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THE ROLE OF ARCHITECTS AND URBAN PLANNERS IN THE FORMATION OF THE CONCEPT AND FUNCTIONING OF SMART CITY

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ABSTRACT

The concept of smart city that has emerged as a response to the growing problems to which the world has been exposed over the last fifty years implies a set of multidisciplinary measures, ideas and policies oriented towards encouraging the development of human and technological resources of urban areas and their interaction aiming at enabling sustainable development and improving the quality of life of its population. All structures of different city systems in a smart city react in a clear and simple way through contemporary technologies and design. High technologies have for a long time influenced a new understanding of the role of architects and urban planners in the formation of the smart city concept. The paper highlights the problems that have led to a widely accepted concept of smart city, such as climate change, increasingly aggressive urbanization, excessive use of all resources, etc. The paper explains the role of architectural and urban planning profession in creating a smart city. Modelling of key systems of urban development requires the architects and urban planners to have new knowledge in different fields, as well as an interactive and creative approach to solving the set tasks. The philosophy of the profession is changing and new fields of activity are opening up, this being a challenge, but also an obligation to master the fields and skills on which the profession has not had influence so far. The architects and urban planners in teams formed in cities throughout the world for the purpose of conceiving this concept are losing the leading position in the processes of design and design management and are becoming equal amongst equals (in infrastructure system designs, amongst construction and traffic engineers, economists, sociologists, ecologists, programmers, city managers, management structures, equipment manufacturers, but also amongst city dwellers who are also becoming actively involved in this process, etc.). On the other hand, the development of new technologies has a positive influence on architecture and urbanism, particularly concerning the rational energy consumption and the use of renewable energy sources. Energy efficient buildings contribute to reducing the CO2 emissions, thus having significant positive effect on climate change. How to reconcile different interests and make the development of new technologies became a part of sustainable development is today one of the most important challenges in the profession, but also in the society as a whole.

Keywords: smart city; climate change; population growth; high technologies; sustainable development; smart city modelling; energy efficiency.

1. INTRODUCTION

Climate change has led to an increase in annual mean temperatures on Earth much faster than predicted. Mankind, faced with sudden climate change, is responding inadequately and inefficiently. On the other hand, the population growth, sudden expansion of cities and over-consumption of resources, shortages of water and other energy sources are becoming global problems.

Globally, more people live in urban areas than in rural areas. In 2007, for the first time in history, the global urban population exceeded the global rural population, and the world population has remained predominantly urban thereafter. The planet has gone through a process of rapid urbanization over the past six decades. In 1950, more than two-thirds (70 percent) of people worldwide lived in rural settlements and less than one-third (30 percent) in urban settlements. In 2014, 54 percent of the world's population was urban. The urban population is expected to continue to grow, so that by 2050, the world will be one-third rural (34 percent) and two-thirds urban (66 percent), roughly the reverse of the global rural-urban population distribution of the mid-twentieth century [14]. These growth rates imply that, every week, a city of one million inhabitants will be built for the next four decades.

Just three countries — India, China and Nigeria — together are expected to account for 37 percent of the projected growth of the world's urban population between 2014 and 2050. India is projected to add 404 million urban dwellers, China 292 million and Nigeria 212 million [14].

The trend of rapid urban growth from the mid-20th century till the present has led to an increase of economic and social wealth in some places, but also to continuing poverty of others. Cities are complex systems and big consumers of energy. The consumption of enormous amounts of energy, water, materials and all natural and man-made resources has as a consequence a powerful effect on the environment.

As the Intergovernmental Panel on Climate Change's (IPCC) report indicated, cities consume somewhere between two-thirds and three-quarters of total global energy and generate 75 percent of global carbon emissions [1].

The concept of Smart City (hereinafter referred to the "SC") has been developed as a response to the growing problems the world has been exposed to over the last forty years, such as climate change, increasingly aggressive urbanization, excessive use of all resources, etc. The concept implies a set of multidisciplinary measures, ideas and policies oriented towards encouraging the development of human and technological resources of urban areas and their interaction aiming at enabling sustainable development and improving the quality of life of its population.

A smart city is one in which the seams and structures of the various urban systems are made clear, simple, responsive and even malleable via contemporary technology and design. Citizens are not only engaged and informed in the relationship between their activities, their neighbourhoods, and the wider urban ecosystems, but are actively encouraged to see the city itself as something they can collectively tune, such that it is efficient, interactive, engaging, adaptive and flexible, as opposed to the inflexible, monofunctional and monolithic structures of many 20th century cities. [11].

Cities are hubs of economic, political and cultural activities and centres of knowledge and innovations at the same time. With their means and capacities, they get the leading role in the development and implementation of measures for increasing the energy efficiency (hereinafter referred to the "EE") and for the use of renewable energy sources (hereinafter referred to the "RES"). Given the data that buildings use about 40% of global energy, out of which heating and cooling account for 90%, the concept of smart city cannot be imagined without the use of RES and EE principle at the level of urban planning and building design. Advocating the smart cities, which also implies new technologies and infrastructure, has its deep foundation in science and practice [6].

The SC concept is closely linked to the development of the information and communications technologies (hereinafter referred to as the "ICTs"), but it is a considerably broader than the one-way implementation of technological solutions and comprises sociological concepts such as maximum social inclusion and transparent decision-making system.

The development of new technologies has seen great progress, and the influence on urban building can be characterized as a new movement in architecture and urban planning. On the one hand, this progress is due to the ongoing development of digital technologies, including the Internet, as well as new software programmes (3D animation, numeric modelling packages etc.) On the other hand, new materials and systems offer architects great possibilities, provided they are available and economically justified [8].

Cities and city dwellers generate a large amount of data that can be used in a smart way with the aim to achieve strategically important goals. The innovative use of ICTs enables a progress in the fight against climate change and improvement in quality of life.

As a result of all this, the city authorities throughout the world and numerous professions that have recognized the importance of the concept of smart sustainable city increasingly advocate the use of high technologies for solving the existing problems. The solving of these problems requires a close cooperation between experts, citizens, companies, organizations and the national and city authorities. All abovementioned puts the relationship of architectural and urban planning profession towards such important global challenges into a completely new context. New knowledge is being developed and the concept of sustainable, green, ecological and energy efficient construction that could slow down, if not stop, negative processes and phenomena has been promoted. Architects and urban planners must prepare themselves for new challenges brought about by new technologies in the SC planning. Schools and academic institutions should become a part of information society based on the exchange of creative ideas, knowledge, information and experiences.

2. SMART CITY MODELLING

The SC modelling is based on the following characteristic criteria: (a) Smart Economy, (b) Smart Mobility, (c) Smart Environment, (d) Smart People(e) Smart Living i (f) Smart Governance. All of these criteria contain a series of indicators based on which the evaluation is performed. Thus, for example, the indicators for (a) Smart Economy include: innovative spirit , entrepreneurship, economic image & trademarks, productivity, flexibility of labour market, international embeddedness and ability to transform; the indicators for (b) Smart Mobility include: local accessibility; (inter-)national accessibility; availability of ICT-infrastructure; sustainable, innovative and safe transport systems, while indicators for (c) Smart Environment include: attractiveness of natural conditions, pollution; environmental protection and sustainable resource management. The factors and indicators for (d) Smart People include: level of qualification, affinity to lifelong learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism/open-mindedness and participation in public life. Furthermore, the indicators for (e) Smart Living include: cultural facilities, health conditions, individual safety, housing quality, education facilities, tourist attraction and social cohesion. Finally, the indictors for (f) Smart Governance include: participation in decision-making; public and social services; transparent governance and political strategies & perspectives. It is necessary to standardise different values considering the heterogeneity amongst some groups of criteria, but also within the groups themselves [12].

By investigating the phenomenon of SC, it can be concluded that there is no ready model of how to find a solution in creating a digital platform, either concerning economic development or structural urban variables. The economic power and greater democratic “openness” certainly contribute to greater investment and development of innovative abilities of a city. Often, the digital infrastructure coverage is not in correlation with the size of a city. The social infrastructure and population density play an important role in the SC formation. Neirotti and group of authors pointed out an important phenomenon that relates to the differences, advantages and disadvantages when it comes to innovative abilities of large and small cities. In essence, small cities are a good ''ecosystem'' in which it is easier to initiate experimental research of limited scope and, when it comes to the previous investment in the ICT infrastructure, they are more flexible and less inert. On the other hand, large cities usually face more critical needs and problems that entail digitalization endeavours and they can attract technology vendors more easily as they can offer a larger potential market of more educated citizens. However, density is a factor in development of SC initiatives, as it increases problems related to urban congestion at various levels of physical infrastructure (e.g. transportation, energy distribution, waste and water management, etc.) [3].

Models of cities in 2D and 3D format and the use of GIS technologies, softwares and tools which have one of the key roles in the development of smart cities would serve for entering the data on the building stock and its physical parameters. In the domain of energy efficiency, being a characteristic of these cities, the geo-information technologies provide an integration of spatial data and their analysis, exploration of development scenarios and, finally, the selection of optimum solutions [6]. The model for the improvement of energy

efficiency of building stock would contain possibility for the valorisation of procedures according to previously defined indicators.

For the decision makers in modelling and efficient city management, the following possibilities of geo-information technologies are particularly important: (a) analysis and modelling of the optimum distribution of population, i.e. users of space or consumers relative to the capacity of space, existing infrastructure and availability of contents, thus reducing the consumption of energy needed for transportation; (b) optimization of the construction and operation of infrastructure systems by improving their efficiency, reducing the costs of construction and exploitation by selecting the most favourable locations for buildings and by planning the roads relative to users; (c) integration of the data from different sensors and measurement devices that collect information of the importance for energy efficiency, their creation and analysis (visualization); and (d) provision of available internet services and services that expose location and navigation-related data, thus rationalizing the spending of time and money; etc.

The development of models for application of the ICT tools relates to the majority of proposed criteria. The goals are set for each group of criteria. Thus, for example, one of the goals of forming the models for application of the ICT tools is to use the web-based platforms and online services for identifying the potential locations for the use of the renewable energy generation systems and for improving the energy efficiency, whether it comes to buildings, industry, transportation or municipal infrastructure.

3. THE USE OF HIGH TECHNOLOGIES IN SMART CITIES - URBAN PLANNIING

Urban expansion on global level is wasteful in terms of land and energy consumption and it increases the greenhouse gas emissions. The urban centre of gravity — at least for mega-cities has shifted to the developing regions. In 1995, there were 22 large cities and 14 mega-cities globally; by 2015, both categories of cities had doubled. The fastest growing urban centres are the medium and small cities with less than one million inhabitants, which account for 59 percent of the world's urban population. [13]. Themedium-sized cities should be given special attention. These cities include almost all larger cities in Serbia. They tend to compete with large metropolises, but they are not sufficiently developed and organized to achieve the critical mass of technological infrastructure and functional reliability and efficiency.

Considering this fact, as well as economic and technological changes caused by the globalization and the integration process, cities in Europe face the challenge of combining competitiveness and sustainable urban development simultaneously. It is very evidently that this challenge is likely to have an impact on issues of Urban Quality such as housing, economy, culture and social and environmental conditions. However, the project European Smart Cities 4.0 does not deal with the leading European metropolises, but with medium-sized cities and their perspectives for development. Although the vast majority of the urban population lives in such cities, the main focus of urban research tends to be on the 'global' metropolises. As a result, the challenges of medium-sized cities, which can be rather different, remain unexplored to a certain degree. The medium-sized cities, which have to cope with competition of the larger metropolises on corresponding issues, appear to be less well-equipped in terms of critical mass, resources and organizing capacity [2].

The technological innovations related to the elements of energy efficiency, modelling, simulation, measurement, etc., are becoming a part of urban planning practice. They have brought about great changes in city planning and have changed the way of thinking and understanding the role of urban planners, architects and the profession as a whole. The development and the use of Internet, computer tools, software, AutoCAD, 3D animations and numeric modelling of building performances have created new possibilities in the fields of planning and design. Technological solutions implemented in urban planning can, to a great extent, provide answers to all current problems caused to cities by climate change, as well as answers to new challenges, ranging from the natural phenomena, demands of the profession, but also of investors, influence of power of big capital, to ecological and social demands. The enhancement of comfort and the environment is an important segment of EE and the use of RES [10].

The urban structure that relates to the energy performances consists of energy network, blue and green urban areas, different types of buildings, green roofs and facades, etc.In SC it is necessary to identify potentials for the use of RES, whether it comes to the sun energy, wind power, potential of biomass, geothermal energy, small hydro power plants in the wider city area, etc. The contemporary technologies enable mapping of renewable energy sources at city level. This includes, for example, vacant and neglected spaces in a city, roofs or facades of the buildings suitable for the installation of solar collectors for water heating and PV power

supply systems. Such procedure would enable both the users and local community or private sector to make decisions on the most optimum locations for the use of RES based on detailed analyses of climatic parameters, different policies and technical limitations exiting in a city. The aim is to mark suitable and unsuitable locations for the installation of renewable energy systems.

New technologies are increasingly adopted and recognized by participants in different professions in a complex process of urban planning. Solving the problems of greenhouse gas emissions, infrastructure systems, energy efficiency, transportation, municipal solid waste, etc., is based on available technologies and mutual connections between the complex information, communications and regulation systems.

One of the possible solutions to the abovementioned problems lies in the concept of integrated urban planning in which the professionals of different profiles take place from the very beginning stages of planning and selecting the location and who can contribute to offering sustainable solutions, reducing energy consumption and environmental protection.

The integrated planning is possible owing to the information and communications technologies and softwares which provide simulations and unlimited number of variant solutions. One the one hand, this concept enables a systematic analysis of the use of different forms of energy in the conceptual stage of planning, while, on the other hand, it enables to calculate investment price at any time, as well as the payback period of a given investment [9].

It should be borne in mind that it is better to invest in all energy-efficiency measures then in new production and new plants. Besides the fact that these measures are economically justified, they also save resources, contribute to environmental protection and to improving the quality of life.

In addition, the possibilities of reducing energy consumption include introduction of smart street lighting technologies through the control and energy efficient lighting systems, energy efficient city transportation, the use of bioclimatic parameters in planning and design, introduction of traffic monitoring and signal control systems across the city, etc.

Urban plans represent an efficient way for improving the energy efficiency, while different tools are used depending on the city size and position, street geometry, vehicle movement, height of buildings, position of green and blue areas, industrial complexes and air pollution dispersion.

In SC special attention is given to the users' experience, scientific research and data in the domain of urban informatics. Research and results are made based on qualitative observations and quantitative analyses of data obtained from the realized projects, their integration and adoption level of technological solutions in urban environments. The aim is to further use the acquired knowledge and experiences, as well as the technological solutions for the design of new prototypes and assessment of the concepts and solutions for mobile network operators, urban and utility services, urban planners and decision makers.

4. THE USE OF HIGH TECHNOLOGIES IN SMART BUILDINGS – ARCHITECTURAL DESIGN

The principles of smart development including different studies preceding the design, which refers to the physical parameters, form, orientation, materials, components and sub-systems of buildings, as well as to the microclimatic conditions. Smart Building (hereinafter referred to as the „SB“) are based on the principles of optimisation, integration of building systems and on the combination of technological solutions and passive systems with the aim to improve building performances.

The use of high technologies in buildings influences the change in concept and way of construction, development and the use of new materials with high performances which meet the complex design, structural, environmental and energy requirements.

Smart architecture cannot be imagined without the use of the Internet, computer tools, software, CAD and CAM technologies, 3D animation, numeric modelling of building performances, programmes for calculating energy consumption, cost-effective use of new technologies, etc.

The development of new technologies has had a positive effect on building performances, particularly in relation to the rational energy use and the use of renewable energy sources. Energy efficient buildings contribute to reducing CO_2 emissions, which in return has a positive effect on climate change.

According to the definition given by Terri Peters, the eco-friendly architecture combines technological, cultural, systemic and user-oriented strategies [4]. It is at the same time also the smart architecture that can use the power of new technologies and tools not only for the optimisation of structures relative to their surroundings, but also for the improvement of social and cultural programmes. The advocacy for eco-friendly construction, energy efficiency, green and sustainable construction fits in the concept of smart city.

The architects in a team conceiving the SC concept are required to include the elements of energy efficiency, sustainability, modelling, simulation and measurements in their projects, as well as to have greater knowledge on physics, but also on mathematics. The concept that implies eco-friendly, energy efficient, green architecture that fits in the natural environment and reacts to nature with minimum negative effects has influenced the change in the attitude of professionals in different fields, and not only in architecture.

Today, the idea of sustainability, using the cutting-edge technologies, is becoming an integral part of the contemporary architectural solutions within an integrated approach to design. These solutions are achieved by harmonizing the aesthetics, functional, energy and economic criteria in planning, design, construction and reconstruction of buildings. Integrated planning and design of new buildings and the restoration of the existing ones facilitate the economic optimisation throughout the lifespan of a building. This integrated approach involves a concept that includes the participation of professionals in different fields from the very first stage of work and selection of the location, who can contribute to reducing the energy use and pollution and to improving the environmental protection. This concept has a positive influence on the improvement of the quality of buildings, on construction of modern low-energy buildings and energy reconstruction of the existing buildings using the innovative technologies and solutions. Such buildings have a better standard and comfort, while the maintenance and energy costs are reduced. With the achieved costs savings, the interest of consumers in a more careful energy consumption management grow, but also the interest of the investors in integrated planning and maintenance of buildings. In this way, the living conditions are improved and the durability and value of the building rises. This concept of design is possible to carry out owing to the emergence of programmes that provide simulation and an endless number of variant solutions. The new technology allows, among other things, the cost of buildings and the payback period of a given investment to be calculated already in the conceptual stage of design, thus raising the price of the building in the beginning stage [5].

It is necessary to use the existing or purpose-designed softwares for calculating the estimate which would provide data on energy use in the existing and new buildings. In addition, it is also necessary to carry out monitoring of the existing buildings using the contemporary technologies such as different devices for measuring the energy use, sensors, thermal imaging cameras, etc. As it is impossible to carry out monitoring of each individual building, it is necessary to first define the typology of the building stock according to the determined methodology. Starting from the existing, recorded conditions of buildings and target energy category (according to the current Regulations on Energy Efficiency in Buildings and the Regulation on Energy Performance Certification of Buildings in Serbia), it is necessary to determine the energy savings potential and propose measures for the realization of this potential. In this way, the necessary criteria would be established and reference values and methodologies introduced, without which it is not possible to ensure energy efficient construction and reconstruction of buildings [6].

The High-Tech architecture that experienced a flourishing in the second half of the twentieth century, whose pioneering architects were Norman Foster and Richard Rogers, can be linked to the SC and SB concepts in a certain way. Yet, they are basically different concepts. High technology is necessary for the functioning of smart city, but it is becoming a means to an end, not an end in itself. The SC is turning to the complex relationship between the user and space, the building and the city, sustainable planning and energy efficiency, environmental protection, carbon emission reduction, climate change mitigation and, certainly, to more humane cities with social policies turned to citizens.

5. CONCLUSIONS

Rural depopulation in Serbia has been going on more than 50 years, while population growth is recorded in a small number of larger cities, particularly in Belgrade and Novi Sad. The cities in Serbia are not prepared neither have they adequately developed infrastructures for a continuous population growth. The regional and urban planning and accompanying legislation at national and local levels are still being conceived on principles of the past, while new concepts and the use of new technologies are being reluctantly accepted. The complex infrastructure systems, such as transportation, energy, sanitary and water supply infrastructures, are centralized and the communications between them are often reduced only to contacts, to which they are

compelled for formal reasons. The cities are not able to meet basic needs of their citizens and, as the time passes, the growing problems are not being solved and the situation is becoming increasingly difficult.

Therefore, it is of extreme importance to start implementing the SC concept in Serbia. This indeed cannot be done quickly as this is a process in which time and money have to be invested in the long run. All the more so, the creation of sustainable models and policies for urban space development are becoming a global imperative. The initiatives that go in the direction of creating the SC model should be recognized primarily by local authorities, professionals and citizens. That is why it is important to first conceive a concept of cooperation between the public, private and academic sectors in combination with professional knowledge in the use of the cutting-edge technologies.

In order to apply the SC concept in Serbia, it is necessary to develop technological platforms and industry for the ICTs, as well as accompanying industries that would fit in this concept, considering the fact that the imported equipment is expensive, thus being an obstacle to the fast implementation. Out of this reason, it is necessary to gradually develop the production of high-tech components in Serbian cities, but also the production of equipment in different fields, such as components for smart buildings, transportation, renewable energy, eco-systems, infrastructure systems, etc.

Social inclusion and raising the awareness not only of citizens, but of local authorities and the profession, play a key role in this process. To make this possible, the issues of new educational programmes and models for engineers of scientific professional profiles should also be placed in the focus of the state and local policies. Without this, it is hard to expect the sustainability of economic and social development of Serbia. The institutional connecting and adjustments in the domain of city management is also necessary.

In parallel with this, the strategies for the young, educated professionals in all fields necessary for the SC functioning, to stay in the country and for their inclusion should be developed.

The multidisciplinarity, education, communicativeness and readiness to accept innovative ideas is a *sine qua non* in forming the smart city development strategies at national, regional and local levels, and then also their implementation. Therefore, it is necessary to form at least one multidisciplinary smart city pilot project. This would open up a new area in which possibilities for including the cities of Serbia into the European network of SC projects could be found, as well as the possibilities for obtaining funds for such pilot projects.

It is also necessary to create a database on researchers (faculties, institutes), experts in different branches of economy, programmers, stakeholders, investors, local authorities, etc., in a single network dealing with the problem of smart city. This database should be initiated by the Standing Conference of Towns and Municipalities of Serbia (SKGO), Chamber of Commerce and Industry of Serbia (CCIS), Serbian Chamber of Engineers, etc., as a part of a single project, and apply for financial support through the European funds, but also to other institutions and industries which can recognize their own interest in this.

All this should be followed by regulations harmonized with the highest EU standards. The creation of a set of regulations and by-laws will mobilize numerous participants in these projects and also stimulate investment in transformation and new technological solutions.

The most successful examples of good practice should be promoted and awarded, but also given a space in media, both local and national ones.

The role of architects and urban planners in the formation of the SC concept and in the “process that lasts” is of extreme importance. However, their involvement in projects and research will not come of itself, but the profession and individuals have to win this. Just like the High-Tech revolution has brought about great changes in architecture and has changed the philosophy and understanding of the role of architects, the new time and new changes bring new challenges, new knowledge and new paradigms. The relationships within space which in itself include the physical, communications and digital parameters are increasingly complex, while the communication between them requires mastering the skills and tools which could have not been imagined until only a decade ago. The smart cities are turned to complex relationships between users and space, the building and the city, sustainable planning and energy efficiency, environmental protection, carbon emission reduction, climate change mitigation and, certainly, to more humane cities with social inclusion and policy in which the citizens and city authorities are involved. All this is bringing about new changes in architecture and urban planning and has changed the way of thinking and understanding of the role of architects and the profession as whole. The way of construction has been changed and new materials with high performances that meet the complex design, structural, ecological and energy standards have been discovered. Smart cities

wait for answers to new challenges, ranging between the natural phenomena, demands of the profession, but also of investors, influence of the power of big capital, to social and ecological demands.

Besides, more frequent extreme climactic events like floods, droughts, strong winds and very cold periods with lots of snow, are a good opportunity to test how vulnerable a settlement is, as well as to examine the possible models for the existing and newly-designed building stock to withstand such challenges. Here, it is necessary to take a multidisciplinary approach to the problem, whereby it is expected from planners and project-designers to have a more active role in the partnership. For this, the existing knowledge must be expanded and there has to be a more intensive exchange of specific information on both the local and the global level [7].

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