citizens of Ukraine about the main priorities for defining the concept of a "smart" city. The most popular among the proposed answers were "smart" waste disposal and energy efficiency.

This topic is relevant especially in the context of solving the issues of designing the urban environment, organizing the construction of buildings using environmentally friendly, renewable energy sources using digital technologies of smart cities.

Key words: digital city, smart planning, urban software, multifunctional system, resident's, innovative technology.

1. Introduction

The world is changing, and the needs of the population are changing, so the creation of smart cities is a challenge of the times. The development of such innovative settlements requires the complete modernization of all areas of activity and the introduction of the latest technologies.

Cities are important centers of human activity, which are of increasing importance for the population and an increasing importance in the global economy. Smart cities are increasingly

appearing as bright markers on our planet, producing new ideas and urban planning standards and are not a frozen utopian model, but a dynamic, transforming process. But there are problems related to the impossibility of large-scale implementation of the concept of a smart city in terms of high costs of paying for services, which are inaccessibly to people with a low standard of living, transportation, and privacy, which have yet to be solved. While the digital revolution offers an unprecedented window of opportunity to improve the lives of millions of city dwellers, there is no guarantee that the rapid spread of new technologies will automatically benefit citizens across the board. Smart city policies should be designed, implemented, and monitored as a tool to improve the well-being of all people. Therefore, smart cities will improve as technology advances and the people who are interested in building it. Thus, speaking of a smart city, we mean an intelligent, networked, space in which, due to digital communication technologies, various urban infrastructure systems are integrated, such as: economy, electricity, water supply, mobility, healthcare, security, services, industrial enterprises, etc.

Over the past decade, various government, scientific and private laboratories, to improve the city and the quality of life of its population, began to develop intelligent city technologies, as well as Internet portals. As a result, it became possible not only to competently program urban infrastructures (urban software), to involve and inform the population in this process but also to create environmentally friendly cities.

According to WHO, by the 30 s. XXI century more than 60% of the world's population will become urban dwellers. Such a rapid level of urbanization can cause excessive pressure on urban infrastructure and cause environmental problems *(Hollands, 2018)*. Reduce the potential risks that are bound to arise in overcrowded cities, perhaps by bringing the concept of a smart city to life. Also, thanks to the "smart city", it is already possible to significantly improve the lives of people living in million-plus cities, large agglomerations, and small towns.

In 2016, close to 4 billion people – 54 percent of the world's population – lived in cities. According to the World Bank, in the last 50 years, the proportion of the population living in cities has increased by 50 percent, and it is estimated that, by 2050, 6 billion people will be living in cities (66 percent of the world's population). Africa and Asia, in contrast, remain mostly rural, with 40 percent and 48 percent of their respective populations living in urban areas. Over the coming decades, the level of urbanization is expected to increase in all regions, with Africa and Asia urbanizing faster than the rest *(Komninos, Kakderi, Panori, Tsarchopoulos, 2018)*. Such urbanization and increased population density "stimulates" the creation or transformation of cities of the past into modern smart cities.

Over the past years, many scientific articles have been published on the concept of forming a smart (Komninos N., Shannon Mettern, Kurtit K. and other) city in the context of determining the benefits of implementing this idea, and some scientific articles also consider this concept from the standpoint of criticism (Hollands R., Shannon Mettern, and other). The main idea of this article is to identify the advantages and disadvantages of the concept of creating smart cities, based on the public opinion of the residents themselves.

2. Definitions of smart cities

The concept of a smart, electronic, or digital city began to take shape at the beginning of the 21st century, when it became clear to the world's leading urbanists that without the use of IT technologies, megacities become unmanageable monster territories with poor ecology, absorbing huge natural resources.

Looking at history, one can make the argument that the greatest periods of economic growth and productivity have occurred when scientists have integrated innovation into the physical environment, especially in cities. The steam engine, electricity grid, and automobile all fundamentally transformed urban life, but we haven't really seen much change in our cities since before World War II. If you compare pictures of cities from 1870 to 1940, it's like night and day. If you make the same comparison from 1940 to today, hardly anything has changed. Thus, it's not surprising that, despite the rise of computers and the internet, growth has slowed, and productivity increases are so low. Therefore, the main mission of modern urban planning is to accelerate the process of urban innovation *(Mettern, 2017)*.

The smart city sustainable concept is still in flux and subject to debate. Definitions of smart cities vary across OECD countries and institutions according to the geopolitical context and the specific issues at hand (Table 1).

The literature reveals three types of drivers of smart cities–community, technology, and policy–which are linked to five desired outcomes–productivity, sustainability, accessibility, wellbeing, livability, and governance. These drivers and outcomes altogether assemble a smart city framework, where each of them represents a distinctive dimension of the smart city's notion *(Yigitcanlar, Kamruzzaman, Buys, Ioppolo, Sabatini-Marques, Moreira Da Costa, Yun, 2018)*.

The prefix "smart" means that residents, using technologies and online applications, can regulate the amount of energy and water they consume, they can remotely control the turning on and off household items in the house, and remotely register in honey. institutions and so on.

Megacities are learning to provide additional services to their residents, trying to make their lives easier, safer, and more comfortable.

This combination of factors has led to the need to find new solutions, and new paradigms for the relationship between the city and its population. Cities are forced to move from the format of an impersonal "territory for survival and satisfaction of the basic needs of residents" to the format of self-identification of the city as a "living being", recognizing residents as subjects, not objects of urban life – and, as a result, to interactive communication of the city with such subjects, as a collective differentiated mind. In other words, to turn a "smart" city, into a Smart City *(Kurtit, Nykamp, 2012 & Krazhan, 2019)*.

Today, a smart city is a multivalued concept that includes a wide range of sometimes contradictory definitions. To the definition of the European Commission, "a smart city is a place where traditional infrastructure and services become more efficient using digital technologies for the benefit of its residents and businesses. But now, to use resources more efficiently and reduce emissions, the smart city is already moving beyond digital technology alone, which means smarter city transport networks, upgraded water and waste management systems, and more efficient ways to light and heat buildings. It also means more interactive and flexible city administration, safer public spaces, and meeting the needs of an aging population *(Albino, Berardi, Dangelico, 2019)*.

Now there are several dozen large cities in the world in which elements of a "smart city" have been introduced. These are Barcelona, Nice, New York, Chicago, Singapore, San Francisco, Copenhagen, Hamburg, and others. Barcelona is distinguished by the fact that from the very beginning a truly integrated approach was implemented there, the concept of a "smart city" was created, and all elements work without duplicating the structure. A whole new eco-smart city is now emerging in Singapore. Also known as the forest city, this new location will become a real refuge of nature. The new city aims to improve the health and well-being of residents, paving the way for a better future. In his new avatar, the forest city will become an example of a good and clean life *(Batty, Axhausen, Giannotti, Pozdnouhov, Bazzani, Wachowicz, 2012)*.

Table 1

Selected definitions of "smart cities"

Country	Definitions	Organization official representative
Denmark	"Smart City" as an evolving concept: "Initially, the concept was only used in a narrow and governmental context especially in relation to environmental, energy and infrastructure issues in terms of how information and communication technologies can improve urban functionality. Subsequently, virtually all other areas of welfare started working with Smart City, for example in business development, innovation, citizen involvement, culture, healthcare, and social services, where the use of data and digital platforms helps smart new solutions."	The Ministry of Transport, Building, and Housing and the Danish Business Authority
Latvia	"Smart City" is a city that implements a strategic package of measures to address the most pressing challenges and boost the competitiveness of the area, providing solutions for citizens and entrepreneurs, inter alia such measures which i) do not require substantial maintenance in the long term (save resources).	The Ministry of Environmental Protection and Regional Development
Spain:	"The Smart City concept is a holistic approach to cities that uses ICT to improve inhabitants' quality of life and accessibility and ensure consistently improving sustainable economic, social, and environmental development. It enables cross-cutting interaction between citizens and cities, and real-time, quality-efficient and cost-effective adaptation to their needs, providing open data and solutions and services geared towards citizens as people."	The Spanish government works, Spanish Association for Standardization and Certification
United Kingdom	"The concept [of the smart city] is not static: there is no absolute definition of a smart city, no end point, but rather a process, or series of steps, by which cities become more "live able" and resilient and, hence, able to respond quickly to new challenges."	The UK Department of Business, Energy and Industrial Strategy

Building from scratch may be easier, but usually about three times more expensive than the regeneration of old districts, Smart City technology can be adapted to existing cities. This will need to be adapted to address contextual and governance issues, but all urban regeneration issues are easier to address with Smart City technology. In order to create more appreciation and accountability in the Smart City paradigm, a simpler framework is proposed, applicable to newer and more mature cities and, in fact, to all forms of the urban fabric, to show how a Smart City can achieve a broader goal of the UN SDG on building "inclusive, safe, resilient and resilient" cities.

3. Energy efficient and environmental focus of digital cities

Speaking about smart cities, one should focus on the environmental focus. The authors of this article in some publications addressed the topic of energy efficiency and energy saving. Consequently, there are no doubts about the relevance of establishing building constructions with the usage of environmentally friendly and renewable sources of energy. It can be achieved in contemporary architecture and construction. Ways to achieve it are: improving

architectural and planning solutions; using external constructions with the necessary level of thermal protection for building envelope; implementing efficient microclimate and energy saving systems in buildings; usage of renewable sources of energy; quality improvement of building design. The transition to such types of buildings can significantly decrease fuel and energy consumption, lower the costs of energy, and reduce greenhouse gas emissions *(Apatenko, Bezlyubchenko, 2019)*.

Smart planning will increase the ongoing efforts and experience of building corporations to provide residents with well-designed homes located in a green and mature city. The use of computer modeling and data analytics will enable construction companies to improve the way they plan and develop their cities, neighborhoods, and buildings, as well as obtain optimal and cost-effective solutions to achieve sustainable development goals.

As urbanization increases, people around the world are tired of seeing precious natural habitats paved with toxic, energy-intensive materials like concrete and steel, according to scientists at the Yale University Center for Ecosystems in Architecture. In the 21st century, the global building practice must innovate toward nature-based solutions for the cities of the future *(Amonov, Nishonov, 2020)*.

Smart cities are usually created in new locations around current cities, in the modernist tradition of new cities. The emergence of new cities close to existing cities poses the risk of encouraging urban sprawl and, as a result, car dependency, consumption of fossil fuels, and unhealthy lifestyles *(Allam, Newman, 2018)*. Information infrastructure can mitigate air pollution levels, information infrastructure mitigates air pollution levels by influencing technological innovation first and then industrial structure upgrading *(Yong; Fan; Weipeng 2022)*.

In 2019, the EY Start-up Accelerator team conducted a survey among residents of Ukrainian cities to determine what exactly they understand by the concept of a "smart" city, what components the components of such a concept, in their opinion, and whether residents enjoy the benefits of a "smart" city cities.

Each of the respondents had the opportunity to choose 5 priority options, which, in his opinion, are most suitable for defining the concept of a "smart" city. The proposed options included both specific manifestations of a smart city (for example, smart parking or smart lighting), and fundamental, broader categories of this concept, covering these and other areas (IT infrastructure, big data analytics, etc.). In addition, respondents could indicate their own version.

Several questions were asked, all the respondents who received one or more options on a preliminary basis: "smart" waste management' (95 people), "energy efficiency" (90 people), and "IT infrastructure" (but 67 people) (Fig. 1–4).

These studies once again confirm the importance of using energy-efficient technologies in construction, especially in residential and civil buildings.

The goal of smart homes is to create a sustainable multifunctional system for effective digital building management to measure, evaluate and optimize the baseline values of energy consumption, lighting, and temperature through the implementation of appropriate technology solutions, as well as an innovative approach to the provision of services to create comfortable places to live and work, manage resources and costs in the most efficient way.

Actual assumptions imply cost savings of 13 to 66% on energy consumption, 24 to 32% on the implementation of an adaptive ventilation system and expected savings from combining all relevant technologies.

Creation of the necessary set of technologies for effective monitoring, reporting, and optimization of energy production and consumption using renewable energy and insulation technologies, waste management systems, water, gas, and ventilation.
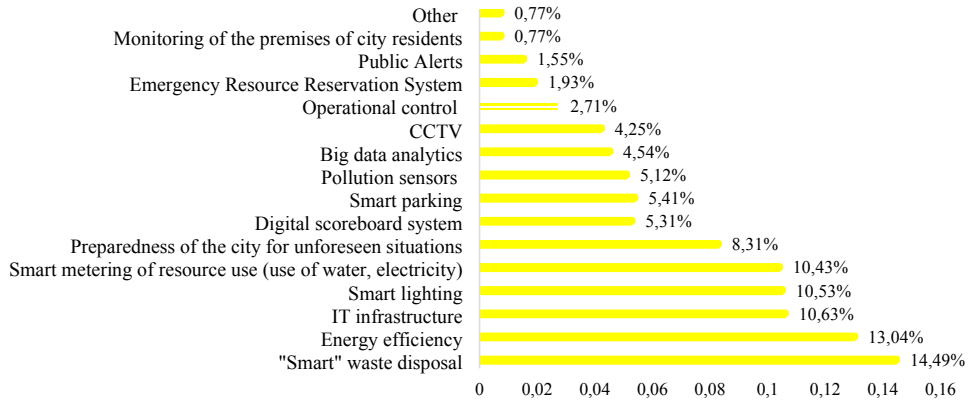
Fig. 1. Citizen survey schedule: What does a smart city mean to you in the first place?
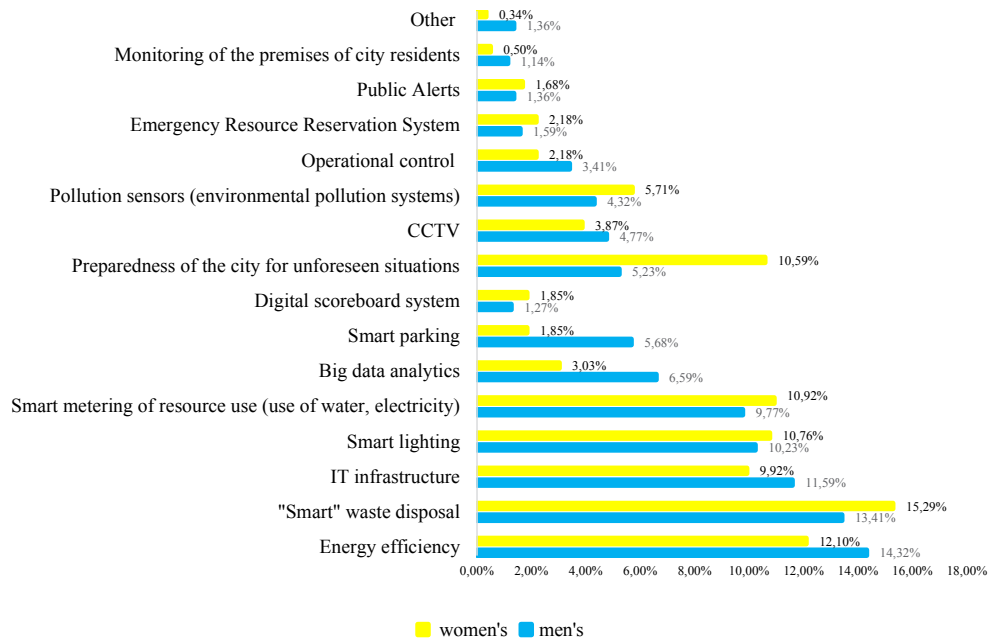

**Fig. 2. Citizen survey schedule: Monitoring of the premises of city residents.
The ratio of men's and women's answers to the question:
"What does a smart city mean to you first of all?**

Integrated systems allow you to collect, analyze and store a lot of data that can be turned into real data for predictive purposes and actual values for decision-making.

The use of solar panels is an integral part of a smart city. Solar panels are installed on the roofs of buildings, which can provide autonomous power supply to individual apartments or houses, depending on their size (Fig. 5).
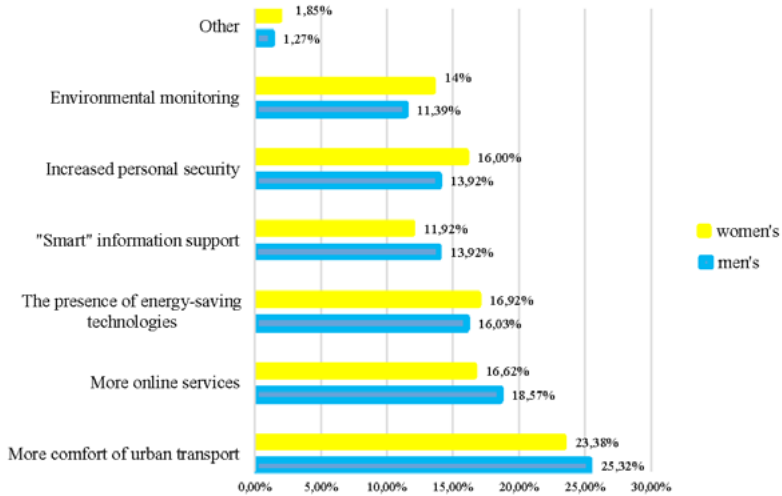
**Fig. 3. Citizen survey schedule:
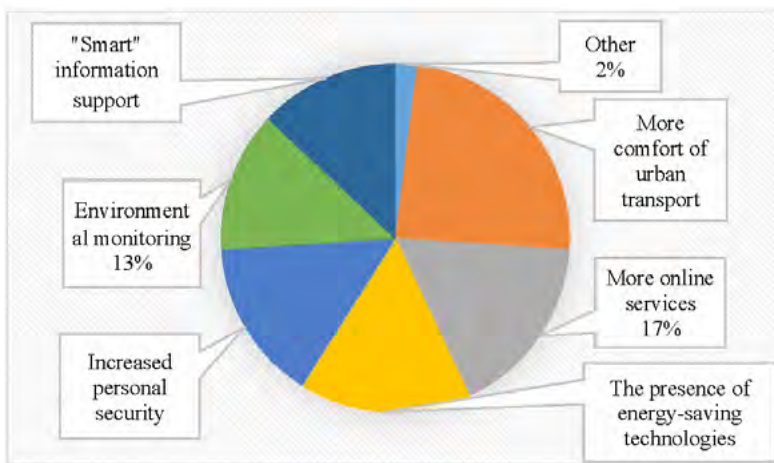Distribution of answers among respondents by gender**

**Fig. 4. Citizen survey schedule: What do you no longer have enough
for a more comfortable life in your city?**

Also, entire cities can be powered by solar farms day and night, storing excess energy with special lithium-ion batteries (Fig. 6).

Energy efficiency should be the main driver of investments, which represent a significant part of the total costs and be economically justified (based on a qualitative or quantitative assessment) over the life of the project.

The project should be an integral part of the local urban development strategy.

Architecture must address the global problem of housing by integrating critical scientific and technological advances in energy, water, and material systems while remaining sensitive to the cultural and aesthetic aspirations of different regions.

**Fig. 5. ENL Moka Smart City; ENL:
Мока, Mauritius**

Source: Allam, Newman, 2018

**Fig. 6. Yihai Smart City, Pailles,
Mauritius**

Source: Allam, Newman, 2018

The implementation of the concept of a smart network – the only system for introducing innovative technologies in all spheres of society – is a challenge of the times. Achieving a high level of development according to the indicators of a modern smart city depends on resource provision and the utmost willingness to invest in smart technologies. Investments in the development of a smart city are focused on achieving long-term results, i.e., the expected effects of such investments are strategic. In conclusion, it can be noted that the concept of a smart city requires further research and values guiding the results of smart technologies.

4. Conclusions

The creation of smart cities will be able to prevent in the future many problems associated with urban overpopulation, environmental problems of large cities, improving the living conditions of the population by creating a comfortable home, etc. The benefits of smart technologies are countered by skepticism about capital investment in innovation and communication technologies, which indicates that in the near future, such innovations will further spread to all spheres of life of the world's population.

The following conclusions were made. First, smart city pilot projects will have a positive impact on regional economic growth, but with a time lag. Secondly, the market and infrastructure influence regional economic growth. Third, capitalizing on the newly created market, several cities with smart industry foundations have developed rapidly.

Over time, an increasing number of smart cities will benefit from built smart infrastructure projects. This study suggests that smart cities can become a new model for regional economic development through market and infrastructure effects.

During the study, the main tasks of smart cities were systematized, their priority based on publicity – a survey of certain groups of society, based on which three main priorities were identified: "smart" waste management', "energy efficiency", and "IT infrastructure". In conclusion, it should be emphasized that the authors intend to continue to conduct research in the field of energy efficiency of buildings using green technologies, following the concept of smart cities.

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