ENERGY
ENERGETIKA 2025
14 - 17. april 2025, Hotel Zlatibor Resort, Zlatibor

Evaluacija mera za uštedu energije na postojećim stambenim zgradama na Novom Beogradu upotrebom modeliranja energetskih performansi zgrada/ Evaluation of Energy Conservation Measures for Existing Residential Buildings in Novi Beograd Using Building Energy Modeling

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Pozadina i motivacija / Background & Motivation

- Buildings account for ~40% of energy use and ~30% of global GHG emissions
- Serbian housing stock is largely built before modern energy standards
- Many Novi Beograd buildings (1960s–80s) lack insulation and have outdated heating
- Improving energy efficiency in residential buildings is key to Serbia’s energy transition
- Aligns with EU Green Deal and Energy Community goals

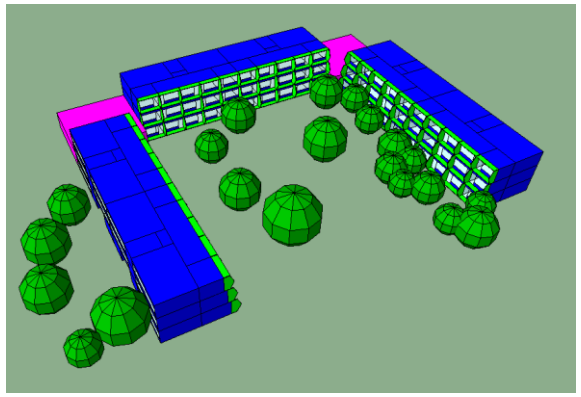

ЕНЕРГЕТСКА МАПА
ПОТРОШЊЕ ЕНЕРГИЈЕ ЗА ГРЕЈАЊЕ
У СТАМБЕНИМ ОБЈЕКТИМА НОВОГ БЕОГРАДА
ЛЕГЕНДА:
45-84 kwh/m2
85-115 kwh/m2
116-140 kwh/m2
141-175 kwh/m2
176-200 kwh/m2
>200 kwh/m2
Београдске електране
ЈАВНО КОМУНАЛНО ПРЕДУЗЕЋЕ

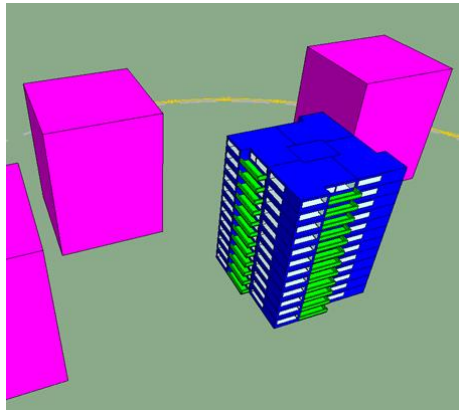
Cilj istraživanja / Objective of the Study

- Analyze potential for energy savings through retrofits in Novi Beograd
- Use dynamic building energy modeling (BEM) instead of static methods
- Assess impact of
  - Upgrading thermal envelope (walls, roofs, windows)
  - Reducing infiltration (uncontrolled air leakage)
  - Implementing hybrid heating systems with renewable sources (heat pumps + DH)

Analizirani tipovi zgrada: D4 i E6 / Target Buildings: D4 and E6

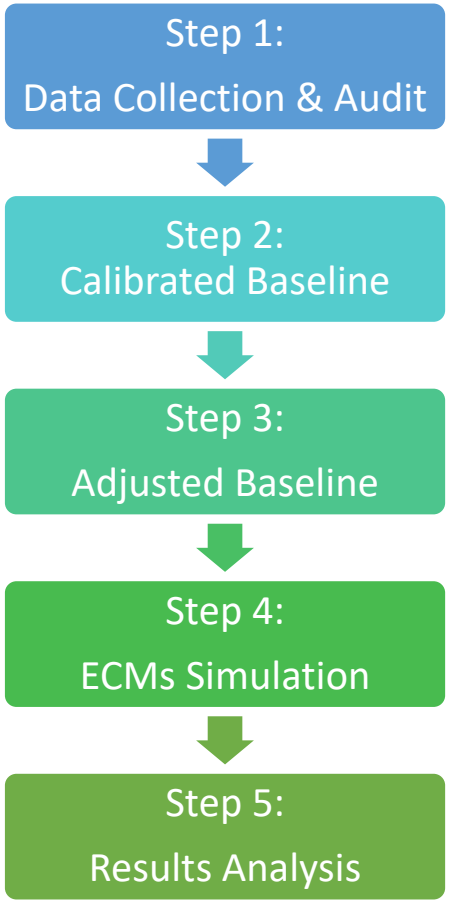
- Lamella-type (D4) – Block 45
  - Low-rise, large envelope area, higher baseline heating use
- High-rise (E6) – Block 70
  - Smaller façade-to-volume ratio, more wind-driven infiltration
- Represent typical residential building stock in Novi Beograd
- Energy audits, architectural drawings, and historical data used





Metodologija i simulacije / Methodology & Simulation Process

- Building record drawings, site audits, and utility data from heating provider
- Weather data: TMY (Typical Meteorological Year) for Belgrade
- Modeling platform: IES VE, compliant with ASHRAE 140 and ISO standards
- Two key models:
  - Calibrated Baseline: matched to actual 2014/15 heating data
  - Adjusted Baseline: post-retrofit assumptions (e.g. window replacement rate)
- Infiltration modeled as constant airflow per m² façade area

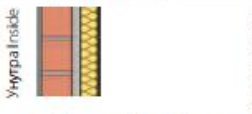
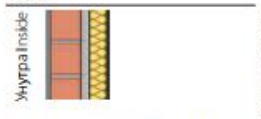
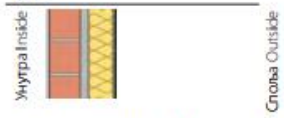
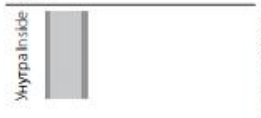


Mere za ustedu energije / Overview of ECMs

- Envelope insulation: Add 10 cm (Imp. 1) or 20 cm (Imp. 2) of thermal insulation
- Window replacement: Double-glazed (U=1.5 W/m²K) or triple-glazed (U=1.0 W/m²K)
- Infiltration reduction: Caulking, sealing—modeled separately for clarity
- Packages combine envelope, windows, and infiltration upgrades
- Realistic, locally available materials and methods used

Mere za uštedu energije / Overview of ECMs

Склопови термичког омотача Elements of the thermal envelope

	Постојеће стање Present state	Унапређење 1 Improvement 1	Унапређење 2 Improvement 2
Спољашњи зид 1 – External Wall 1	 малтер 2cm, гитер блок 19cm, монтажни бетонски парапет 5cm, мозаик плочице 0,5cm plaster 2cm, clay block wall 19cm, prefabricated concrete panel 5cm, mosaic tiles finishing 0.5cm	 малтер 2cm, гитер блок 19cm, монтажни бетонски парапет 5cm, термоизолација 10cm, малтер 1cm, мозаик плочице 0.5cm plaster 2cm, clay block wall 19cm, prefabricated concrete panel 5cm, thermal insulation 10cm, plaster 1cm, mosaic tiles finishing 0.5cm	 малтер 2cm, гитер блок 19cm, монтажни бетонски парапет 5cm, термоизолација 15cm, малтер 1cm, мозаик плочице 0.5cm plaster 2cm, clay block wall 19cm, prefabricated concrete panel 5cm, thermal insulation 15cm, plaster 1cm, mosaic tiles finishing 0.5cm
U (W/m²K)	1.74	0.31	0.22
Спољашњи зид 2 – External Wall 2	 малтер 2cm, гитер блок 19cm, вештачки камен 5cm plaster 2cm, clay block wall 19cm, marble aggregate plaster 5cm	 малтер 2cm, гитер блок 19cm, вештачки камен 5cm, термоизолација 10cm, малтер 1cm plaster 2cm, clay block wall 19cm, marble aggregate plaster 5cm, thermal insulation 10cm, plaster 1cm	 малтер 2cm, гитер блок 19cm, вештачки камен 5cm, термоизолација 15cm, малтер 1cm plaster 2cm, clay block wall 19cm, marble aggregate plaster 5cm, thermal insulation 15cm, plaster 1cm
U (W/m²K)	1.61	0.28	0.20
Зид ка негрејаном степеништу – Partition Wall to Unheated Staircase	 малтер 2cm, бетон зид 20cm, малтер 2cm plaster 2cm, reinforced concrete wall 15cm, plaster 2cm	 НЕМА ИЗМЕНА NO CHANGES	 НЕМА ИЗМЕНА NO CHANGES
U (W/m²K)	2.55	2.55	2.55
Зид ка суседној ламели (дилатација) – Wall to the adjacent Entrance (Dilatation)	 малтер 2cm, гитер блок 19cm, ваздух 5cm, гитер блок 19cm, малтер 2cm plaster 2cm, clay block wall 19cm, air gap 5cm, clay block wall 19cm, plaster 2cm	 НЕМА ИЗМЕНА NO CHANGES	 малтер 2cm, гитер блок 19cm, инјектирајућа термоизолација 5cm, гитер блок 19cm, малтер 2cm plaster 2cm, clay block wall 19cm, injectable thermal insulation 5cm, clay block wall 19cm, plaster 2cm
U (W/m²K)	0.89	0.89	0.44

Склопови термичког омотача Elements of the thermal envelope

	Постојеће стање Present state	Унапређење 1 Improvement 1	Унапређење 2 Improvement 2
Прозори и балконска врата – Windows and Balcony Doors	 Дрвени, двоструки са размакнутим крилима (уска кутија) и једноструким стаклом. Дрвена *еслингер* ролетна – Wooden, double frame, double sash (narrow box) with single glazing. Wooden roller blind	 Дрвени са двослојним изолационим нискоемисионим стакло-пакетом испуњеним инертним гасом – Wooden, double glazed low-E glass unit, inert gas filling	 ПВЦ са трослојним изолационим нискоемисионим стакло-пакетом испуњеним инертним гасом – PVC, triple glazed low-E glass unit, inert gas filling
U (W/m²K)	3.50	1.50	1.00
Улазна врата – Entrance door	Дрвена, дуплошперована – Wooden, plywood leaf	НЕМА ИЗМЕНА – NO CHANGES	Метална, крило са термоизолационом испуном – Metal, insulated leaf
U (W/m²K)	3.00	3.00	1.50

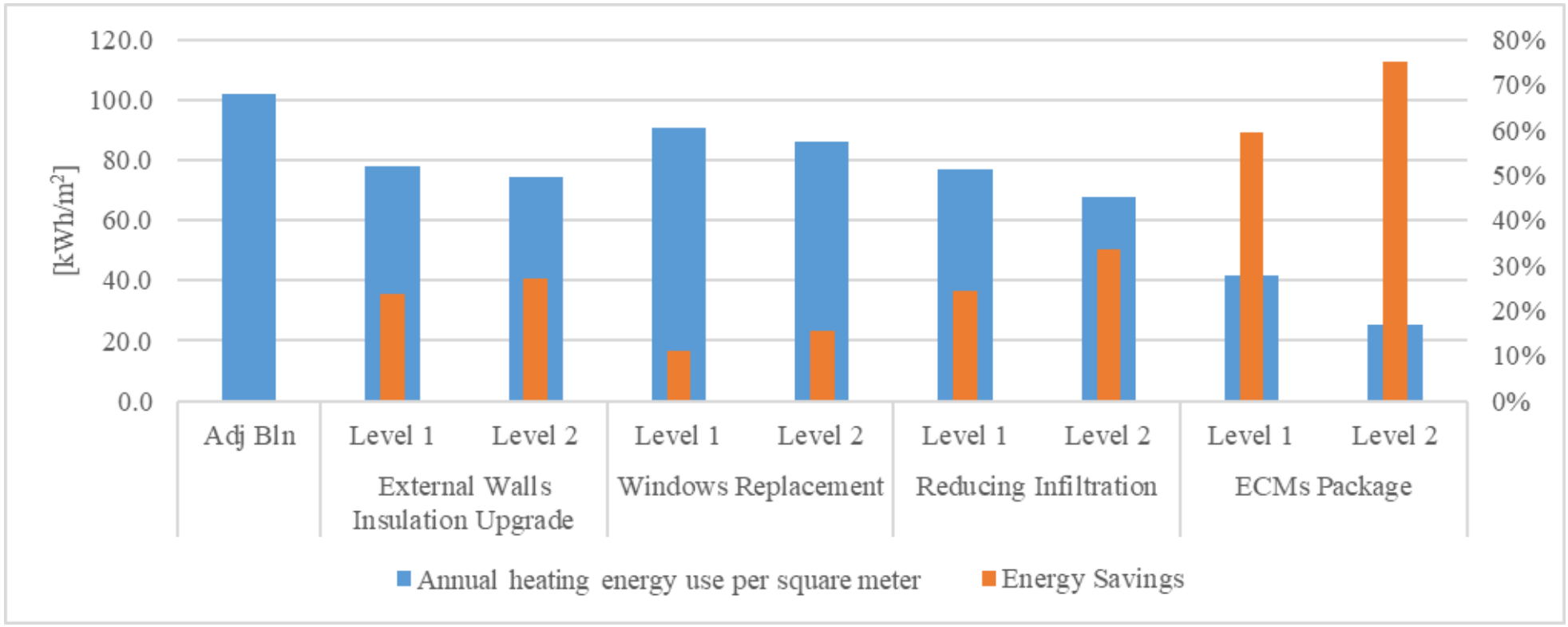
Hibridni sistem grejanja / Hybrid Heating System

- Modeled air-to-water heat pump (ASHP) with district heating (DH) backup
- ASHP active when outdoor air ≥ 4 °C; DH used when colder
- Heating switchover temp based on ASHP capacity and outdoor reset curves
- Performance modeled with biquadratic COP equation (Todb, Telt)
- Reference COP = 2.3; Max COP = 4.0
- Seasonal COPs between 2.4 and 2.6, depending on scenario

Rezultati: soliter (E6) / Results: High-Rise Building (E6)

- Adjusted baseline heating demand: 102.2 kWh/m²
- ECM Package (Imp. 2): drops to 25.2 kWh/m²
- Overall 75% reduction in heating demand
- Hybrid heating saves additional 27–30% site energy
- Infiltration reduction and system modernization especially impactful
- Suitable for buildings with lower energy intensity but high leakage

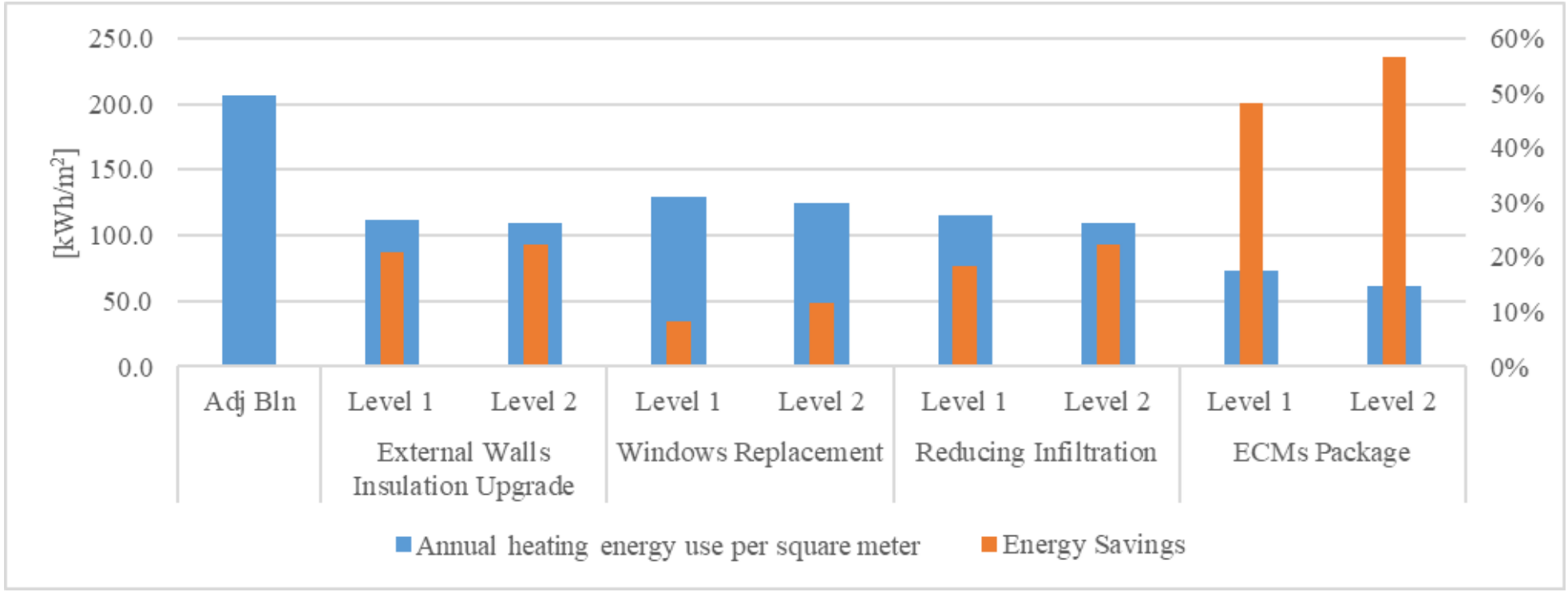
Rezultati: soliter (E6) / Results: High-Rise Building (E6)



Rezultati: lamela (D4) / Results: Lamella Building (D4)

- Adjusted baseline: 206.9 kWh/m²
- ECM Package (Imp. 2): 61.1 kWh/m² → 57% savings
- Hybrid system adds ~38% energy savings on site
- Larger building envelope = greater potential for insulation benefit
- Highlights importance of combining envelope and system improvements

Rezultati: soliter (E6) / Results: High-Rise Building (E6)



Uporedni pregled rezultata / Comparative Summary Table

- ECM packages highly effective for both building types
- Hybrid heating systems further amplify savings

Building Type	Adj. Baseline	After ECMs	Total Reduction	+ Hybrid System
High-Rise (E6)	102.2 kWh/m²	25.2 kWh/m²	75%	+30% site energy
Lamella (D4)	206.9 kWh/m²	61.1 kWh/m²	57%	+38% site energy

	High Rise Building		Lamella Type Buildings	
	Package 1	Package 2	Package 1	Package 2
Total Heating Energy [kWh]	187,546	114,189	331,804	276,228
District Heating Energy [kWh]	91,113	60,867	124,367	103,454
ASHP Heating [kWh]	96,433	53,322	207,437	172,775
ASHP Electricity [kWh]	39,450	22,259	80,428	67,364
Seasonal COP [kWh]	2.44	2.40	2.58	2.56
Final Energy Savings [kWh]	56,984	31,063	127,009	105,411
Final Energy Savings [%]	30%	27%	38%	38%

Najvazniji rezulati / Key Takeaways

- Combined ECMs cut heating use by 57–75%
- Hybrid systems reduce fossil energy use and boost efficiency
- Infiltration control critical in older concrete-panel buildings
- Envelope-only retrofits insufficient—systems must be upgraded too
- Dynamic BEM captures building behavior more accurately than static models

Politike i tržišna relevantnost / Policy and Market Relevance

- Study supports strategic retrofits, not isolated measures
- Retrofit programs should include envelope + system incentives
- EU Renovation Wave and Energy Community framework provide funding channels
- Design tools like BEM essential for decision-makers and engineers

Zaključci / Conclusions

- Novi Beograd buildings have high retrofit potential
- Up to 75% heating reduction possible with deep retrofits + RES
- ASHP-DH hybrid systems suitable for transition zones
- Integrated retrofitting is cost-effective and scalable
- Future work: cost analysis, occupant behavior, PV and solar thermal integration

Zahvalnica / Acknowledgment

- This research is supported by the Science Fund of the Republic of Serbia, #GRANT No. 4344, Forward-Looking Framework for Accelerating Households' Green Energy Transition - FF GreEN

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HVALA NA PAŽNJI!

Thank you for your attention!

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