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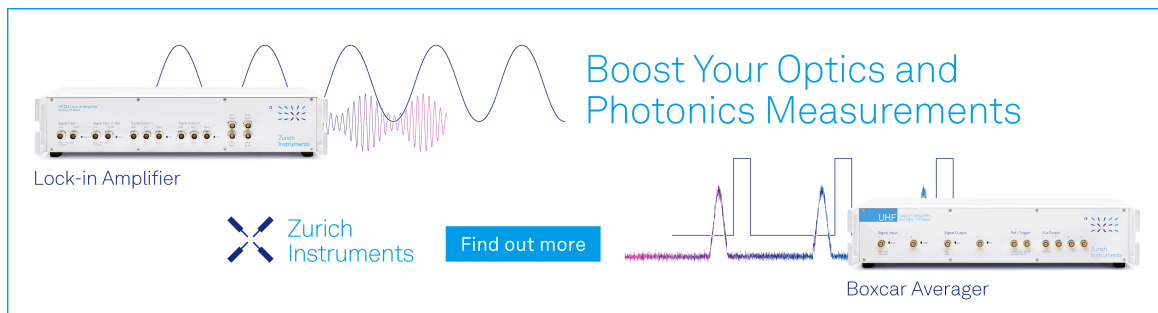
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Quantitative Assessment of a Smart City on the Example of Ekaterinburg

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Abstract. The article presents the «Concept of the project of digitalization of urban economy Smart City» adopted by the Ministry of Construction and Housing of the Russian Federation in December 2020 as a basis for the systemic development of smart cities in Russia. Unique methods based on parameters for quantitative assessment of the effectiveness of the changes, such as the urban environment quality index and the city IQ indicators of smart cities are presented. These parameters made it possible to analyze the level of implementation of smart city technologies in Ekaterinburg and to position it as a city with a high rating among Russian cities, with comfortable and safe living conditions for citizens.

INTRODUCTION

The concept of "smart city" involves the widespread use of information and telecommunication technologies in all spheres of city management, including transport, housing and communal services, security, health care, ecology, economy, education, tourism and others. The concept of "smart city" refers to the analysis of data coming from various urban systems for making management decisions for economic development and ensuring high living standards for citizens.

The concept of a smart city was formed in the early 2000s and went through a number of stages. The systemic view of a smart city, first presented most fully in 2006 by IBM, has changed in the process of its evolution, transforming from a technocratic definition to a more humanitarian one, in which a citizen himself is actively involved in the process of city management. A number of concepts have emerged that define technologies that affect the level of intellectualization of the city. The very concept of Smart City was fixed in international regulations in 2014: the dictionary of smart cities "BSI PAS 180-2014 Smart cities. Vocabulary" contains a wide range of terms and phrases used to discuss smart city systems [1].

In the study of the Center for Strategic Research, based on the analysis of world practice, three conditional stages of the formation of smart cities are identified [2], reflecting the change in key technologies and types of projects being implemented. Smart City 1.0 is focused on new technologies, the physical infrastructure is being re-equipped, and individual IT solutions are being implemented. The main stakeholders are solution and service providers. Smart City 2.0 is a high-tech driven city. Technologies are being used to improve the quality of life and solve problems in the fields of health, transportation, the environment and ecology. The Internet of Things, the 4G mobile radio standard, high-speed and mobile Internet access are being introduced. The main role in the development of the city is assigned to the city authorities. And finally, Smart City 3.0 is a highly intelligent integrated city that allows real-time data collection and analytics, and process management in all areas of infrastructure. This unified system contributes to the involvement of citizens in the development of the city. For example, in 2014, the Moscow government launched the

Active Citizen system to collect public opinion on topical issues in the city. In Ekaterinburg, it is planned to make a full-fledged analogue of this system, currently a beta version has been developed [3].

Thus, in modern readings, the concept of Smart City is not limited to technology as the main factor of development. Cities are considered to be truly smart if they have all the conditions for the growth of human capital. The modern smart city model provides not only various ways of using intelligent technological solutions, which was emphasized in the early models, but also the active involvement of residents in their development. A modern smart city is a municipality with a well-developed technological infrastructure, where human life takes on a new quality thanks to smart solutions.

In December 2020, the Ministry of Construction and Housing of the Russian Federation approved a document entitled "Concept of the project for digitalization of urban economy Smart city" [4]. The concept formulates key terms, the goals of the project, the challenges that cities face when introducing technologies, the expected effects from the implementation of events, explains the main advantages of a smart city for residents, business and the state, and also determines the sequence of digitalization stages. The document was prepared taking into account international experience, current challenges and current trends. The principles for the implementation of the project were approved, including the orientation of the city to human needs, the formation of a stable and safe urban environment, increasing openness, accessibility and convenience of services, as well as the priority of long-term solutions, rather than short-term benefits.

In recent years, a number of national programs and projects of various levels have been adopted to solve the urgent problems of digitalization of cities. As part of their implementation, experts under the auspices of the Ministry of Construction and Housing of the Russian Federation have developed unique methods based on parameters for quantifying the effectiveness of the changes, such as the urban environment quality index, the city IQ, the results of which have been summed up since 2018. In 2017, the results of one of the first studies to quantify the implementation of smart technologies in Russian cities were published by the Moscow Research Institute of Technology and Communications (NIITS) "Smart Cities Indicators" [5].

Further, on the basis of these methods, quantitative estimates for Ekaterinburg will be shown in dynamics, behind which there are significant qualitative changes in the life of citizens as a result of the transition to digital technologies. In 2018, the official portal of Ekaterinburg published the results of a sociological study by the Financial University under the Government of the Russian Federation of the quality of life of the population in 78 cities of Russia with a population of more than 250 thousand people [6]. Ekaterinburg was recognized as one of the 10 cities with the highest quality of life in the country. The study took into account such parameters as the quality of medical care, the state of the road infrastructure, the development of culture and education, the work of housing and communal services and the volume of housing construction, and the work of the city authorities.

Support of The "Smart City" Project at The Government Level

The "Smart City" project of the Ministry of Construction of the Russian Federation was developed as a part of the national project "Housing and Urban Environment", which is a part of the national program "Digital Economy of the Russian Federation". In October 2018, the order of the Ministry of Construction of Russia No. 695 / pr "On approval of the passport of the departmental project for digitalization of the urban economy Smart City" was signed. In 2019, the Order of the Ministry of Construction of February 4, 2019 No. 80 "On the organization of the implementation of the Smart City project and on the procedure for organizing the selection of pilot implementation projects" came into force. In March 2019, the document was signed – "Smart City Standard", on the basis of which regional standards are formed. The Internet portal "Smart City" [7] contains up-to-date information on this project – documents, information materials, including the "Smart City Solution Bank", which receives ready-made solutions in such areas as energy efficiency, safety, waste management, water, energy and heat supply, transport, construction, ecology, information city.

The foreign analogue of the bank of smart city solutions can be considered the information system of smart cities "EU Smart Cities Information System" (SCIS) [8], which contains projects funded by the EU. It is a knowledge platform for collaboration to create smart cities that provide a high quality of life for citizens in clean, energy efficient and supportive urban environments. The information system brings together project developers, research institutes, industry, experts and citizens from all over Europe. The presented projects are aimed at the development of sustainable

energy, strategic sustainable urban planning, energy efficiency in buildings, environmentally friendly modes of transport, the development of information and communication technologies.

On December 25, 2020, the Ministry of Construction of Russia, by order No. 866 / pr, approved the Concept of the Smart City Digitalization Project. When developing the document, the experience of Russian and foreign concepts and strategies of smart cities, such as the United Nations, Moscow, Singapore, India, France, Catalonia, was taken into account. In 2021, the Concept becomes a fundamental document for the further development of smart cities. We will briefly present the main provisions of the Concept as an integrating basis for this research.

The Concept says that a common information field is being created for the project participants. The Smart City project is currently being implemented in 209 selected cities in Russia. The introduction of urban technologies should be inextricably linked with the solution of key problems of citizens, and local governments should understand which direction to make a priority. First of all, you need a basic infrastructure - sensors and modern communication networks, you need an understanding of the architecture of smart cities. The concept should become a common document that can be consulted in the development of digitalization programs and the introduction of technologies in various areas of the urban economy.

The concept is divided into three sections. The first section defines the terminology, goals and principles of implementation, the architecture of a smart city. The second specifies the directions of the project. The third describes the organizational mechanism for the implementation of the project until 2024.

Of the main concepts that are defined in the Concept (urban environment, services, services, public spaces, spatial development, etc.), here we give two: the definition of a smart city and its architecture.

A smart city is an approach to city development that uses digital tools to improve living standards, quality of services and management efficiency while meeting the needs of present and future generations in all relevant aspects of life. A smart city is characterized by functioning highly intelligent integrated systems in the following areas: urban environment, safe city, digital urban governance, investment climate, human well-being.

Smart city architecture is the basic organization of the elements of a smart city such as information systems and platforms, databases, workstations embodied in their own components and their relationships with each other; associated with the environment (standards and rules for the exchange and use of data, regulations for access levels, etc.), as well as with the principles and standards that determine the design and development of the information system.

Smart city architecture assumes a three-tier organization. At the first basic level, a complex of hierarchical models is being developed for the interaction of information systems: information (data), physical (sensors, networks, storage), logical (the logic of interconnection of systems and the logic of processes within the system) infrastructure and a conceptual model that represents all systems of a smart city. The second level is providing, these are services for the maintenance and control of the timing and quality of services. And the third level is directly the electronic services themselves and services for individuals and legal entities.

A set of services covers all aspects of city life. These are smart housing and communal services (energy metering systems, monitoring of the operation of municipal equipment, automated control of outdoor lighting, management of heating networks, etc.); sustainable transport system (transport monitoring, forecasting passenger traffic, intelligent traffic control, parking management, etc.); safe city (public safety: intelligent video surveillance, alerts; transport safety: video monitoring, accident analysis; environmental safety: remote monitoring of air and water quality, predicting pollution risks). Smart city management ensures the coordinated work of government agencies. The objects of management are urban planning, public services, synchronization of the work of different services and departments. Open government relies on digital platforms to engage citizens in urban development. An important place is occupied by issues of human well-being: services for remote diagnosis of diseases and receiving medical services, social support, digitalization of schools, museums, solutions for the development of tourism. For the stability of the economic system, it is necessary to develop services for small and medium-sized businesses, industry, business incubators, data collection systems for the analysis of investment-attractive zones.

The principles of the Smart City project form its value basis:

- human orientation;
- formation of a sustainable and safe urban environment;
- maintaining a balance of interests, development principles and opportunities;
- availability and convenience of services;
- integration, interaction and openness;

- continuous improvement of management quality;
- emphasis on economic efficiency;
- the primacy of long-term decisions over short-term benefits;
- application of the best available technologies.

MEASURABLE PARAMETERS FOR ASSESSING SMART CITIES

Smart City Indicators

Fifteen million-plus cities participated in the NIITS study to assess the implementation of smart technologies in Russian cities "Smart Cities Indicators": Moscow, St. Petersburg, Novosibirsk, Ekaterinburg, Nizhny Novgorod, Kazan, Chelyabinsk, Omsk, Samara, Rostov-on-Don, Ufa, Krasnoyarsk, Perm, Voronezh, Volgograd and 16th – Sochi. The indicators were compiled on the basis of data obtained from open sources for 26 indicators characterizing the level of development of 7 key areas of a smart city. Key areas include: smart infrastructure, smart economy, smart finance, smart governance, smart residents, smart technologies, and smart environments. All directions are characterized by a set of indicators. For example, the direction of smart environment is measured by the level of activity of residents and the city administration in the elimination of illegal landfills and the level of development of systems for monitoring and preventing threats to environmental safety.

A comparison was made between cities in terms of the degree of implementation of smart technologies. In terms of the integral indicator, Ekaterinburg is in 4th place after Moscow, St. Petersburg and Kazan and, along with Kazan, is included in the group of effectively developing cities. In such areas as smart finance, economics, technology, smart residents, Ekaterinburg occupies high positions. According to the indicator "The number of ATMs relative to the city area", it is in the first place. Ekaterinburg took the second place in terms of the number of visitors to the official web portals of the city administration for the year relative to the population of the city. As for such areas as smart management, smart infrastructure and smart environment, which characterizes the ecological state, the city is on the average and below the average level.

Urban Environment Quality Index

The quality index is a tool for assessing the quality of the material urban environment and the conditions for its formation, and at the same time, it is a global systematization of data. The methodology was developed within the national project of the Housing and Urban Environment to assess the effectiveness of the changes being made by the Ministry of Construction and Housing of the RF. The methodology is based on 45 Russian and international assessment systems, taking into account four main criteria: safety, comfort, environmental friendliness, identity and diversity. Among the index criteria and guidelines for improving the urban environment, visual, acoustic and climatic comfort, cultural diversity and diversity of space types, air quality, landscaping, waste disposal efficiency were taken into account.

The urban environment quality index is determined for each Russian city on the Internet portal [9]. Here, on an interactive map of the Russian Federation, you can see the value of the index for each Russian city. The cities are divided into 10 size and climatic groups. The index takes into account 36 indicators, each of which is estimated at 10 points, thus, the total settlement can be assigned 360 points. In cities with more than 180 points, the urban environment is considered as favorable.

The index was calculated for the first time in 2018. Then the share of cities with a favorable urban environment was 23%, the average score in Russia was 163. Thanks to the data obtained from this study, many cities were able to identify development priorities and make the necessary management decisions. As a result, in 2019, the share of Russian cities with a favorable environment for citizens' life was 26.9% (299 out of 1115). The average value of the urban environment quality index reached 169 points against the planned indicator of 166. The greatest positive dynamics was noted for such criteria as improving the appearance of cities, reducing emergency housing stock, creating a barrier-free environment. In 2020, the share of Russian cities that are comfortable for living increased over

the year from 26.9% to 33.6%. The national average value of the index increased by 4% in 2020 compared to the previous year and reached 177 points. 375 out of 1116 Russian cities have become comfortable.

In 2020, among the million-plus cities, 8 cities became favorable for life: Moscow (288), St. Petersburg (249), Kazan (204), Nizhny Novgorod (201), Rostov-on-Don (200), Ekaterinburg (194), Ufa (189) and Krasnoyarsk (181), the number of points is indicated in brackets. The rating remained unchanged compared to 2019, with all the leading cities increasing their indicators accordingly. Ekaterinburg in 2019 had 188 points and also took 6th place, and in 2018 it was in 3rd place with 191 points.

The detailed presentation of the index, which is calculated for all cities and presented on the portal in the form of infographics, allows to identify the directions in which the city is developing dynamically, and in which it lags behind. The index is calculated for 6 spaces, each space is evaluated by 6 criteria with an assessment of up to 10 points each, from which 360 is added. The spaces are listed in the first column of Table 1, and the criteria are as follows: safety, comfort, environmental friendliness and health, identity and diversity, modernity and relevance, management efficiency.

Table 1. Evaluation of Ekaterinburg spaces in dynamics from 2018 to 2020.

City spaces	2018	2019	2020
Accommodation and adjacent spaces	43	42	45
Street and road network	36	35	41
Green spaces	17	21	22
Public and business infrastructure and adjacent spaces	27	27	22
Social and leisure infrastructure and adjacent spaces	26	29	29
Citywide space	42	34	35
The amount of points for the year	191	188	194

As we can see, improvements have occurred in such areas as housing and adjacent spaces, street and road network, landscaping and the development of social and leisure infrastructure, while the assessment of public and business infrastructure and city-wide space has decreased. Such a structuring of urban spaces and their assessment make it possible to determine the quality of the changes being made and to find a solution to the identified problems.

IQ of Cities

The index of digitalization of urban economy "IQ of cities" was developed by the Ministry of Construction of Russia together with the Moscow State University in the Smart City project. It was first defined in 2018, and these metrics provide a baseline benchmark. The indicator, which was obtained in 2019, shows the effectiveness of the measures that cities have implemented under the departmental project "Smart City", and allows you to identify promising directions for their further development.

The IQ index reflects the results of the digitalization of the urban economy of 191 cities – these are cities with a population of over 100 thousand people and administrative regional centers that by default participate in the Smart City project, as well as pilot cities with a population of less than 100 thousand people that participated in the calculation of the index on its own initiative.

The accepted methodology for calculating the IQ of cities index assumes the division of cities into 4 groups by population size by analogy with the calculation of the urban environment quality index: the largest cities (from 1 million) – there are 15 such cities, large cities (from 250 thousand people to a million) – 63 cities, big cities (from 100 to 150 thousand people) – 93 cities and 20 cities with a population of less than 100 thousand people, these are administrative centers participating in the Smart City project, as well as municipalities participating in pilot projects.

The methodology for calculating the IQ index of cities was approved by order of the Ministry of Construction of Russia dated December 31, 2019 No. 924 / pr "On Approval of the Methodology for Assessing the Progress and Efficiency of the Digital Transformation of Urban Economy in the Russian Federation (IQ of Cities)" [10], approaches to its determination were discussed with the expert community, representatives of regions and municipalities participating in the project. After testing and refinement, the IQ of cities will be synchronized with the urban environment quality index.

The city's IQ index is an integral indicator, which is calculated based on the values of sub-indices, there are 47 indicators in total, which are an assessment of the development of 10 areas of digital transformation of the urban economy:

- city government;
- innovations for the urban environment;
- intelligent public safety systems;
- communication network infrastructure;
- housing and utilities;
- urban transport;
- intelligent systems for environmental safety;
- tourism and service;
- intelligent systems of social services;
- economic condition and investment climate.

Report-2018 [11] contains the results of calculating IQ indices for the cities participating in the program. In the group of the largest cities, Moscow, Kazan and St. Petersburg are leading, the last 15th place is taken by Ekaterinburg. But if we turn to the results of assessing the progress and effectiveness of digital transformation for 2019 [12], we can see that the top three have changed: Moscow, Ekaterinburg, Kazan. The dynamics of the Ekaterinburg index in relation to the base value of 2018 is 37%, which is more than in all other cities.

CONCLUSION

Modern information technologies, implemented in the form of “Smart City” managed platforms, make it possible to realize comfortable and safe conditions for the life of citizens, form an effective system for managing city resources and improve the quality of life. Of interest is the possibility of quantitatively assessing the effectiveness of the changes being made: indicators of smart cities, the quality index of the urban environment, the IQ of the city. On the example of Ekaterinburg, the corresponding techniques and the results of their application were shown. These indicators make it possible to identify the strengths and weaknesses of the changes being made and to determine the vectors of further development.

Ekaterinburg takes leading positions in all the above ratings. In the article [13], you can find a list of smart solutions implemented in Yekaterinburg, as well as those that can be implemented and to a greater extent reveal its potential.

In the strategic development plan of the city, Ekaterinburg is defined as an interregional industrial and financial center, aimed primarily at innovative development. Digitalization of urban economy in the form of a platform Smart city is designed to play one of the leading roles.

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