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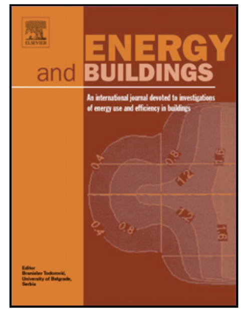

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REDUCING THE IMPACT OF CLIMATE CHANGE BY APPLYING INFORMATION TECHNOLOGIES AND MEASURES FOR IMPROVING ENERGY EFFICIENCY IN URBAN PLANNING

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Highlights

- Solutions that rely on information technologies in urban planning are proposes.
- Two projects were analyzed-in undeveloped landscape and in urban built environment.
- The measures in urban planning depends on the level of the built environment.
- The planning in the field of energy efficiency depends on the quality of data.
- Stages of work are different for new building and reconstruction.

Abstract

The paper provides an overview of a part of research related to the analysis of information technologies and measures for improving the energy efficiency in urban planning that can contribute to mitigating the impact of climate change. The first part of the paper deals with problems supported by the numerous data on negative effects of climate change on the cities, such as urban heat islands, energy and ecological crisis. The second part of the paper proposes solutions that rely on information technologies which facilitate process of urban planning. Two projects related to the implementation of measures for improving the energy efficiency in urban planning were conducted within this research. The first one is considering the design of a spa centre in an undeveloped mountain landscape and the second one is dealing with reconstruction of a residential block in urban built environment. In the first case study, the proposed solutions rely on the information technologies, while in the second case study they rely on the implementation of measures for improving the energy efficiency in urban planning. The results show that the application of different measures in urban planning depends on the level of the built environment.

Key words: climate change, information technologies, ecological urbanism, energy efficiency in urban planning

1. Introduction

Over the last several decades, the information technologies have influenced architectural design and urban planning. With increase of awareness about climate change and its evident consequences, the influence of information technologies is becoming more important because they enable simple and faster problem solving with simulations and great number of variants. The negative effects of climate change manifested in cities with high population density include high energy consumption and huge concentrations of carbon dioxide emissions. The development and influence of information technologies in the context of climate change are less evident in the field of urbanism than in the field of architecture. In the book "Ecological Urbanism", the authors Mostafavi and Doherty [1] conclude the following: "While climate change, sustainable architecture and green technologies have become increasingly topics, issues about the sustainability of the city are much less developed". The information technologies in urbanism are primarily used in the infrastructure and transportation solutions, as well as in the use of renewable energy sources. However, there are important steps forward in the process of urban planning, where new concepts of technological solutions and measures to increase energy efficiency find their application in the urban context.

On the other hand, the cities are recognized as promoters of the development directed towards the climate change mitigation. Many cities are joining together and with a serious organization and capital influence the development of information technologies. These actions are often a question of prestige not only when it comes to cities, but also when it comes to the less developed countries which would also like to support these actions. Many projects and initiatives are directed towards the issues related to the development of the information technologies which will facilitate the planning process at all levels, but also to the specific interventions in urban space if necessary.

The UN Habitat has initiated a project entitled „Cities and Climate Change Initiative". The Assessment Report stated that properly planned cities use spaces and energy in an efficient way by reducing the transportation and infrastructure, thus contributing to reducing the effects of climate change [2]. The Intergovernmental Panel on Climate Change (IPCC) has prepared a special study that considers the projection of these problems by linking the aspect of climate change and the infrastructure, demographic and energy aspects of urbanization [3].

In this context, the paper provides the possibility of considering the effects of the use of information technologies in the process of urban planning conducted within two projects for two different environments - the first one is considering the design of a spa centre in an undeveloped mountain landscape and the second one is dealing with reconstruction of a residential block in an urban built environment. This paper will analyse how application of the information technologies and the 3D analyses and modelling in urban planning reduce energy consumption.

2. Cities and climate change: interactions, negative phenomena - causes and effect

2.1 Climate Change

Climate change to a great extent depends on anthropogenic factors and directly influences the future development of human community on the planet Earth. Climate change has led, faster than predicted, to an increase in Earth's annual average temperatures, floods, soil erosion, hurricane winds, sea level rise, droughts, etc. Mankind faced with an abrupt climate change is responding in an inefficient and inadequate way. Nevertheless, many steps have been taken in the fields of architecture and urbanism. The concepts of sustainable, green, ecological and energy-efficient building design that could slow down the negative processes made under the influence of climate change have been promoted [4].

One of the key indicators of climate change is an increase in global average surface temperature by 0.65°C measured for the last 50 years. In its 5th Assessment Report in 2013, the Intergovernmental Panel on Climate Change (IPCC) stated that "most of the observed increase in global average temperatures (which is more than 95 per cent) since the mid-twentieth century is very likely due to the observed increase in anthropogenic GHG." In the same IPCC's Fifth Assessment Report, it was also concluded that global temperatures are likely to rise by 0.3 degrees to 4.8°C by the end of the century, depending on how much the governments control the carbon emissions [3].

2.2 Energy and Ecological Crisis

Climate change on Earth and the global ecological crisis that have occurred as a result of an uncontrolled growth of cities, industrial development, inefficient technologies and an excessive use of fossil fuels present one of the greatest problems in this century. The consequences of global warming are not yet present to the extent that would initiate large-scale activities producing the quick and visible results. The changes are slow and according to the so-called Giddens's paradox, the significant progress will not occur as long as the consequences of global warming will not be felt in everyday life. For this reason, Giddens emphasizes the importance of joint action of modern technologies, the use of renewable energy sources, communication networks and functional social framework that would lead to a positive model, the so-called low-carbon life [5]. The air pollution from greenhouse gas emissions, depletion of ozone layer that protects the Earth's biosphere from a large part of the ultraviolet radiation, and the global warming are problems that threaten today's generations and, should such trend continue, it will threaten future generations as well.

The energy crisis is the next world's most pressing issue. It emerged in the seventies of the 20th century as a result of petroleum market disturbances. The fossil fuel reserves (discovered and probable) are limited, while according to the projections, and depending on the type of energy resource and consumption, it is possible that most of them will disappear by the middle of this century when the next energy crisis might occur [6].

The cities, especially megacities, as the biggest consumers of energy and natural resources, can contribute to the exhaustion of natural resources of the Planet. Their constant growth without support of both the social and the infrastructure systems is not sustainable. The cities that consume an enormously great amount of energy and matter require enormous support by different ecosystems, practically occupying 500-1000 times greater areas than themselves in order to be able to function [7]. The consumption of an enormously great amount of energy, water and all man-made resources results in a strong impact on the environment.

The energy crisis accompanied by ecological crisis has led to the general attitude that the current level and way of resource exploitation are unsustainable. Such conclusions clearly derive from the data on water and air pollution, changes in the chemical composition of the atmosphere, appearance of ozone holes, soil degradation, disappearance of certain plant and animal species, reduction in forest cover, etc.

Thus, the challenge lies in the answer to the two main questions: how to ensure sufficient amount of energy in future, and how to reduce negative environmental impacts from the use of traditional energy sources? The sustainable production and consumption of energy can be deemed as one of the most important ways in creating the green community. The ecological and economic crises have led to the acceptance of the concept of a limited amount of natural resources at the global and local levels. As the result, the concept of sustainable development emerged, which can be transposed to all segments of human activity, thus also to urban planning [6].

2.3 Urban Heat Island (UHI) Effect

Many cities worldwide face the problems associated with the urban heat island effect and temperature inversions. The cities accumulate solar energy during the day and at night they emit energy in the atmosphere, thus disabling the cooling of the built environment. The values of night time urban air temperatures during the summer are several degrees centigrade higher compared to the surrounding countryside. As villages grow into cities, their average temperature increases 2 to 6°C above that of the surrounding countryside [8]. This formation of heat islands primarily occurs in the cities located in valleys and areas where there is no air circulation and permanent ventilation.

This phenomenon also causes a temperature inversion and creates an invisible so-called membrane above the city. The polluted, warm air caused by emissions from industrial processes, heating and transportation remains below the so-called membrane line that separates two temperature inverse spaces and thus stays “trapped” in the lower layers of atmosphere, often causing a low visibility or fog. In case the stable weather conditions continue for another few days or even few weeks, the pollutant concentration may reach levels that pose a serious health risk [9].

In addition to the aforementioned, there are also a number of other causes of urban heat islands and temperature rise in settlements. They include the geographic position, the size of the city core, position of industrial zones and other branches of economy prevailing in a region, type of architectural and urban designs, type of urbanization and urban forms, massive and uncontrolled (often illegal) construction, way of land use, increasing amount of impervious surface due to urbanisation, reduction in green space within the city's boundaries and surroundings, population growth and population social structure, etc.

All this leads to a series of negative effects such as: health problems, microclimatic changes, general summer temperature rise, increased consumption of energy for cooling, air pollution, as well as the occurrence of storm water in the urban and suburban settlements that often turn into a natural disaster causing human causalities and material damages.

The urban designs and forms that neglect local climatic conditions and the cooling effects of green areas tend to aggravate the heat island effect. The cities of poor tropical countries are particularly affected [10].

As a vicious circle, climate change will increase energy demand for air conditioning in urban areas and contribute to the urban heat island effect through heat pollution. The heat pollution, smog and ground-level ozone are not only urban phenomena, but they also affect surrounding rural areas, reducing agricultural yields [11], increasing health risks [12] and spawning tornadoes and thunderstorms.

According to Voogt [13], it is possible to reduce the urban heat island size through different mitigation strategies and measures. They primarily include the urban planning and architectural measures, but prior to taking this measures a series of investigations based on modern technology should be carried out. It is necessary to map the urban heat islands, identify the types of urban heat islands and factors contributing to their development, as well as to formulate a terminology important for understanding and mitigating this phenomenon. This requires a long period of monitoring by means of instruments and available GIS systems. It is also necessary to identify all areas that contribute to the formation of urban heat islands (industrial plants, large combustion plants emitting large amounts of CO_2, etc.).

3. Urban Ecology, Information Technologies and Measures to Improve Energy Efficiency in Urban Planning

Globalization and rapid technological development often seek to promote architectural and urban design and planning without taking into account the natural conditions of the surroundings and the context. Today, in the era of global urbanization, cities are growing bigger and denser, and space must be used even more economically, flexibly and multifunctionally. The pressure on the urban green space and quality of the urban environment is continuously increasing. In order to preserve or (re-)create sustainable and liveable settlements from central business districts to rural villages, new approaches must be found and incorporated into planning [14]. Some solutions are offered by urban ecology, a relatively new field of study which, besides biodiversity, deals with completely new aspects of climate change that affect the cities. The development of the so-called green and ecological technologies is particularly important for this field of study.

By solving the problems associated with the urban heat islands, greenhouse gas emissions, infrastructure systems, energy efficiency, transportation or municipal solid waste, the sustainable solutions can be found based on different technologies and the interlinking between the complex information and regulatory systems. The eco-tech planning design may provide at least part of the answer to these problems.In the Preface of the book written by many authors from all over the world [14], Ercoskun (Ed.) stated: ”There are four separate eco-technologies that may be utilized by city planners and other professions dealing with space in the planning and design of a settlement: "Environmental Technologies (ET)", "Information Technologies (IT)", "Geographic Information Technologies (GIS)" and "Communication Technologies (CT)". The Environmental Technologies (ET) encompass a broad range of technologies related to energy, water and waste. The Information Technologies (IT) include a broad range of computer-based hardware and software and environmental sensing technologies for the gathering of environmental data. The Geographic Information Technologies (GIS) provide for the storage, transformation, manipulation, management, visualization, updating, querying, and reporting in related databases of geo-referenced data in a tabular format, and incorporates an Urban Information System that facilitates the land use analyses, the preparation of development and environmental plans, monitoring and control of eco-zones, transportation, et cetera, and allows for their dissemination on the Internet. The Communication Technologies (CT) are used for the transfer of environmental data, information, knowledge, and decisions in the wired or wireless environments.

3.1. Urban planning and information technologies

The spatial and urban plans represent an efficient way for using the methodologies, techniques and tools that enable the adaptation of certain environments to climate change. The plans represent an important potential for solving problems of the urban system vulnerability. Urban planning is increasingly important in managing climate change because well-planned cities are better able to adapt to climate change and are more resilient to its negative impacts than unplanned or poorly managed cities. The accompanying GHG emissions in cities are a consequence of energy consumption by buildings, transport and industry. Cities are also the hubs of economic, political and cultural activity and centres of knowledge and innovation. With their assets and capacity, they will play a major role in developing and implementing the climate change adaptation and mitigation actions and strategies [2].

An important part of the problem posed by global warming can be solved through planning and development of cities and towns. The form, structure and functioning of the city can either reduce or increase energy demand, as well as influence the energy production, distribution and use. The changes in climate induced by urbanization depend on several factors such as: size and position of the city, street geometry, vehicle movements, height of buildings, position of parks and water areas, industrial complexes and air pollution dispersion. Good distribution and grouping of buildings can significantly contribute to reducing heat losses, reducing energy consumptions and CO_2 emissions, which directly affects climate change.

Considering the expansion of cities in future, it is necessary to develop powerful ecosystem based on information and communication technologies for managing the surroundings. Technological innovations must become an integral part of architectural and urban planning practice. This primarily refers to the elements of energy efficiency, modelling, simulation, measurement, etc. The strategies related to technologies for mitigating the effects of climate change in cities are primarily directed towards reducing the greenhouse gas emissions and towards the efficient energy use. The architects and town planners need to have a much broader knowledge and understanding of information technologies related to infrastructure systems and use of renewable energy sources (RES). High technology denotes a style, concept and way of construction, development and use of new materials with high performances that meet the complex structural, ecological and energy requirements. The products considered high-tech are often those that incorporate advanced computer electronics. The development and use of Internet, computer tools and different types of software, modelling, numerical modelling of energy performance of buildings, programmes for calculating the energy consumption are some of the IT that provide huge assistance in the field of urban planning [4].The increasingly frequent weather events, such as floods, droughts, strong gusts of wind and very cold periods with large amount of snow, are a good opportunity to examine the vulnerability of settlements, as well as to study possible models for the existing and newly designed building stock in order to resist these challenges. The research in this paper necessitates a multidisciplinary approach to problem solving, whereby planners and designers are expected to play a more active role, for which they need to expand their knowledge, but also to more intensely exchange specific information at local and global levels.

In order to be able to analyse different types of settlements, it is first of all necessary to create a database for each type of settlement, which is done through a model study. This database should contain data on the site (site-specific micro-climate, terrain configuration, sunlight exposure, percentage of location usage, and types of structures). Such database should be created for several typical settlements (one for the individual, one for the collective or mixed settlement, one in the old city core, the other in a rural environment, etc.) [15].

The quality of any planning, thus also the planning in the field of climate change (effects of climate change on cities and contribution of cities to climate change) depends on the quality of data serving as a basis for the formation of concepts, policies and operational programmes. For this reason, it is necessary to create a database at the city level that would contain the administrative, financial and documentation data for all relevant fields, such as: climate data, data on architectural and urban characteristics of a city (buildings, infrastructure systems, transportation systems, green spaces, water areas, etc.), energy (production and consumption of all forms of energy in residential buildings, accompanying functions and industry), renewable sources of energy (potentials, distribution at the local and national levels, possibility of use, potential producers, users, institutions, etc.), current and proposed technologies that can be used, data on economic activities, relevant statistical data, legal documents and regulations. The database should also contain information on the technological and development scientific research demonstration projects in this field. The information system should enable technical and economic analysis, the development of monitoring the market, analysis of effects of political decisions and regulations on sustainable and economic development, etc.

3.1.1 Digital urban settlement

The digital city represents a form of information space that refers to a specific physical space in the city. Digital cities cover a vast area of digital networks and programs that facilitate various aspects of social and economic life in cities. Every digital city, based on its goals, has different architectures, organizations and services. Many cities throughout the world have already implemented smart technology and have started with „investment into the future“.

The cities such as Singapore, Brisbane and Stockholm are already working on reducing traffic jams and air pollution by applying the intelligent solutions to the public transportation systems. Rotterdam will implement a system for control and smarter management of water and power supply which will make it the first so-called „Smart Delta City“–the first city to use information in real time in order to manage systems and infrastructure that have an impact on climate change [16].

3.2 Information and Communication Technologies

The creation of a knowledge base within the database should become one of the strategic priorities. The bad characteristics of most knowledge bases at the national level in this field include the fragmentation and incoherence of large amounts of information. The reasons are manifold and complex and one of the most evident ones lies in the fact that knowledge on climate change is multidisciplinary, dynamic (it increases rapidly and channels for the exchange of such knowledge are increasingly efficient), diverse and difficult to follow [15].

In Serbia, several projects related to the different aspects of climate change impacts on the natural and man-made environment are underway [1]. An active knowledge base has been created to support one of the projects. Stored in the

[1] One of such projects is entitled „Spatial, Environmental, Energy and Social Aspects of the Development of Settlements and Climate Change – Interaction“ TP 36035 (for the period 2011-2015) financed within the Ministry of Education, Science and Technological Development.

hardware resources of the Academic Network of Serbia and technically supported by the Belgrade University Computer Centre, this knowledge base has been created using WordPress as a Content Management System (CMS). The contents that are entered into and linked within this base are chronologically structured according to the categories and key words, as well as according to the subject of a referential external knowledge. [17].

Today, the contemporary approaches to developing software solutions move towards the improvement of the procedures for the generation of software components, establishment of an integration platform for communication and exchange of information between different team members, different levels of abstraction and different tools and languages of formal specification, as well as towards the organization, optimization and improvement of all activities at all levels of complexity of a software solution development process [18].

The Geographic Information Technologies (GIS) are used in the creation of databases for the spatial and urban plans, for basic and advanced spatial analyses, remote detections, 3D analyses and modelling, statistical and spatial analyses, visualization of plans by creating maps, drawings, diagrams, animations etc. The GIS technologies have been quickly adopted by different professions, so that new experiences have been acquired through the integration of the spatial planning solutions and architectural designs, thus contributing to the further development of this information technology. In addition to methodological improvements, the necessity for adaption to climate change requires the intensified control and monitoring of climate change indicators, various research related to climate change, development of prediction model, development of scenarios, economic analyses, monitoring of the impact of extreme temperature change, modification of current adaptation strategies and measures and stakeholder inclusion [19].

4. Case Study 1: Energy efficiency in the Spa Centre on the Stara Planina Mountain

The first case study in this paper represents the application of Geographic Information Systems (GIS) and 3D modelling for the Spa Centre on the Stara Planina Mountain. In this case, we have analysed the impact of climate on the design of free-standing building in nature, actually in a mountain area of exceptional value.

The tourist facilities are usually not energy efficient and consume more energy per unit area than buildings planned for other purposes. There are a number of factors that influence energy consumption in tourist facilities, such as local climate, conditions of the terrain, type of tourist facility (hotels, spas, sports buildings, etc.), year of construction, used ma..terials, existence or non-existence of thermal insulation, techniques and technologies of construction, infrastructure systems (heating, cooling, number of electrical devices), number and behaviour of users, etc. [20]. Because the spa and wellness centres belong to the category of health tourism, they tend to become sustainable, thus also attempting to improve the environment and provide social wellbeing or economic prosperity by significant profits that go to local communities.

According to the data on energy consumption for tourist facilities, the total energy consumed for the building greatly depends on the external climate conditions [20]. That was the reason why the concept of this spa building was based on the use of favourable characteristics of the site that have been verified and tested through electronic information tools.

The first phase of the analysis of the site for the spa building included the collection, selection and integration of available data that were used to create a GIS database. Different parameters including temperature, durations of sunshine, geothermal sources, wind direction, as well as terrain conditions (Table 1), were used as input data for further study [21].

Location of Spa on the Stara Planina Mountain	Average annual temperature	Average temperature differences between January and July	Average annual durations of sunlight	Average annual precipitation	Average snow depth for 4 months
1,700 meters above sea level	3,0-3,5 ^{0}C	difference up to 20 ^{0}C	between 1900 and 1950 hours often with cloud and fog	1100mm	ranging between 110 and 150cm

Table 1. Analysis of climatic parameters of the location[22]

The second step in the analyses was making various diagrams that clarify and visualize the data collected for climatic characteristics, such as: analyses of sunshine duration in Serbia, temperature on the site throughout the year, daily climatic parameters by seasons, soil temperature by seasons, etc. (Figure 1).

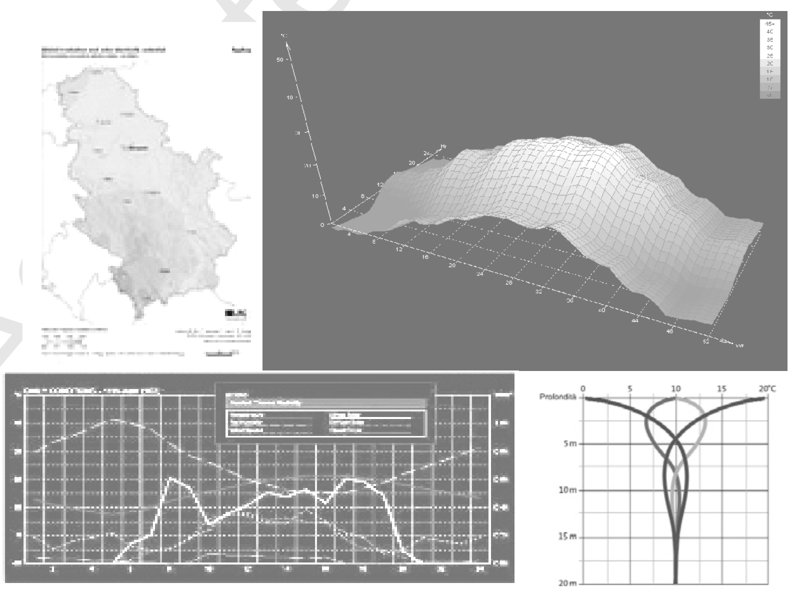

Figure 1. Analysis of climatic parameters (Analysis of sunshine duration in Serbia, Temperature on the site throughout the year, Daily temperature parameters by seasons, Soil temperature by seasons) [23]

The third step was implementing the 3D technology, where the obtained data were examined through a model of the spa building with very precise virtually made geo-referenced terrain. With this 3D modelling it was possible to create direct changes in the design of building in accordance with the conditions of the site. The modelling showed that south-east part of the location was extremely favourable due to a greater amount of daylight. The disposition of the terrain turned out to be suitable for creating a more compact form of the building with the orientation of main indoor spaces and pools towards the south and saunas towards the north. Burying one part of the building into terrain was a measure for partly reducing the heating, as concluded by directly reviewing through 3D modelling (Figure 2).

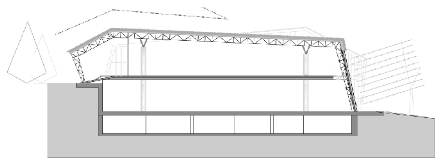

Figure 2. Protecting the building from the north wind by burying it into the terrain and reducing the surface to be heated [22]

The next 3D model analysis was determining the orientation towards the sun and the shadow analysis (Figure 3). This type of analysis is of particular importance for buildings with large surfaces of glass. Using GIS, the shadow maps have been prepared and folded as layers for typical periods of year (summer solstice, equinox, winter solstice) and served for the creation of dynamic analysis of natural light within the building. Analysis of sun path in summer and in winter carried out for the location of the Spa Centre indicates that the building is well oriented by favourizing its southern facade [24].

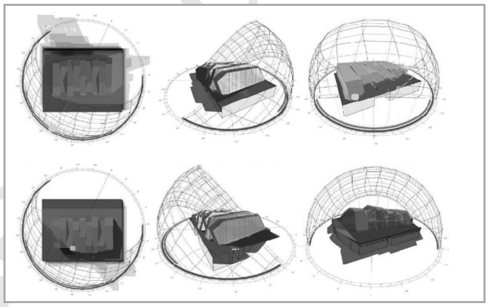

Figure 3. Sun and shadow analysis [22]

At the end of planning, the position of the Spa Centre and the effects of winds were analysed (Figure 4 and 5). This type of GIS analysis is the result of a fusion of general climatic parameters of the location (speed, temperature of prevailing winds) together with geometry of the building. The fluid dynamics of air flow was simulated in the carefully chosen typical planes according to dimensions and geometry of the building. The direct application of the information technology (GIS) and modelling (3D max) is most evident in the design of the roof of the building, where it was concluded that, based on the wind analysis, it would be better for the roof to go up and down because of aerodynamics, as well as better natural ventilation.

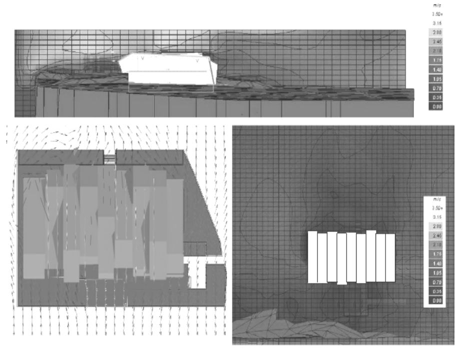

Figure 4. Wind analysis for the site [22]

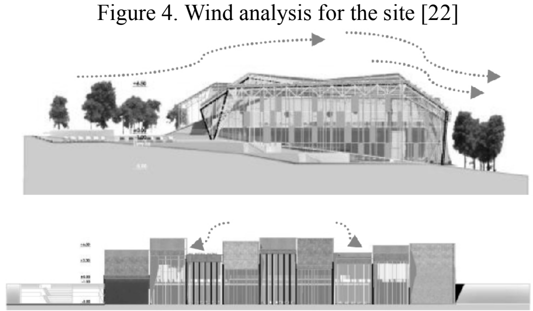

Figure 5. Interrelation between wind directions and the form of the building

With the tools of information technologies, the detailed study of spatial characteristics of location contributed to the final location selection. These technologies also enabled the application of urban measures and the use of the existing natural elements (shown in the summary Table 2) to the design of the building, which eventually led to the reduced energy consumption in the building.

	Urban data	**Criteria**	**Spatial characteristics of SPA Centre- measures for implementing the criteria**
Planning the location	Terrain configuration	Degree of utilization of terrain slope	*Burying into the terrain* reduces wind effects, enables the use of the zone of warm air
	Orientation towards the sun	Sunlight exposure	*Southern orientation* enables greater sunlight exposure and increase in temperature during winter, as well as the creation of more pleasant ambience
	Wind effects	Natural ventilation	*Orientation towards the south-east, i.e.* perpendicular to the wind directions, and a *corrugated roof* enables ventilation of the building in summer and aerodynamics and better natural ventilation, thus reducing the energy costs

Table 2. Impact of climatic conditions on the implementation of urban measures for the Spa Centre

5. Case Study 2: Energy savings through reconstruction of an urban block in New Belgrade

The second case study is analysing a built city block. The Block 7/3 in New Belgrade was analysed in order to explore the possibility of the energy efficiency reconstruction of city blocks using the existing data available in the documentation and the 3D model that served for the analysis of both the current and the future state. As this residential bl.ock was built in 1960s, the obvious deterioration of the building stock and poor social conditions were the main problems that initiated an investigation of the possibility of the city block reconstruction and revitalization (Figure 6).

The energy consumption and energy supply costs were extremely high due to poor quality construction and bad orientation of buildings [25].

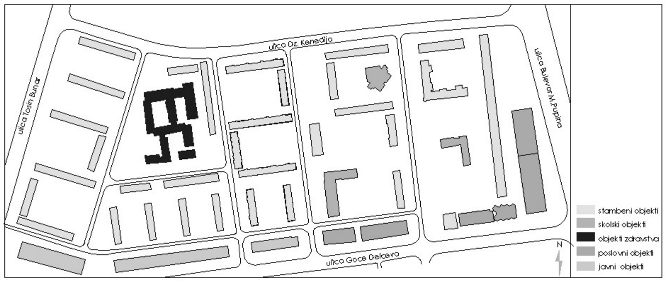

Figure 6. Layout plan of blocks 7/3– the current state [26]

To some extent, the current circumstances in Serbia make the organization and financing of residential blocks impossible (low standard and poor ownership status of apartments). Individual initiatives of private investors can contribute to a changed energy image of the mentioned block by a direct application of a model of reconstruction for improving the energy efficiency in buildings. One of the ways of financing the reconstruction includes attic extensions on the existing buildings, sale of apartments and the use of the mentioned means for improving the energy efficiency, as well as for reducing the individual investments of tenants. In addition, the sources of financing may include the donor or government funds (within agencies for reconstruction or local administrations) [26].

The energy-efficient building design implies not only energy optimization, but also a comfort optimization. There are methods to lower the energy consumption in old buildings [27] and this case study will explain how the implementation o.f urban and architecture measures could improve thermal insulation.

The first step of the analysis of the urban block was creating layers of information for database. This database of spatial and geographical data allows faster and efficient analyses. It can show the current impacts of the climate on the selected block, such as orientation towards the sun, wind analysis, etc. As a research using the real data provides a connection of geographic datasets with its location, the presentation of the real state is made possible (Figure 7 and 8). Therefore, the work methodology differs from the one applied in the urban structures that are yet to be planned.

Figure 7. Block 7/3 in New Belgrade built at the end of 1950s and in early 1960s

Figure 8. Consequences of the groundwater level rise in the New Belgrade block 7/3

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The following Table 3 shows the main characteristics of the current state of this settlement.

Table 3. The current state

Settlement	Urban parameters	Location characteristics	Engineering geological conditions	Problems
Block 7/3	Number of floors: GF+6 to GF+8 area: 26.3ha	- moderate continental climate; - average annual temperature: 11.8^{o}; - annual amount of precipitation: 664.3mm; - dominant winds: west and northwest winds; - sunshine duration: less than at the level of the city;	- the area lies on surface clay that prevents infiltration of atmospheric precipitation, thus causing further devastation of the building stock	- poor maintenance of buildings; - bad orientation of residential buildings; - one-sided orientation of apartments; - high level of groundwater; - poor hydro-insulation; - heat loss in buildings; - strong impacts of west winds (citizens install the PVC joinery at their own expense)

The next step was creating a 3D model of the building with the obtained data and the examination of microclimate parameters through modelling the influence of wind and sunlight on already defined position of the residential building. The 3D modelling showed that it was possible to create an independent structure – a greenhouse on the southern orientation of the building as one of the measures to obtain a thermal comfort (Figure 9). This is only one of the possible solutions that the technology can offer to a particular problem very easily.

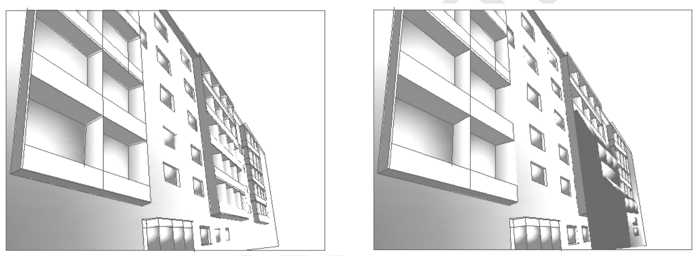

Figure 9. The current state (a) and proposed interventions on the building (b) [28]

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Given that the mentioned settlement may serve as a representative example of design and reconstruction according to principles of energy efficiency, the Table 4 shows possible goals and implementation measures for the reconstruction of the subject block [28].

Table 4. Interventions for reconstruction of urban block

Settlement	Goals of reconstruction	Implementation measures
Block 7/3	- improve the existing building stock; -enhance thermal and acoustic comfort of residents; - increase efficiency in heating system by installing passive and active solar systems; - improve aesthetic housing conditions.	- build an independent structure-greenhouse, on new foundations on the southern orientation; - install windows (reference values: 1.4 – 1.7 W/m^{2}K); - insulate exterior walls (reference values: 0.35 – 0.4 W/m^{2}K) Insulate ceilings towards the unheated space (attic, basement and ground) , (reference values: 0.3 – 0.4 W/m^{2}K) - use passive solar system; - install active solar system; - reduce the number of apartments with one-sided orientation; - find solutions for ventilation system; - replace radiators, install thermostatic radiator valves and heat consumption measuring devices.

Besides the energy reconstruction projects, all envisaged interventions must have investment studies including the econ.omic indicators and prices (elaborated in several possible scenarios). The payback period, which is calculated through energy savings, should be an important parameter in these scenarios. In addition to money-saving, the quality of life as an imperative of sustainable development is also an important factor.

6. Conclusions

The field of urban and regional planning is experiencing some fundamental changes that contribute to the increasing use of computer-based models in the planning practice. One of the key changes is the use of cheap and easy-to-use GIS and 3D modelling. This has led to the creation of more extensive spatially-referenced datasets, making them an essential tool for planners. Under the influence of technological innovations and in addition to direct changes in the physical structure of urban spaces, the thinking about urban space is also changing. Today, due to the rapid development of technology, the spatial planners, urban planners and architects act in a different way than few years ago. The use of information technologies can help cities to adapt themselves to new conditions, but these technologies are still not largely used in urban planning. The idea of sustainability using the information technologies is today becoming an integral part of urban planning. It is possible to use this concept of planning and design owing to the information and communication technologies and different types of software that enable simulations and unlimited number of variant solutions. The living conditions and the lifetime values of urban structures are thereby improved.

In conclusion to this research, the quality of any planning, thus also the planning in the field of energy efficiency depends on the quality of data that serve as a basis for forming concepts and operational programmes. That is why it is important to first define the methodological procedure and determine its implementation schedule. The analysis of two different types of settlements shows that it is necessary to create an information base for each type of settlement. It also indicates that it is possible to implement the same methodology in both cases. This analysis should be carried out through a model study. The following parameters should be entered for each type of settlement: 1. General climate data (sunlight exposure, wind, temperature, humidity, terrain configuration, etc.); 2.General data on the settlement, morphological and environmental conditions (general urban parameters, building-stock age, open space around buildings, paved areas in the immediate vicinity of buildings which contribute to additional heat load, roof shapes, impact of neighbouring buildings on sunlight exposure and daylight intensity, the use of artificial lights, etc.); 3. General data on buildings (shape of buildings, relationship between of the total usable heated area and the total surface area; relationship between the surface area of the building envelope and the heated volume; percentage of solid walls; percentage of windows; etc.); 4. Technical data on buildings (K-value of walls, windows, roofs, floors in W/m^2K, etc.); 5. Data on technology for heating in buildings (average and desired K-values in W/m^2K, maximum need for heating energy in W/m^2 and kW/ha, etc.); 6. Existing and potential sources of energy (conventional, renewable, waste heat, energy savings potential); 7. Existing energy supply systems (individual heating, district heating, heat pipeline, gas supply system, electricity, etc.).

The above mentioned methodology of collecting data is useful for planning and designing new buildings and settlements or for the reconstruction of the existing devastated city blocks. But when it comes to stages of work, the main difference is that the process of modelling and mapping is longer for new construction because it includes searching for appropriate location. When selecting the best locations, the key is two things: 1. Analysis of a wider location, all of its physical-geographic and anthropogenic features. It is necessary to explore the entire area in the same way; 2. Visualization of the area and its influence. It is essential that all project participants have equal conditions of knowledge and understanding of the issues. This enables active participation in giving solutions. The role of GIS tools in the site selection process is that it allows faster separation and clearer presentation of favourable and unfavourable locations based on pre-determined criteria. On the other hand, when it comes to the reconstruction, the location is already known, thus the analysis and modelling are less complex because they do not cover wide surrounding and because the number of variations is reduced. The stages of work for both types of settlements include: 1.Location analysis; 2. Sun and shadow analysis; 3. Reconstruction projects in urban area or planning new projects for open space landscaping (main difference between these two types); 4. Energy efficiency projects (3-4 scenarios); 5. Feasibility study; 6. Monitoring after implementation, 7. Using the results for new projects.

A great opportunity for rational energy consumption lies in respecting the simple urban measures in the design of a building. It is possible to create a concept of design through programs and simulation models using the parameters of the site. In this way, it is possible to know the consequences of any decision in all stages of the work.

As these results have shown, the geographic information systems (GIS) and 3D modelling are the best tools for collecting and processing the information about the changes, phenomena and processes in space as updated information. Defined as systems for the spatial visualization, data management, decision modelling and spatial decision support, they are powerful tools that can be used in urban planning. The information technologies and space-based information systems allow the fast and efficient creation of scenarios about the possible use of the space in the future, so that the consequences of planning objectives and solutions can be easily visualized. This system encourages the speed and flexibility of the planning process, participation of actors and monitoring of changes in the environment.

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