



Application of sunspaces in fostering energy efficiency and economical viability of residential buildings in Serbia



Dušan Ignjatović*, Milica Jovanović Popović, Jasna Kavran

Faculty of Architecture, University of Belgrade, Serbia

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ABSTRACT

Residential building sector in Serbia has changed dramatically over the last two decades. Large scale projects have given way to individual, private initiative resulting in smaller interventions rarely exceeding one lot. For this reason architectural concepts, building types, scopes and construction technology have been marginalized and fallen under the influence of market mechanisms and stringent local planning procedures.

New regulations on energy efficiency have risen the standards for thermal insulation therefore increasing the thickness of building enclosure. This actually means that construction costs are increased and net built area, therefore expected profit, reduced. In order to provide the viable ground for both implementation of new regulations and economic benefits for investors, authors of energy efficiency regulations in Serbia have noted a whole set of solar systems, among which sunspaces that would not count as a part of gross area, provided that they contribute to the increase of energy performance of the building.

This paper describes the case of a typical residential new construction in Belgrade that has applied the prescribed solutions and became the first building that has obtained the building permit by applying a sunspace as an efficient strategy for energy saving.

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1. Serbian building stock

Structure of the Serbian building stock has been influenced by the turbulent history and great devastations resulting in the fact that more than 95% of all multifamily buildings originate from the period after II World War, or, more precisely, 8.53% were constructed before 1960. These data present some of the results of the vast research of residential building stock, conducted by a team from Faculty of Architecture University of Belgrade, which resulted in formulation of National typology of residential buildings in Serbia [1]. Also, by evaluation of more recent types of construction we can say that the whole doctrine of construction process has changed in postsocialist period and is today characterized by simplification of construction technologies, reduction of building types and smaller scale activities commonly driven by the individual initiative and financing schemes of private investors. Some very common building types which were representatives of socialist prosperity and industrial progress, like high-rise (approx. 7%

in the period 1960–1980), are not being constructed at all anymore. Others, like lamella¹ type buildings represented with more than 50% in period 1970–1990 to around 40% in the period after the 1990, decreased in numbers, while representation in the overall building stock of some types has risen (buildings constructed as part of the city block, from around 10% in the 1970–1990 to more than 20% after the 1990). This tendency is likely to continue and will gradually change the whole structure of the residential building stock. For the purpose of this work buildings constructed within the city block, as a fastest growing portion of construction activity have been analyzed, especially since the restrictions of possible solar design elements are highest for this type. Other building types, like free standing or lamella types, have free (less obstructed) facades and therefore more possibilities for application of various solar systems.

Bettering the overall performance of this type of buildings from the perspective of their energy efficiency is limited mainly by the urban layout. This is illustrated in the study catalogue of energy characteristics of typical residential buildings in Belgrade [2]. By analyzing the behaviour of typical representatives of Belgrade

* Corresponding author at: Faculty of Architecture, University of Belgrade, Bulevar Kralja Aleksandra 73/II, 11000 Belgrade, Serbia. Tel.: +381 641322198; fax: +381 113370193.

E-mail address: ignjatovic.dusan@arh.bg.ac.rs (D. Ignjatović).

¹ Lamella building is defined as the composition of several visually and technologically identical segments combined in certain spatial order.

building stock and investigating their thermal envelope performance by the means of infrared inspection a set of standardized improvement methods have been proposed and their impact on energy performance and payback period of investment calculated. By *standardized improvements* are defined those focused only on composition of the building envelope and materialized mainly through addition of layers of thermal insulation and facade finishings or by replacing the windows, without including any passive or active solar design elements. If we analyze only the segment of the building stock that has been designed and constructed according to the latest regulations on thermal protection of envelope elements, before the introduction of procedures for determination and certification of energy consumption, we can see that improvements of buildings belonging to the type built within a closed city block are ranging from 5 to 20% of energy savings with payback period from twenty to almost hundred years. This leads to the conclusion that a different approach has to be applied if we were to improve the energy performance of buildings built in last twenty years. Newly constructed buildings, designed and constructed upon the more stringent regulations, have envelopes that are already improved compared to the analyzed models, therefore principles of alternative ways of bettering their overall performance is even more complex and calls for innovative ways of design thinking and use of renewable technologies.

2. Current urban planning and architecture design practice

In order to investigate the possible ways of achieving superior energy performance of the new types of residential constructions we have to understand the principles that are driving the construction process. It has to be said before any preliminary analysis of the procedures that in Serbia construction activity is determined by the number of laws, bylaws and urban planning regulations which, depending on the region, often have postulates that are not mutually harmonized and can result in different interpretations for each different case.

At the state level, the Law on Planning and Construction [3] presents a framework which regulates construction and defines general procedures for the preparation of required documentation and for the procurement of necessary permits. Urban planning regulations are enacted for cities and municipalities and they are generally based on spatial planning at the level of the state and of a particular region. The general and detailed regulation plans precisely determine the use of space, the types of buildings which can be built on particular lots, and a number of parameters that determine the precise shape and size of the building. These parameters are:

- The *regulation line*, defining the boundaries of the buildable lot;
- The *construction line*, defining the position of the building;
- The *occupancy index*, defining the maximum buildable area of the lot, including bay windows, canopies, balconies, etc.;
- The *construction index*, defining the maximum gross buildable area above the ground, where gross area is defined as the unfolded building floor area encompassing all building structures, insulation, railings, etc.;
- The number of floors;
- The height of the building, the height of the atica or of the roof ridge;
- Various distances between the front and the rear boundaries of the lot, between the side boundaries of the lot, between the adjoining buildings, etc.

These parameters determine the shape and the size of the building, while maximum allowed values cannot be exceeded. In

addition to these parameters, the *net floor area* of the building, i.e. its usable floor area, is directly affected by the quality of the design, the selected construction technology and all other elements of the building structure: its envelope, partition walls, installations, etc. The legislation and the current practice have shown that the net floor area ranges from 75% to 80% of the gross floor area. This area also determines the profit in the real estate market.

3. Real estate market conditions

Contemporary residential construction activity nowadays usually takes place in the centre parts of the cities rather than in the outskirts. These developments are taking place in densely built urban structures, replacing old and often devastated buildings, upon newly formed “free” lots. Resulting urban matrix is following the pattern of existing city blocks with minor adaptations of grid in order to meet the planning regulations. No major changes of the matrix are being executed and majority of the lots are preserved in original state apart from adaptations to the planned building and regulation lines. Also, there is no planning mechanism which would encompass merging of several lots and providing guidelines and incentives for creation of more sustainable and energy efficient designs on the block level, since usual residential blocks are inefficient from the solar energy utilization point of view [4]. Relationship between urban texture and energy consumption of buildings has been investigated by several researches [5–7] all concluding that urban design has a great impact on the overall energy performance of buildings and that it has to be addressed if we are to utilize maximum of the available natural resources. However, in domestic practice, design parameters which derive from planning regulations are seldom adjusted to the potentials for a more sustainable design. Also, since there is no rule that urges the owner to comply to the envisioned urban structure the process is left to the individual initiative and is often subject to various speculative actions.

Practice has shown that development either starts with acquirement of the lot by the investor, or, more frequently, by setting up of joint investment with the owners of the lots. In later, the investors would finance the entire construction of the building and the owners, instead of compensation in currency, would be given a certain percentage of the built floor area of the building. The amount is largely depending on the location and the expected price that could be achieved per m² of the living area on market. With downtown locations, this share exceeded 35% of the total net built area at the time when the apartments were sold at as much as 4000 €/m². More remote locations were characterized by less amount of constructed space allocated to the owners, down to 25% (20%), with the apartment prices ranging from 1600 to 2000 €/m². It should be pointed out that these principles were formed in the period of 2006–2008, which was characterized by the highest real estate prices [8].

On the other hand, new regulations on energy efficiency in buildings [9] have set new requirements regarding the performance of the buildings significantly decreasing the respected indicators: the allowed *U* value for walls was reduced from 0.9 W/m² K to 0.3 W/m² K and for windows from 2.7 W/m² K to 1.5 W/m² K. More stringent requirements are also set for all other elements of the thermal envelope. The regulations require, for the first time on our market, certification of buildings, stipulating that all new buildings and major refurbishments fulfil at least C rating [10]. This is confirmed by provision of detail study of buildings energy efficiency as part of technical documentation for obtaining a building permit, and verified by issuance of Energy performance certificate (EPC) in the process of technical approval for obtaining the usage permit. C category is defined as the relative ratio of calculated annual energy

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