

# Mathematical modelling and development of methods and technique for diagnosis of energetic efficiency of existing and new buildings

Project: NPEE 451-03-1549/2003-01/EE813-197B

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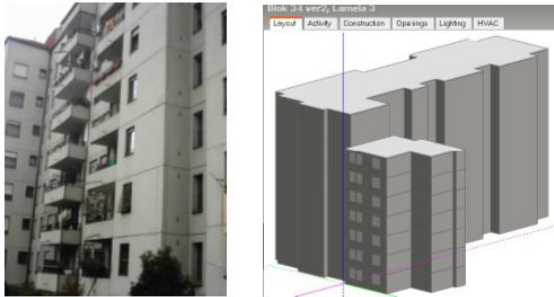


Figure 1. Experimental building and model for numerical simulation in software package *DesignBuilder/Energy plus*

**BACKGROUND:** Energy and ecologically sustainable construction understands:

- Diminishing of the heat loss from building by improvement of thermal insulation of building envelope and by favorable ratio of outside area and volume of the building.
- Increase of heat gains in building by orientation of building and the use of solar energy.
- The use of renewable energy sources.
- Increase of energy efficiency of HVAC system.

**OBJECTIVE:**

- Definition of the optimal structural solutions of building envelope from the view of energy savings and environmental protection.
- Definitions of the quality system on the base of determination of real parameters of building functionality which can be valorized and controlled.

**SUBJECT:** Mathematical modelling for the need of development of the methods for diagnosis of the dynamical thermal behavior, for the purpose of evaluation of the integral energy efficiency of existing and new buildings and HVAC systems. Models encompassed examination of energetic efficiency of the experimental building in New Belgrade, Bulevar AVNOJ-a 213 (Figure 1), by the use of computational models (Figure 1) and numerical analysis by the software package *Design Builder/EnergyPlus*, as well as in-house software for transient heat transfer. Considered building is simulated as virtual building from the point of view of the envelope and inner walls, location, HVAC system, meteorological data, activities of occupants and lighting, in design winter and summer conditions and characteristics days in heating season.

**PRICE OF PROJECT:** 30750 Euro

**PROJECT STATUS:** The estimated duration of project is three years. Third year of research.

**APPROACH:** Project consists of the next main activities:

- Calculations of the energy consumption in design winter and summer conditions and characteristics days in the heating season.
- Recommendations for the application of numerical simulations methods used in this research for design of the HVAC systems
- Comparative review of the energy consumptions for the apartments in which reconstructions of envelope and replacement of windows are performed.
- The quantitative and qualitative discussions of obtained results, as well as comparison with available results of measurements on site (Figure 3).

**DELIVERABLES:**

- Implementation study of the rehabilitation procedure and conservation of building's envelope by silicon paints.
- Evaluation study of the rehabilitation of building's envelope by silicon paints from the aspects of the increase of energy efficiency.
- Evaluation study of the energy efficiency of apartment without changes.
- Evaluation study of the procedure of increase of energy efficiency of experimental apartment by the replacement of windows.
- Production of prototype of the mobile measurement equipment for the measurement of temperature fields in buildings.

**BENEFITS TO PARTICIPANTS:** By varying of any of the input parameters of the envelope and inner walls, HVAC system, activities of occupants per zones, meteorological data, windows and openings and lightings, the precise simulation and analysis of theirs changes can be performed. By comparison of obtained results we can obtain the complete picture of the thermal performance of the considered building, as well as insight in the most influential factors. In the most of the European countries new settlements are design and build with average energy consumption bellow  $100 \text{ kWh/m}^2$  per year, and reconstruction of existing buildings have objective to attain the similar energy efficiency. By following European accomplishments and directives, the final goal of this project is to contribute in the revision of domestic legal and technical regulative for the purpose of design and construction of energy efficiency buildings.

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**PROJECT RESULTS:** Selection from research results: Integral numerical simulation of energy efficiency of the experimental building:

The vertical of the building in Bulevar AVNOJ-a 213 New Belgrade. The thermal behavior of apartments on the first, second and third floor of considered building is analyzed. The integral numerical simulation of the energy efficiency is performed from the point of view of: of view of the envelope and inner walls, location, HVAC system, meteorological data, activities of occupants and lighting, in design winter and summer conditions and characteristics days in heating season.

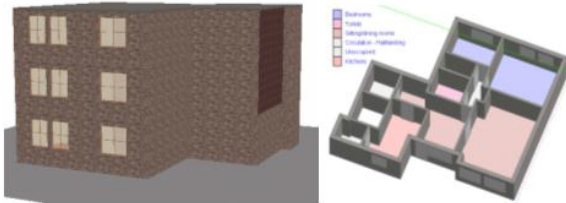


Figure 2. Model of the experimental apartments.

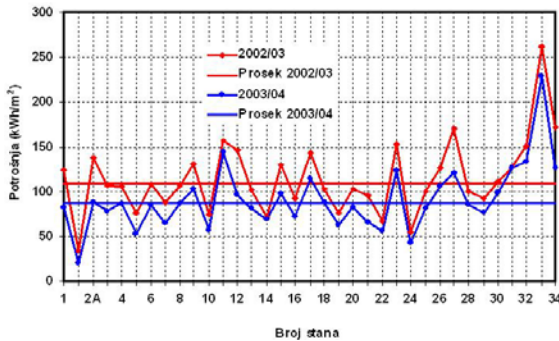


Figure 3. Measured specific yearly consumption of the heat energy (for validation purposes)

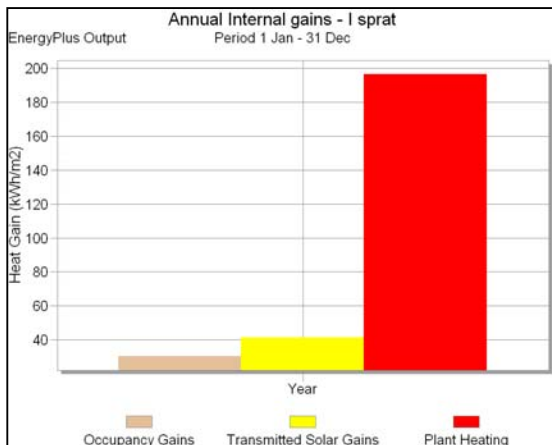


Figure 4. Heat gains in winter season from occupancies, transmitted solar gains and plant heating

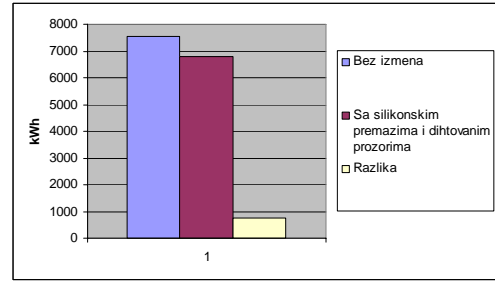


Figure 5. Total heat energy savings in experimental apartment with sealed windows and envelope painted with silicon paints

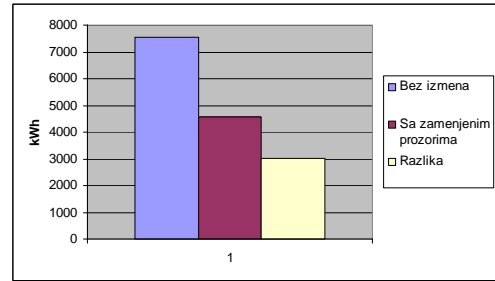


Figure 6. Total heat energy savings in experimental apartment with new PVC windows

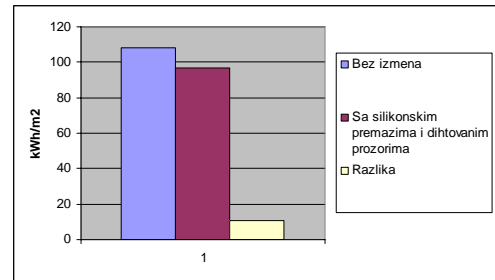


Figure 7. By sealing windows and silicon painting the saving of about 10 % of the heat energy per year is shown

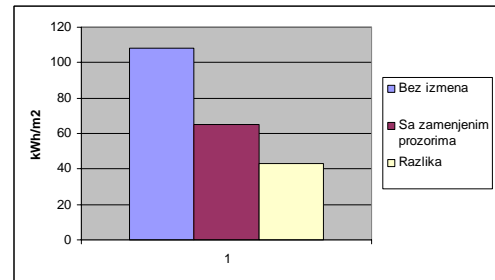


Figure 8. By mounting of PVC windows instead the old wooden windows the saving of about 40 % of the heat energy per year is shown

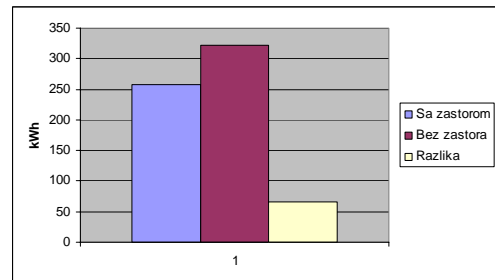


Figure 9. Electric energy savings for cooling of living room in considered period by the use of curtains