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Assessing renovation measures by the effectiveness

Designing a renovation is a big European challenge knowing that about 80% of the current building stock will stay in place beyond 2050. The effectiveness of the entire renovation is strongly influenced by the measures taken in the early-design-phase. This article explains the effectiveness of individual renovation measures for typical houses in Serbia. The results from dynamical simulations were delivered in a form of a toolbox, which could be used as a support instrument for the design. Understanding the potential of the measures could provide an upgrade for the house renovation design process.

Keywords: energy savings, effectiveness, house, thermal insulation, renovation measures, toolbox.

VLADIMIR JOVANOVIC
PhD student
Institute for Architecture and Design
TU Wien, Austria
jovanovic.vlad@yahoo.com

Developing the approach

Residential buildings build in 1970's and 1980's are identified by the First Serbian National Energy Efficiency Action Plan as the biggest problem regarding energy efficiency in the country [4]. In Serbia, about 70% of the population lives in houses. Moreover, the similar situation is in the neighboring countries [5].

This article summarizes the previous scientific work [1-2]. Developed methodology assessed the effectiveness of individual renovation measures for houses in the South-East European (SEE) climate conditions. Analyzed locations were two Serbian cities: Belgrade with 2520 heating degree days and Nis with 2613 heating degree days. Three typical detached houses were extracted from the catalogue of typical housing designs from 70's and 80's (**Figure 1**) [6]. This was done with the purpose to identify the average saving potential for these three houses regarding their heating demands. Three buildings had typical concrete-structure with brick-block walls, semi-fabricated ceiling construction, plaster finishing and no thermal insulation. Dynamic simulations were performed in Euro Waebed (EW) and Geba simulation software. The main focus was on energy conservation measures. In addition, economic and social implications were discussed.

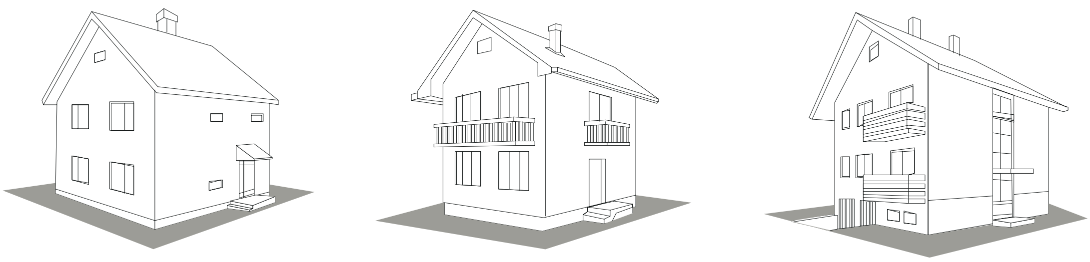

Figure 1. Analyzed houses positioned in two cities marked by codes from the catalogue. [6]

Simulating settings were changing only one building component in the reference model. This approach enabled evaluating the individual contribution of each measure. The external walls, ceilings and roofs were insulated with an expanded polystyrene (EPS); the internal insulation was performed with a capillary thermal insulation system; the ground-floors were insulated with an extruded polystyrene foam (XPS). Windows replacement considered both double and triple glazing. For the ventilation, heat recovery (HR) device with 95% efficiency was used. All renovation options were systematically arranged in a form of a "toolbox" (**Table I**).

Table I. Overview of assessed energy-conservation measures.

External wall	Floor	Roof	Windows	Air-control
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Windows ventilation
Outdated insulation	Floor on ground – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Floor on ground – insulated	Pitched roof – no ins.	Upgrade existing windows	Airtight envelope
ETICS – additional thickness	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated below	Green roof	Replace: 3x glazing	
Ventilated facade			External shading	

Energy saving potential

Although reference houses differed by the initial heating demands, the applied measures showed the similar effectiveness in each case. The average saving potential of the measures is shown in the **Figure 2**.

The external walls demonstrated greater potential than any other building element. Savings by insulating the walls were up to 39%. This supported that the external walls should be the basic element for the refurbishment. The ground-floor upgrade indicated 11% of savings

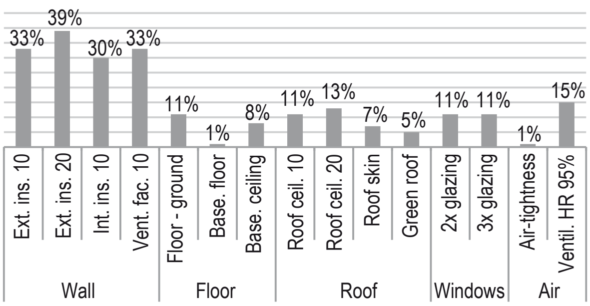

Figure 2. Calculated savings in heating energy for renovation measures when implemented individually.

comparable to 8% of savings by insulating the basement ceiling construction. The roof ceiling renovation demonstrated 13% of savings.

Interestingly, double-glazed and triple-glazed windows showed equal energy saving potential. The windows replacement considered double glazed option (4-12-4 mm) and triple glazed option (4-8-4-8-4 mm), both with the krypton gas filling. Regarding these circumstances, the high quality double-glazed windows were the optimal solution. Improving the air-tightness showed low savings, due to the separated evaluation of the measures. In EW simulations, the length of windows joints was set to 3 m per square meter of glazed area, while the value for the air flow through the joints was modified from 2.5 to 0.5 m^2h^{-1}. When applied individually on the basic non-insulated models, window sealing showed low savings. The settings regarded changing the air leakage of windows from 2.5 to 0.5 m^2h^{-1}. However, the sealing was obligatory measure for achieving the comprehensive passive house refurbishment (**Table IV**). Taking these settings into account, the window sealing would have greater contribution only if combined with other renovation measures. The ventilation system with heat recovery demonstrated reducing the initial consumption for 15% on average.

"When applied individually on the basic non-insulated models, window sealing showed low savings. The settings regarded changing the air leakage of windows from 2.5 $m^3/h/m$ to 0.5 $m^3/h/m$. However, the sealing was obligatory measure for achieving the comprehensive passive house refurbishment (**Table IV**)*."*

Economical issues

Regarding local socio-economic conditions the effective measures were insulating the walls and ceilings, windows replacement as well as improvements on air tightness. Insulating the floor on the ground was the most expensive option, followed by the installation of the HR ventilation system. A period of the investment-return was relatively long due to the relation of the investments to the local energy prices. For more information see the reference [2].

Summer conditions

Overheating requires a special attention in designing the renovation in the SEE region. GEBA simulations showed that almost all options improved thermal comfort during summer by reducing the temperatures in critical south-oriented rooms. This created more comfortable and healthier living environment. Nevertheless, insulating the floor on the ground induced an increase of the inner temperatures. This should not be neglected since the well-being is one of the important reasons for tenants to invest in renovation.

Applicability

Having an overview of the effectiveness, a combination of the measures was evaluated in one case study. The model was previously introduced "HP+1-116" house (**Figure 1**). The toolbox was employed to diagnose the basic case and to develop two renovations by choosing set of measures. In the initial case, the house had brick-block walls without insulation, low performance windows and non-airtight envelope. In the first renovation scenario (R1), the intention was to achieve over 50% of the savings. Therefore, following measures were applied: an addition of 10 cm of EPS insulation on the external walls and the roof ceiling as well as an installation of double glazed windows. In the second scenario (R2), the aim was to achieve the national passive house standard. For that purpose, the walls and the roof ceiling were insulated with 20 cm of EPS, the basement slab with 10 cm of EPS as well as the roof skin. An airtight envelope was made; the double glazed windows with external shutters were installed as well as the HR ventilation system with 95% efficiency. The renovation-boxes for these scenarios are marked in the **Tables II-IV**.

In the R1 scenario, the reduction of the heating demands was up to 58%. In the R2 scenario, the "factor-10" renovation with 90% of savings was achieved which indicated reaching the passive house standard. The case study highlighted how the systematic knowledge can facilitate designers to develop suitable renovations.

Table II. Initial case diagnosis.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling-insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Table III. Scenario R1.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Table IV. Scenario R2.

WALL	FLOOR	ROOF	WINDOW	AIR
No insulation	No basement	Roof ceiling – no ins.	Single glazing	Window ventilation
Outdated insulation	Ground-floor – no ins.	Roof ceiling – insulated	Double uncoated	Non-airtight envelope
External insulation (ETICS)	Ground-floor – insulated	Pitched roof – no ins.	Upgrade of existing windows	Airtight envelope
ETICS 20 cm	Basement ceiling – no ins.	Pitched roof – insulated	Replace: 2x glazing	Ventilation with heat recovery
Internal capillary insulation	Basement ceiling – insulated	Green roof	Replace: 3x glazing	
Ventil. Facade			Shading	

Conclusion

The toolbox provided data on energy saving potential (**Figure 2**). The intention was to describe to designers and investors the impact of their possible choice of renovation. Significant savings of heating energy, up to 90%, were achieved by employing the proposed renovation procedure (**Table IV**). Since a triple-glazing did not show significant difference in reducing energy demands, double-glazed windows seem to be a sufficient solution for the analyzed models in SEE climate conditions.

Due to the sampling procedure, the data could be helpful for retrofitting the homes from 1970's and 1980's in the most suitable manner. A bigger sample could lead to a higher generalization of the theory. The recommendation is that house owners and planners should perform environmental, economic and social assessment and develop the most appropriate renovation for a specific case.

The output information could be integrated into planning procedure in the very early-design-phase, thus enhance the conventional renovation process.

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References

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