Some Possibilities of Extensions in Building Renovation

Natasa Cukovic-Ignjatovic and Dusan Ignjatovic

Faculty of Architecture, University of Belgrade, Belgrade, Serbia

ABSTRACT: It is estimated that some 45% of Belgrade's building stock could be efficiently upgraded regarding the energy use and overall environmental impact. However, the costs of renovation are usually the most discouraging factor and main obstacle for practical implementation. At the moment there is no government initiative for housing sector and there are no available funds that would support energy efficient renovations. Lateral and vertical extensions open opportunities not only for technical aspects of energy optimisation but can be very encouraging for tenants/investors to engage such interventions providing instant benefits in terms of gained surface and rather short period of overall payback time. The paper explores the possibilities, scale and economic impact of such interventions applicable on the most common building types for Belgrade urban area. Methods and typology are based on the results of scientific project "Energy optimization of buildings in context of sustainable architecture" conducted by the Faculty of Architecture University of Belgrade.

Keywords: extensions, energy, renovation

1. INTRODUCTION

An overview of Belgrade's building stock showed that almost 38% of gross built surface dedicated to housing was constructed between 1947 and 1970[1]. Furthermore, many of the buildings completed in early 1970's were designed during the 1960's, and first regulations requiring use of thermal insulation and limiting allowed heat losses were introduced in 1967, so the number of buildings with very poor thermal characteristics is rather significant. On the other hand, these buildings were built from rather durable materials and their lifespan justifies interventions aimed to improve their performance and meet the needs of contemporary housing. This portion of Belgrade's building stock is the subject of research presented in the paper.

The financial aspect, when both private owners and the state are being neither capable nor willing to invest in project with vague economic effects, produces numerous obstacles for serious implementation of eco-refurbishments. Extensions are therefore very interesting type of intervention since they instantly produce new, commercially valuable surface which could compensate the costs of energy-optimisation. The focus of this paper is primarily on the lateral extensions - vertical extensions were numerous in Belgrade metropolitan area since the 1990's but the control over these projects is very weak, leaving the doors open for many misuses of ownership and abuses of architectural heritage; lateral extensions are not so easy for an individual investor to undertake and therefore they are more suitable for organized approach and controlled actions.

2. GENERAL RESTRAINTS

Extensions of residential buildings are complex interventions, and they require delicate approach in design that would adequately deal with set of restraints comprising the questions of protection of built heritage, changes of urbanistic parameters as well as limitations deriving from structural and functional characteristics of a building.

2.1 Questions of Architectural Heritage

Any kind of extension produces significant changes of the original building; obviously, the appearance is altered, but also are the numerous characteristics of the original design, so the question of terms and conditions for these modifications arises.

At the moment, no residential buildings erected after World War II are subject to any kind of official protection nor are labelled as part of Belgrade's architectural heritage. Certain portion of this production is result of valuable research, national and international competitions often presenting unique qualities that surely deserve more attention and special care in the future. However, huge part of housing production dated 1947-1967 followed some typical layouts and rather reduced design aspirations, coping with constant shortage of housing capacities. These buildings leave room for various approaches with more opportunities for innovative design and technical solutions.

2.2 Urban Layout

Urban layout of the existing building(s) generates two sets of general restraints:

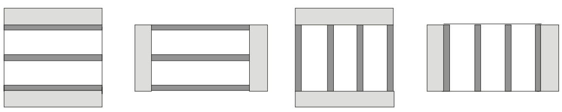
- restrictions derived from urban regulations
- limitations derived from conditions of particular site

Urban regulations define primarily physical capacities of certain area (site, block, community, etc) through set of numerical data. In cases where these capacities are already full, the options for extensions are very limited, but in many cases there are good chances for increasing densities and actions inherent to the theories of compact city.

Local conditions of a particular site might generate certain limitations in design or potential use of certain systems, but often offer opportunities to improve energy characteristics of remodelled entity and better use of bioclimatic potentials of the location.

2.3 Building's Structure

Buildings constructed using typical design layouts had rather simple structure[2]: massive masonry walls supported ribbed concrete slabs. In some cases reinforced concrete frame system was applied, but generally speaking, bearing walls (or frames) are placed parallel to longitudinal or transversal axis of a building. Figure 1 shows typical dispositions of lateral extensions related to the building's primary structure: when the extension is parallel to bearing walls (Figures 1.a and 1.d) options for lateral extensions are somewhat limited – their dimensions are restricted to potential consoles or completely new bearing module should be added. When extension's structure can follow building's primary construction (as in figures 1.b and 1.c), the dimension of extension is much less dependent on the existing structure.



1.a 1.b 1.c 1.d

Figure 1: Typical dispositions of lateral extensions related to the building's primary structure

2.4 Functional Scheme and Floor Layout

Options for lateral extensions are strongly related to functional scheme of apartments and floor layout of a building. Buildings that are subject to this research have rather modest layouts, apartments are very small, rooms were designed having in mind minimal dimensions so possibilities for lateral extensions are often very attractive for tenants as a way of improving the quality of their apartments by increasing the floor surface area, upgrading the functional scheme and meeting the needs of contemporary housing.

In theory, various aspects of such interventions can be searched into and benefits derived from these actions considered and easily translated into very encouraging numbers. In reality, problems of ownership (tenants own their apartments but who owns the building remains unclear) and building management (tenants are mostly self-organized in matters of building maintenance and management) pose serious obstacles for realisations. At present condition, interventions that would require moving out during the works are practically impossible; therefore, radical modifications in floor layout remain in the domain of theoretical considerations.

3. SCALE OF INTERVENTION

Scale of intervention was examined regarding the relation between the added structure and the existing building where the following parameters were analysed:

- volumetric relations – new part being a complement, extension or new volume adjunct to the existing structure
- functional relations – new part acting as an extension of existing apartments or providing new housing units; attached to the existing ones or detached,…
- structural relations – new part is supported by the existing structure, or requires modifications of the existing structure, or is designed as a structure completely separated from the original one
- improvements in energy use and in the environmental impact

Generally, regarding the scale of intervention, lateral extensions were considered within three basic types:

- small-scale extensions
- large-scale extensions with unchanged basic composition of a building
- extensions involving changes of building's original composition

3.1 Small-scale Extensions

At small-scale extensions, a new, rather shallow (usually 0.6-2.4m) "zone" is introduced, partially or completely covering the existing envelope (Figure 2).

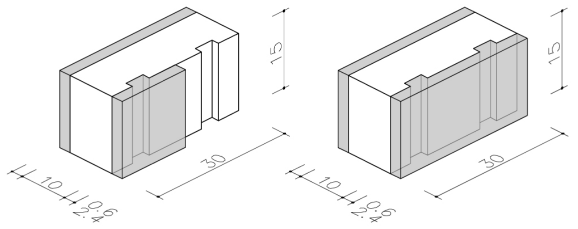


Figure 2: Small-scale lateral extensions

This type of intervention can be considered as a complement to the basic volume and original building's layout since it does not imply major changes in the functional scheme of a building and its apartments; more likely it enlarges certain segments of housing units. Addition or its portions may also function as a sun-space.

With this type of extension, the added part can be supported in whole by the existing structure, or introduce new bearing elements if necessary as discussed earlier in the chapter 2.3.

Most urbanistic parameters remain unchanged by such interventions; usually only the data derived from overall and net surface area are being modified.

Energy-efficiency of a building can be improved in various ways:

- heated volume/contact area ratio can be significantly improved
- better insulation, reducing heat losses
- sun space

- thermal and acoustic buffer zone
- functional modifications
- application of photovoltaic systems, direct gain, etc…

Double-facades also belong to this group of interventions but chances for their use in this portion of the existing building fond are only theoretical.

3.2 Large-scale Extensions with Unchanged Basic Composition of a Building

This type of extension comprises adding larger volumes without changing the basic composition of a building; the extension of a building implies rather significant extensions of the existing apartments (Figure 3).

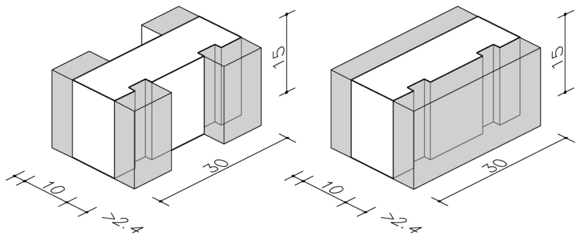


Figure 3: Larger-scale lateral extensions

Larger depth of new volume (usually more than 2.4m) often requires changes in the apartment's functional scheme so in some cases it is possible to expect more radical modifications of the original design at the individual apartment level. Through such interventions major portion of installation and support systems can be reorganised and modernized and the whole unit can be remodelled according to the principles of ecologicaly-concious design.

Urbanistic parameters in this case change following the same pattern as with smaller-scale extensions.

Larger-scale lateral extensions require new supporting structure, following the logic of the original one, or designed as a separate static entity.

If applied without thorough design research, these extensions might produce negative effect on the building's energy balance. However, since the individual apartments can be significantly improved, the possibilities for overall upgrades in the buildings energy balance should by all means be explored in each individual case.

3.3 Extensions Involving Changes of Building's Original Composition

These interventions comprise addition of new volumes containing their own vertical communications (stairs, elevators, installation ducts etc.) and new, separate apartment units, but still forming single entity with the original building (Figure 4).

Introducing new volumes takes advantage of the unused potentials of a site and allows optimisation of density and more efficient use of the existing infrastructure. The new volume acts rather independently, and it can be designed completely in a way that would minimise its environmental impact.

As a strategy, this type of intervention is very interesting since it can act as an initiator for upgrades of the existing volume – façade refurbishment, alterations in the heating system etc. Also, most new service units could cover both the existing and the new structure. Since usually the tenants are neither able nor willing to cover the costs of energy optimisation of their building, by engaging production of new commercially interesting apartments, some part of generated profit can be used to cover the cost of upgrades on the existing building.

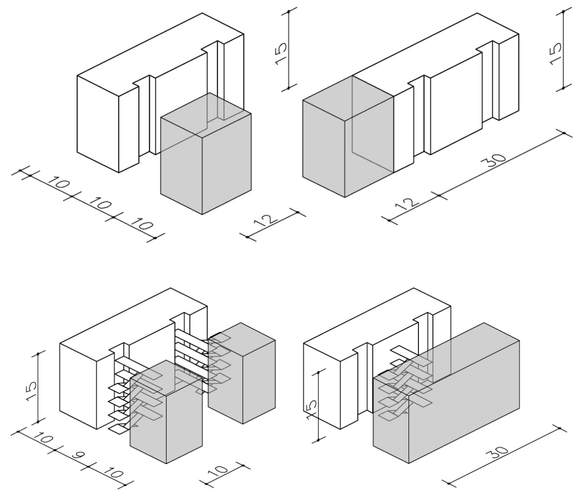


Figure 4: Adding new volumes

4. IMPACT ON BUILDING'S ENERGY PERFORMANCE

Regarding the energy performance of the altered building, the changes can be traced on three basic levels:

- changes in the heated volume/contact area ratio
- upgrading the performance of building's envelope
- improving the functional zoning

4.1 Changes in the Heated Volume/Contact Area Ratio

Ratio of heated volume and the contact surface between heated and unheated space is an illustrative indicator of building's potential heat losses. Extensions obviously alter this parameter and in order to examine how it is being changed, some basic calculations were made for a simple model presenting typical building 15m high, 30m long and 10m wide. The extensions were made parallel to the longer façade (transversal extensions, Figure 5.a) or to the side façade (longitudinal extensions, Figure 5.b). The additions of 1.2m were model for smaller scale interventions and additions of 4.2m for larger scale interventions were introduced and the results are presented in Table 1.

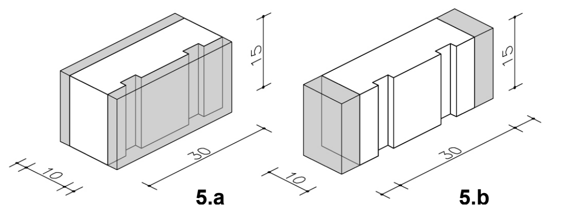


Figure 5: Basic model with transversal (5.a) and longitudinal (5.b) extensions

Table 1: Changes of shape factor as a result of lateral extensions

		transversal extension			**longitudinal** extension		
		V[m³]	A[m²]	f_o[m⁻¹]	V[m³]	A[m²]	f_o[m⁻¹]
existing condition		4500	1800	0.4	4500	1800	0.4
extension [m¹]	+1.2	5040	1908	0.38	4680	1860	0.397
	+2*1.2	5580	2016	0.36	4860	1920	0.395
	+4.2	6390	2178	0.34	5130	2010	0.392
	+2*4.2	8280	2556	0.309	5760	2220	0.385

V – volume of the heated space;
A – area of the contact surface between heated and unheated space
f_o – shape factor (A/V)

Even this simplified model shows that transversal extensions tend to be more efficient than the longitudinal ones; the shape factor was reduced up to 25% with transversal extensions compared to reduction of less than 5% with longitudinal extensions. Taking into consideration that generally the geometry of side façades is simple and shows as less relevant in total score, in reality the improvements might even be better than on the model.

4.2 Upgrading Building's Envelope Performance

Extensions open wide range of opportunities for upgrades in building's envelope performance – not only the new façade acts better but various interventions should be applied on the existing exterior walls, since buildings dated before 1967 have no or very poor thermal insulation and old glazing resulting in significant heat losses. In Table 2, some of the most relevant functions of building's envelope are elaborated regarding their involvement in building's energy performance and upgradeability[3].

Table 2: Possibilities for upgrading some functions of building's envelope

Function	participation in building's energy performance	possibilities for upgrading
Illumination		
Ventilation		
Moisture control		
Thermal protection		
Wind protection		
Sun protection		
Glaze protection		
Visual contact		
Safety/security		
Acoustic protection		
Fire protection		
Energy gain		

options
more ... less

It is crucial to treat the building as a whole throughout all design stages. Also, it is necessary to pay close attention to joints between the old and the new part – continuous thermal and hydro insulation, joints, dilatations and all relevant detailing should be consequently designed for the complete building. Use of sun space, Trombe walls, sun collectors and photovoltaic units can further improve the overall energy balance after refurbishment.

4.3 Thermal and Functional Zoning

Lateral extensions can often improve thermal and functional zoning of a housing unit and induce better comfort in certain areas thanks to adequate orientation, exposure to sun and sun protection, air circulation, contact with complementary spaces and functions etc. The options for improvements though better zoning are directly related to the extent/scale of intervention and it was already elaborated in the text.

5. TECHNO-ECONOMICAL ANALYSIS

As a part of this research, a separate study was made in order to explore technical options, scale and type of intervention regarding the payback period and possible gains through various interventions on the selected building types[4]. It turned out that pure refurbishment of building's envelope can not produce positive economic effect. The best economic effect was achieved with lateral (transversal) extension combined with vertical extension: an average 55m² apartment unit was enlarged by approximately 22m² (40% of the original surface) at the building cost of €9350.00. Lateral extensions which did not include vertical extensions also showed significant economic potential since the investment remained within 25% of the total value of the extension.

6. OPTIONS FOR IMPLEMENTATION IN BELGRADE

Residential buildings erected during post-war construction in Belgrade (1947-1967) present rather suitable material for various extensions that might produce quality architectural solutions significantly upgrading the existing building fond. The need for such actions can be recognized, both on the level of general, public interest (reduced overall energy consumption, better use of the existing infrastructure, optimized urban densities, application of new materials and technologies, engaging local contractors, extended longevity of the existing buildings etc.) and also by the tenants/owners (improved thermal and acoustic comfort, extension of their own apartments, reduced heating costs, better layout and functional organisation etc.).

The regulations demand the consent of tenants owning at least 50% of total habitable surface, but in reality it is quite possible for single owner to block the procedure. The research project also produced an algorithm[5] (Figure 6) for procedure scenario open for sponsorships, institutional engagement, and monitoring of the results in order to stimulate pilot projects with realisations that would serve as a role-model for future interventions.

7. CONCLUSION

Introducing lateral extensions into the processes of building renovation seems to be very promising in case of designated portion of Belgrade's building stock. The paper explored some limitations of such actions, possible extent of the intervention, potential improvements regarding energy performance and economical repercussions in search for refurbishment proposals for typical building layouts used in the post-war residential construction.

This particular portion of Belgrade's building stock contains building designs repeated numerous times - sometimes grouped into blocks (major ones are Blocks 7 and 7a in New Belgrade with dozens units repeating almost identical design) and sometimes dispersed within inner city area. Those identical buildings with different dispositions present promising material: one set of solutions can be used to outline the recipe, working scheme which can further develop to produce various architectural designs. The research is thus optimized and procedure can be almost uniform whereas different design approach could introduce more diversity into monotonous city blocks.

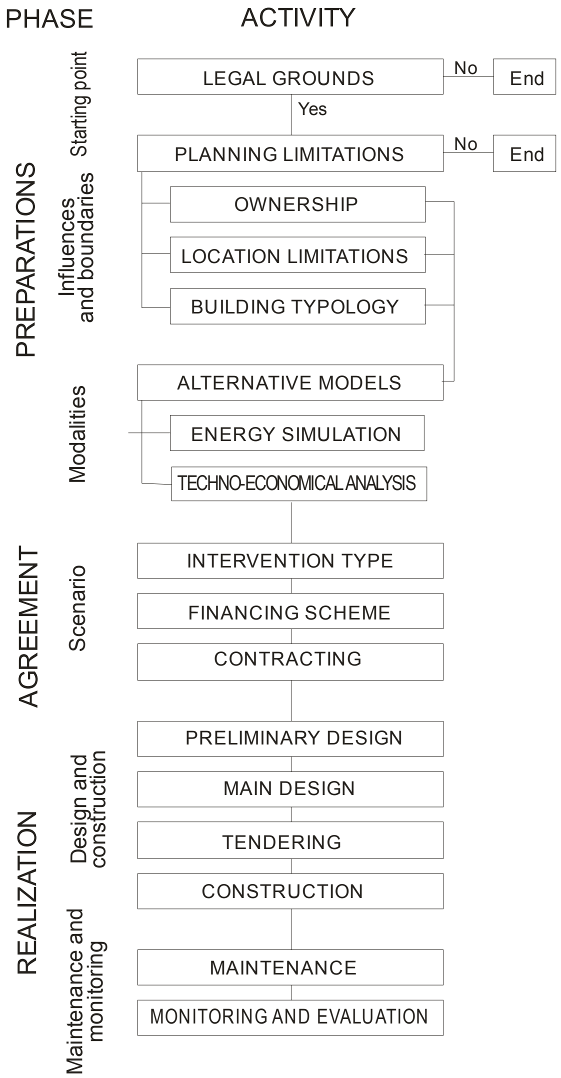


Figure 6: Algorithm for energy optimisation of residential building

ACKNOWLEDGEMENT

This paper presents results obtained through participating scientific project "Energy optimisation of Buildings in the Context of Sustainable Architecture" *(Energetska optimizacija zgrada u kontekstu odrzive arhitekture) conducted* by Prof. Dr. Milica Jovanovic-Popovic at the Faculty of Architecture, University of Belgrade 2002-2005.

REFERENCES

[1] N. Cukovic-Ignjatovic, D. Ignjatovic, Possibilities for Upgrading the Existing Building Stock in Belgrade, SD-MED Conference Proceedings, Athens, Greece (2005)
[2] S. Dimic, Konstrukcija i materijalizacija fasadnih zidova postojecih objekata *[Structure and Materials of the Façade Walls of the Existing Buildings]*, in Analiza strukture gradjevinskog fonda, - Phase 1 of the scientific project "Energetska optimizacija zgrada u kontekstu odrzive arhitekture", Faculty of Architecture University of Belgrade (2003), 133.
[3] N. Cukovic-Ignjatovic, Analiza mogucnosti unapredjenja zidova i konstrukcije omotaca *[Analysis of Options for Upgrading Envelope's Walls and Structure]*, in Mogucnosti unapredjenja energetskih karakteristika gradjevinskog fonda, - Phase 2 of the scientific project "Energetska optimizacija zgrada u kontekstu odrzive arhitekture", Faculty of Architecture University of Belgrade (2004), 47
[4] M. Pejanovic, Tehnoekonomska analiza dogradnje postojecih objekata *[Technoeconomical Analysis of the Extensions of the Existing Buildings]*, in Mogucnosti unapredjenja energetskih karakteristika gradjevinskog fonda, - Phase 2 of the scientific project "Energetska optimizacija zgrada u kontekstu odrzive arhitekture", Faculty of Architecture University of Belgrade (2004), 161
[5] M. Jovanovic-Popovic, D. Ignjatovic, Formiranje algoritma energetske optimizacije *[Formulating an Algorithm for Energy Optimisation]*, in Mogucnosti unapredjenja energetskih karakteristika gradjevinskog fonda, - Phase 2 of the scientific project "Energetska optimizacija zgrada u kontekstu odrzive arhitekture", Faculty of Architecture University of Belgrade (2004), 174