

# REHABILITATION PROJECT OF AN APARTMENT BUILDING IN BELGRADE, SERBIA

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*As a part of a scientific project conducted at the Faculty of Architecture University of Belgrade a detailed survey of building fund has been made and a typical 1950's building was chosen as a demonstration project for the energy conscious renovation and retrofit procedure.*

*Rehabilitation has been done in three main phases:*

- *Detailed analysis and inspection of present state based on available project documentation, on site inspection, thermography, as well as interviews with tenants. In this phase strategies for reconstructions were analyzed and evaluated*
- *First phase of rehabilitation mainly concerned improvement of performance of envelope (façade, windows) with addition of an attic level.*
- *Second phase maximizes performance of building using various architectural and technical methods.*

*Addition of new volumes (glazed loggias, and partly double skin façades), heat recuperating units, and hot water collectors with redefinition of heating system was the main objectives.*

*For both phases techno-economical analyses were made optimizing possible thermal performance gains and used technology in accordance with economic potential and pay-back period. Also a detailed procedure algorithm was developed in order to give guidelines for future projects of this type.*

**Keywords:** *rehabilitation, energy optimisation*

## INTRODUCTION

Extensions, refurbishments and conversions of unused parts of apartment buildings became very popular way of gaining new apartment units during the 1990's. The investors were individuals already living in the existing building, or private entrepreneurs who would (in return for allowance to intervene on the dwelling) compensate the owners by performing major works on their building, such as repairs and refurbishments on the façade, halls and staircases, installing elevators etc. The extent of these interventions and the quality of works varied a lot, since it was up to the two parties involved (owners and investors) to make an agreement and neither party was professional on the subject. Regulations were inconsistent and unclear, leaving plenty of opportunities for manipulations and malpractice. The need arose

for some sort of guidelines that would make better use of these interventions, and encourage search for modernized and environmentally friendlier design and research works began in many disciplines related to architecture and urban planning.

The project of energy based rehabilitation of an apartment building in Belgrade has been organized by Velux (Denmark) and Faculty of Architecture University of Belgrade and sponsored by BIF (Building Improvement Foundation - Denmark). Ministry of Education and Sports as well as Ministry of Science and Capital investments also participated as supporting bodies.

Project was based on the premises of creating an applicable model for further interventions. This model had to be based on real economic grounds and incorporate direct participation of

both tenants and experts. For this reason an extension of existing structure was chosen as a generator of the rehabilitation project providing sufficient value for the whole process.

In the preliminary period it was decided that the gained space is to be donated to the University of Belgrade to accommodate young specializing professionals for a limited time period.

## CHOOSING THE MODEL BUILDING

The first phase of the research that preceded the pilot project was focused on detailed analysis of Belgrade's building stock in order to identify building types and single out the one that would be the most suitable for energy rehabilitation. The major building types seemed to have corresponded to the certain phases of housing development in Belgrade –

the construction prior to the World War II (buildings dated before 1941), the post-war construction (1946-1970), the directed housing strategy (1966-1980), etc [1].

Some 15% of present building stock was constructed before World War II and it could not be considered as representative mainly because of rather modest number of apartments and great variety of building types. Also, many of these buildings are important part of architectural and cultural heritage and their refurbishment demands specific and more complex approach.

On the other hand, by the late 1960's, first building regulations regarding thermal insulation were introduced, and most buildings constructed during the period of directed housing strategy were designed according to these regulations; by the late 1980's Yugoslav standards in the area of building physics were based on German DIN standards at the time and were compulsory part of building design.

The buildings constructed during the 1950's and 1960 have presented the most interesting material for this research due to the particular set of characteristics:

They have no thermal insulation, so even modest interventions could result in noticeable improvement

During this period some 30% of Belgrade's building fund was constructed, mainly repeating the same model with minor variations. This means that the same guidelines could be applied on a large number of buildings, and a good model could provoke and initiate numerous interventions

Long life span of primary construction (although built with rather limited resources, they are made of solid, traditional materials, mainly brickwork and concrete) supports the idea of rehabilitation instead of demolition

The apartments are equipped with chimney installation, heated individually, using electricity mainly, with no gas or district heating connection, so tenants could feel benefits from rehabilitation instantly, both financially and in terms of thermal comfort

Their very limited architectural value provides space for architectural research for improvements in building appearance and identity

The model building was chosen as typical representative of this particular building type. In order to meet the needs of all the participants in the project, we looked for a building in a traditional city block, located in the greater central area of Belgrade, preferably with the disposition that would enable introducing some passive and/or active solar systems and optimal use of solar gains.

Finally, the building in 112-120 Cvijiceva street built in 1957. was chosen to be the subject of the pilot project (Figures 1 and 2). It was built within a traditional city block, it has all the characteristics of designated building type, with street façade facing north and court façade facing south with courtyard wide enough to provide good solar exposure. The building was in rather poor condition, and needed some refurbishment and repairs that the owners could not carry out themselves.



Figure 1: Building in Cvijiceva 112-120: street (North) façade – existing state



Figure 2: Building in Cvijiceva 112-120: court (South) façade - existing state

## MODEL BUILDING – PRELIMINARY INVESTIGATION

The first project activities were dedicated to the detailed examination of the existing state of the building in order to investigate possible limitations for planned activities. At this stage, preliminary investigations were carried out regarding:

- technical data, involving technical investigation, measurements and a questionnaire for each individual flat
- legal issues, and
- feasibility study

The collected data were structured into the Technical report that covered all engineering aspects:

- General description that presented the designed and the existing state of the building in general, characteristics of its envelope, materials and equipment that were used
- Geotechnical conditions that covered geologic and hydrogeologic soil features, as well as seismic characteristics of the ground
- Structure condition where the designed and the existing state of building's structure were presented, and possible restrictions regarding the reconstruction were explored
- Waterworks and sewage installation networks
- Electrical installations
- Mechanical installations in the sense of the option for possible district heating connection and new heating installations for all apartments was elaborated
- Survey which covered all apartment owners, identifying the changes made by tenants during the exploitation and their approval or disapproval regarding each particular potential intervention proposed as part of the pilot-project
- Appendix which included complete set of technical drawings, schemes, illustrations and photos that accompanied sections 1-7

Later during the research, when thermal camera was acquired, thermal images showed the patterns of heat losses and identified the most critical parts of the building regarding its energy performance. Figures 3 and 4 show that the most evident losses occur in the areas

where concrete slabs intersect with the façade and on the windows. Some variations are visible on the South façade (Figure 4) where tenants have used their loggias as extension of living space, having them enclosed in their own way.

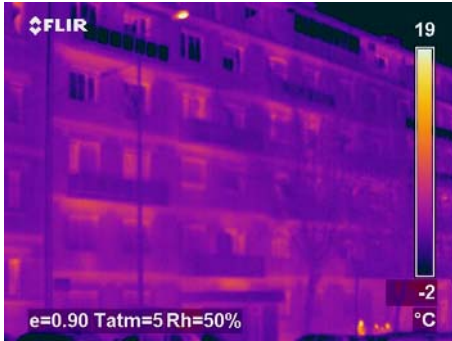


Figure 3: North façade – thermographic image



Figure 4: South façade – thermographic image

## REHABILITATION

### First Phase

Based on the detailed technical report first phase concentrated on vertical extension and envelope improvement [3]. Interventions were planned in three major fields:

- construction of new attic.
- reconstruction of the envelope (changing or servicing the windows, adding thermal insulation on the façade and along the staircases)
- connecting the building on distant heating system network

Figures 5 and 6 present the perspective views of the North and South facades as designed for

the first phase. The design was approved by all participating parties.



Figure 5: North façade – the first phase of reconstruction



Figure 6: South façade – first phase of reconstruction

New attic was designed to have minimal impact on existing structure combined with simple construction method. Several architectural and technological solutions were considered and evaluated [2]. All new structures and installations systems were designed to be an extension of existing ones. Roof structure was designed as ventilated construction with 25cm thermal insulation. Shaped in the form of Mansard roof, it provided adequate use of roof windows insuring sufficient light and ventilation.

Façade of the building was to be fully renovated and insulated using Rockwool façade system (with additional 10cm insulation). Depending on their state, windows and balcony doors were either renovated or changed using PVC windows (5 chambers PVC profiles, low emission glass) equipped with external blinds. Internal staircases were insulated with 5cm insulation.

An approval from the city authorities for connection to the district heating system was obtained and new substation planned (within the building). Main distributing pipes were planned in staircases and tenants were obliged to provide radiators and local branching. An automated valves and individual measuring system for each flat were also planned. The effects of individual measuring system do not show on direct calculations but it can be expected that tenants are encouraged to reduce their consumption if they pay accordingly to the energy used, and not per m<sup>2</sup> of their flat as it the case in Belgrade district heating system.

First phase of rehabilitation was mainly focused towards reaching the desired energy standard and level of comfort as well as improving the overall state of building. For the Base case and for the Reconstructed case the dynamic building model (DOE 2.2) has been established. The theoretical estimations of energy consumption showed that the annual amount of energy used for heating could be reduced up to 63% (Figure 7).

### Second Phase

The second phase concentrated on additional methods for energy optimization and improvement of total building performance.

In this phase new structure was added on the south façade (Figure 8). This structure serves both as a thermal buffer zone and an extension of existing flats. Constructed from steel frames and glass covering it is connected directly onto the primary structure of the building serving as a sunspace to which every flat can be extended. Sufficient internal shading in the form of Venetian blinds and lateral openings were designed to prevent overheating in summer period.

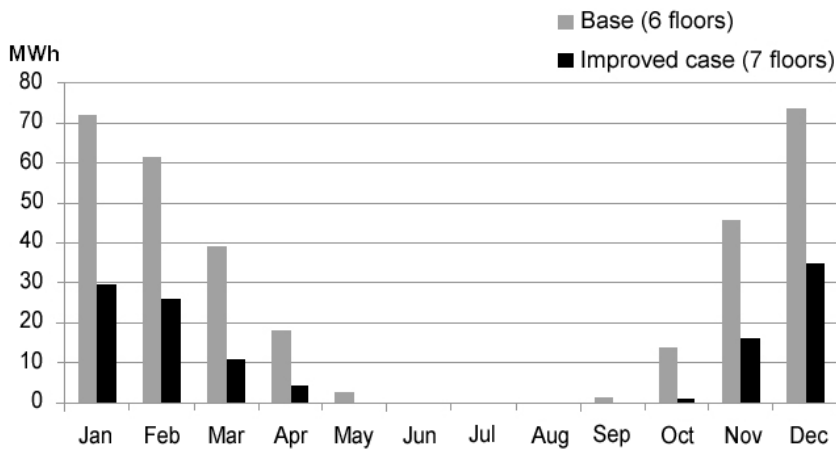


Figure 7: Annual energy load for heating



Figure 8: Reconstructed court façade – phase 2.

A system of hot water collectors was also planned, but serving only to newly constructed flats as an individual system. Since more complex system providing hot water for the whole building required extensive works and lack of legislation it was not concerned in the project.

A ventilation system with heat exchange units located in each flat was also designed using abandoned chimney pipes (no longer in operation due to the central heating system installation) as installation ducts.

In addition to this phase introducing active solar systems such as photovoltaic cells and various measures for reducing complete environmental footprint of the building were taken into consideration.

## ECONOMIC ANALYSIS

For both phases of rehabilitation project, a preliminary cost calculation was created, providing sufficient data for decision-making process.

It was estimated that the first phase would cost €762.550, out of which some 40% is designated for the reconstruction of existing building without an extension.

fiscal authorities such as waivers or reductions in taxing thermal insulation, automated valves etc., and the overall costs could be significantly reduced.

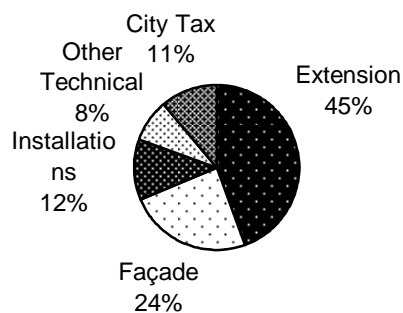


Figure 9: Structure of the costs for the first phase

Pie-chart shown on Figure 9 presents the structure of the costs for the first phase of reconstruction. Total costs for the extension are estimated on €334.791, façade works together with necessary repairs and replacements of windows €183.260, installations (with the substation and all necessary equipment for district heating) €98.485, other technical costs (surveillance, design and insurance) for €63.014 and City tax would be €83.000. City authorities were not willing to waive this tax, although it could reduce the total costs for 13%. Also, general VAT (18%) is included in this cost calculation. With some support from

Pie-chart on Figure 10 presents the structure of the costs for more elaborated refurbishment, as designed for the phase 2. With total costs of €1.003.450 it is by 31.6% more expensive than the proposal for phase 1, with glazed addition costing more than the primary façade refurbishment. Since the habitable surface of the existing flats is increased, the costs for the City tax increase (the tax is paid per m<sup>2</sup> of new habitable surface achieved).

This structure of costs implies that for improvements designed in phase 2, more participation from the owners is needed and it could be expected only if such intervention would immediately reflect on the increase of market value of their apartments that would cover the initial investment. At the moment, it is not the case and interventions on this scale could not be expected to occur in near future unless strongly supported by local authorities or donations.

## IMPLEMENTATION

The primary goal of the pilot-project was to optimize the energy performance of the selected building, using the methods and resources that could serve as a model scheme for future interventions, preferably carried out by the tenants/owners with some encouragement and support from the municipality level. Figure 11 shows the algorithm with phases and corresponding actions that should enable the complete realization with monitoring and evaluation providing data on real benefits of intervention. This algorithm was elaborated having in mind not only the participants in the particular pilot-project, but the real actors that would be involved in a similar process elsewhere in Belgrade metropolitan area [4].

The absolute preconditions for the interventions are solid legal grounds, where complete accordance with planning limitations is required in order to make any intervention legally possible. Preparations phase covers analysis of limitations deriving from local characteristics of particular site, building type and ownership status. In search for modalities of intervention, alternative models can be proposed with energy simulations and techno-economical analysis that could help clarify the most suitable intervention type. For the chosen intervention, financing scheme is elaborated and at that point contracting can begin. Realization covers all standard phases, from preliminary design up to the construction and should be followed by adequate maintenance and involve monitoring and evaluation that would provide feedback data if possible.

Theoretical research and surveys described in previous chapters covered the phases prior to the actual realization – contracting and construction. Since the results of the survey showed that the apartment owners were willing to support the intervention, and BIF and VELUX were willing to cover the costs presented in techno-economic analysis, the design was further elaborated up to the stage of main design documentation.

Major set-back for the pilot-project came when several apartment owners asked for extension of the original contract, implying that the participants should cover all potential repairs

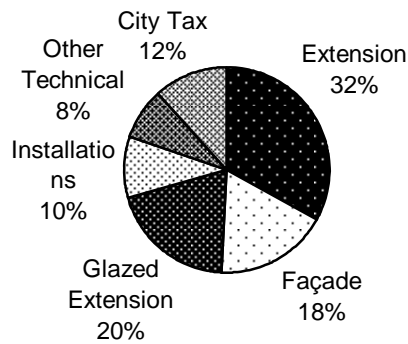


Figure 10: Structure of the costs with the second phase included

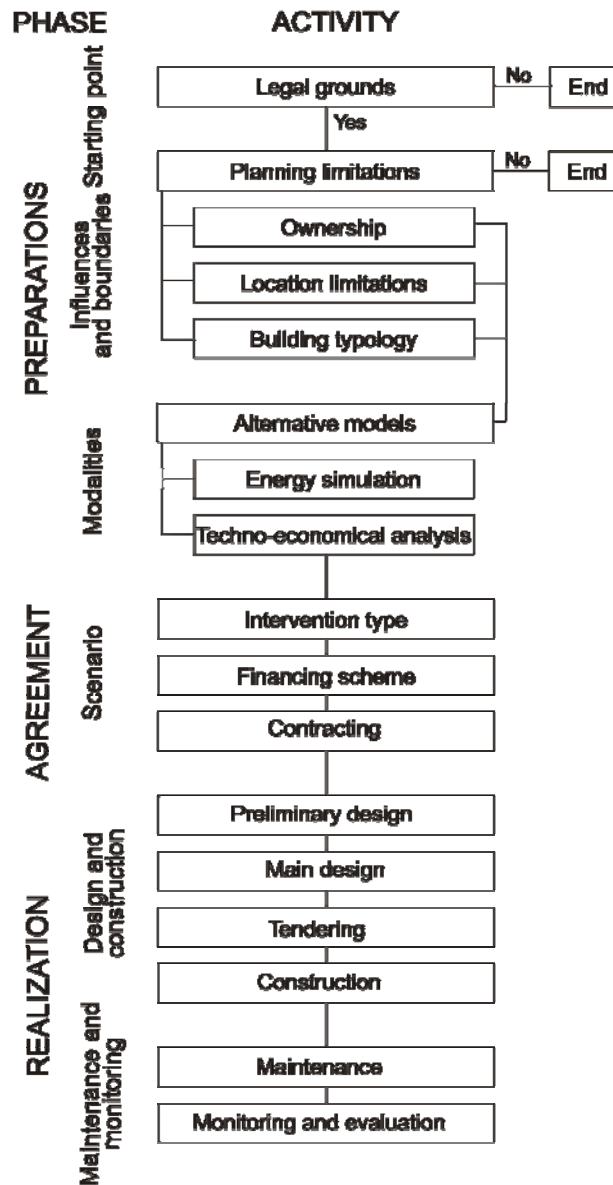


Figure 11: Algorithm for energy optimisation

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for any damages occurring after the intervention, regardless of their cause. The donators were not able to take that kind of liability, the beneficiaries redrew their accordence, and the final contract was never signed. Although the relevant legislation did not demand 100% accordence for such intervention, the donators required the complete accordence throughout the whole process and the construction was never carried out.

## CONCLUSION

Sustainable use of building fund is very important issue urban areas. Energy efficient and environmentally friendly refurbishments offer opportunities for optimized use of the existing building stock. This research has elaborated the topic, analysing the structure of Belgrade's existing building stock, choosing a model-building to conduct a pilot-project of energy optimization.

The research and theoretical findings have proved that an ordinary multi-storey apartment building can be refurbished to reduce the energy consumption using the same building techniques as in common construction practice in Belgrade. Even so, some support and encouragement from local authorities is still necessary, either in financial (through programs like "Let's Fix it Together", or tax reductions, donation programs etc) or in administrative area (to facilitate the procedures that sometimes last longer than the actual construction, enable individual measuring for district heating etc.). For more complex interventions, higher degree of investment and active participation of all actors is needed, and that is very hard to carry out during the transition years with very limited financial resources.

Although the pilot-project lacked the final execution, the findings of the research are very useful regarding the great number of buildings very similar to the actual subject of this particular project. The prices for all energy consumed in housing rise constantly, and the energy performance of apartments starts to reflect on their market prices. Individual owners now tend to improve their thermal insulation and use windows with lower U-values when refurbishing their apartments. These

interventions are at the moment random and partial but with more coordination on the municipality level, the whole city blocks could be upgraded to meet the contemporary standards both in comfort and in environmental performance.

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