Intelligent municipal system and sustainable development of the urban environment: conversion prospects

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Abstract. This article raises the problem of rapid development of cities, conditions for comfortable living, management of urban infrastructure and urban planning. Smart city is a tool for achieving strategic goals of socio-economic development of the city. Identified and described indicators characterizing the development of key areas of smart city: the environment, infrastructure, urban planning, construction and architecture. Also, the authors developed a method of improving the energy efficiency of the housing stock on the example of Rostov-on-Don and recommendations for improving its energy efficiency.

Introduction
The continuous growth of the population, the deterioration of the urban administration and the high consumption of resources when it is necessary to reduce it are the main problems faced by most cities. At such high rates of urban growth, conventional methods of regulation by urban and municipal services have almost exhausted themselves and do not meet modern safety, logistics and environmental requirements [1].

The problems of rapid development of cities, creation of comfortable conditions for the population and management of urban infrastructure can’t be solved without the use of modern information technologies and because of the innovative, modern paradigm of smart city [2].

The main projects affecting the development of information technologies are the state program "Information society (2011-2020)", which was based on the Federal target program "Electronic Russia", "Strategy for the development of the information society in the Russian Federation for 2017-2030" and the program "Digital economy of the Russian Federation". These projects play a key role in the implementation of modern information systems in state and municipal authorities. The use of information technology will improve the efficiency of management [3].

Smart city is a systematic approach to the use of information technology based on data analysis to provide services for the management of natural, energy and urban resources that contribute to sustainable economic development and high standards of living.

Energy efficiency as an indicator of smart city
The concept of smart city is based on the extensive use of information and telecommunication technologies in all areas of city management, including transport, housing and communal services,
security, health, environment, economy, education and others. Analysis of data from different urban systems is needed for management decision-making, sustainable economic development and high standards of living.

The methodological base of indicators of smart city is based on the strategy of socio-economic development. Indicators of smart cities in the framework of a unified urban space – the phenomenon of systemic, integrative, and interdependent [4]. Table 1 offers indicators that characterize the development of 4 areas of smart city.

**Table 1. Indicators of smart city**

| №  | Area              | Indicators                                                                 |
|----|-------------------|-----------------------------------------------------------------------------|
| 1  | Environment       | Application of green building standards                                      |
|    |                   | Systems of monitoring and prevention of threats to environmental safety     |
| 2  | Infrastructure    | Use of geographic information systems and databases for integrated infrastructure assessment |
|    |                   | Information management systems for urban space development                  |
| 3  | Urban planning    | Development of territorial planning documents                               |
|    |                   | Information system for urban development                                    |
| 4  | Construction and architecture | Use of BIM (Building Information Modeling) technologies at all stages of the life cycle |
|    |                   | Digital 3D model of the city                                                |
|    |                   | Development of information systems for energy saving management, energy modeling |
|    |                   | Use of renewable energy sources                                             |

Within the framework of energy saving management, the project "Energy efficient city" was developed for the development of the methodology and implementation of the energy efficiency program in the housing stock of Rostov-on-Don [5].

The basic housing stock was classified by the signs influencing energy efficiency: the period of building, material of walls, number of stories. Classification of objects of housing stock of Rostov-on-Don is presented in table 2.

**Table 2. The classification of housing stock**

| Development period | Wall material          | Floors | Number | Area [m²] | Energy efficiency class | Number of objects- analogues |
|--------------------|------------------------|--------|--------|-----------|-------------------------|-----------------------------|
| before 1927        | wood, mud walls        | 1,2    | 301    | 31 970    | D/E                     | 7                           |
|                    | brick walls            | 1      | 1325   | 179 350   | E                       | 20                          |
|                    |                        | 2      | 678    | 527 500   | E                       | 24                          |
|                    |                        | 3…5    | 546    | 492 130   | E                       | 10                          |
| 1928-1945          | brick walls            | 1…3    | 356    | 173 160   | E                       | 7                           |
|                    |                        | 4…8    | 177    | 448 210   | E                       | 5                           |
| 1946-1957          | brick walls, load-bearing panels | 1…3 | 543 | 260 730 | D/E | 10 |
|                    |                        | 4…6    | 150    | 399 920   | E                       | 4                           |
| 1958-1970          | brick walls            | 1…4    | 1139   | 612 080   | E                       | 18                          |
|                    | panel walls            | 5…10   | 296    | 1 231 280 | E                       | 6                           |
Next, a spatial analysis of the territory on the technical condition of the housing stock in the ArcGIS environment was carried out (figures 1, 2).

| Period       | Type of Walls          | 1971-1980 | 1981-2000 | After 2000 | Total in Rostov-on-Don |
|--------------|------------------------|-----------|-----------|------------|------------------------|
|              | brick walls            | 1…4       | 92        | 50 470     | E                      | 3                     |
|              |                        | 5…16      | 497       | 2 077 050  | E                      | 9                     |
|              | panel, block walls     | 5…17      | 357       | 1 954 310  | E                      | 7                     |
|              | brick walls            | 1…4       | 79        | 57 570     | D/E                    | 3                     |
|              |                        | 5…9       | 289       | 1 190 260  | E                      | 6                     |
|              |                        | 10…1      | 191       | 1 133 930  | E                      | 4                     |
|              | panel, block, monolithic walls | 4…9     | 380       | 2 279 860  | E                      | 7                     |
|              |                        | 10…1      | 196       | 1 150 700  | E                      | 5                     |
|              | brick, panel, monolithic walls | 1…9     | 125       | 404 040    | C                      | 4                     |
|              |                        | 10…2      | 515       | 4 756 350  | B/C                    | 10                    |

**Figure 1. Spatial analysis (density)**

**Figure 2. Graphical analysis**
Then recommendations for energy efficiency improvement were developed and modeling of changes in the energy efficiency class of residential buildings as a result of the implementation of energy saving measures (table 3) was performed. The step-by-step carrying out of energy obligatory actions is offered:

1. increase of thermal protection of enclosing structures (except wall insulation);
2. improving the energy efficiency of building engineering systems;
3. insulation of external walls (for priority objects for which this event is economically feasible).

| Development period | Wall material        | Floors | Energy efficiency class | Energy efficiency class after events |
|--------------------|----------------------|--------|-------------------------|-------------------------------------|
|                    |                      |        | Wall insulation | Roof insulation | Basement insulation | Heating and ventilation update | Window replacement | Reconstruction of power supply and lighting | Complex rehabilitation |
| before 1927        | wood, mud walls      | 1.2    | D/E          | D              | D                | D                | D                | D                | B                |
|                    | brick walls          | 1      | E            | D              | D/E              | D/E              | D                | E                | D/E              | B+               |
|                    |                      | 2      | E            | E              | E                | E                | E                | E                | E                | B+               |
|                    |                      | 3...5  | E            | E              | E                | E                | E                | E                | E                | D                |
| 1928-1945          | brick walls          | 1...3  | E            | D              | E                | D/E              | E                | E                | E                | B+               |
|                    |                      | 4...8  | E            | E              | E                | E                | E                | E                | E                | E                |
| 1946-1957          | brick walls, load-bearing panels | 1...3 | D/E          | D              | D/E              | D/E              | D                | D                | D                | B                |
|                    |                      | 4...6  | E            | E              | E                | E                | E                | E                | E                | D                |
| 1958-1970          | brick walls          | 1...4  | E            | E              | E                | E                | E                | E                | E                | B                |
|                    | panel walls          | 5...11 | E            | E              | E                | E                | E                | E                | E                | C                |
| 1971-1980          | brick walls          | 1...4  | E            | D              | E                | D/E              | D                | D/E              | D/E              | B+               |
|                    | panel, block walls   | 5...16 | E            | E              | E                | E                | E                | E                | E                | C                |
| 1981-2000          | brick walls          | 1...4  | D/E          | D/E              | E                | E                | D/E              | E                | D/E              | C                |
|                    |                      | 5...9  | E            | E              | E                | D                | E                | D                | C                |
|                    |                      | 10...19| E            | D              | E                | E                | E                | D                | E                |
|                    | panel, block, monolithic walls | 4...9 | E            | D              | E                | E                | D                | E                | E                |
|                    |                      | 10...18| E            | D              | E                | D                | E                | D                | C                |
Summary

Thus, according to the results of the study, the indicators characterizing the development in key areas of the Smart city, which may reveal the level of development of such technologies in Russian cities, were identified. The proposed indicators of these areas: environment, infrastructure, urban planning, construction and architecture - allow to better assess the comprehensive indicators of urban development to improve the quality of life. Also, a method of improving energy efficiency in the housing stock on the example of the city of Rostov-on-Don was developed and recommendations for improving the energy efficiency of buildings and structures of the city were given.

The results of the study allow city administrations to assess the indicators:
1. Current level of development of modern technologies for solving urban problems in the field of environment, infrastructure, urban planning, construction and architecture;
2. Strengths and weaknesses of the city, and to form priority directions of development in the future in accordance with the "Strategy of development of the information society in the Russian Federation for 2017-2030" and the Program "Digital economy of the Russian Federation;"
3. Energy efficiency of urban housing in terms of the period of construction, wall material, number of storeys.

The study revealed a number of problems: the lack of legal and regulatory framework of smart cities in the Russian Federation, the lack of systems of municipal statistics in relation to the elements of smart city.

References

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| after 2000 | brick, panel, monolithic walls | 1...9 | C | B/C | 10...2 4 | C | B | B+ | B++ | 4 | C | B | B+ | B++ | A |
|-----------|--------------------------------|-------|---|-----|--------|---|---|----|-----|---|---|---|----|-----|---|
| 2000      |                                |       |   |     |        |   |   |    |     |   |   |   |    |     |   |