City of Belgrade, residential building fund,
energy performance, improvement possibilities.

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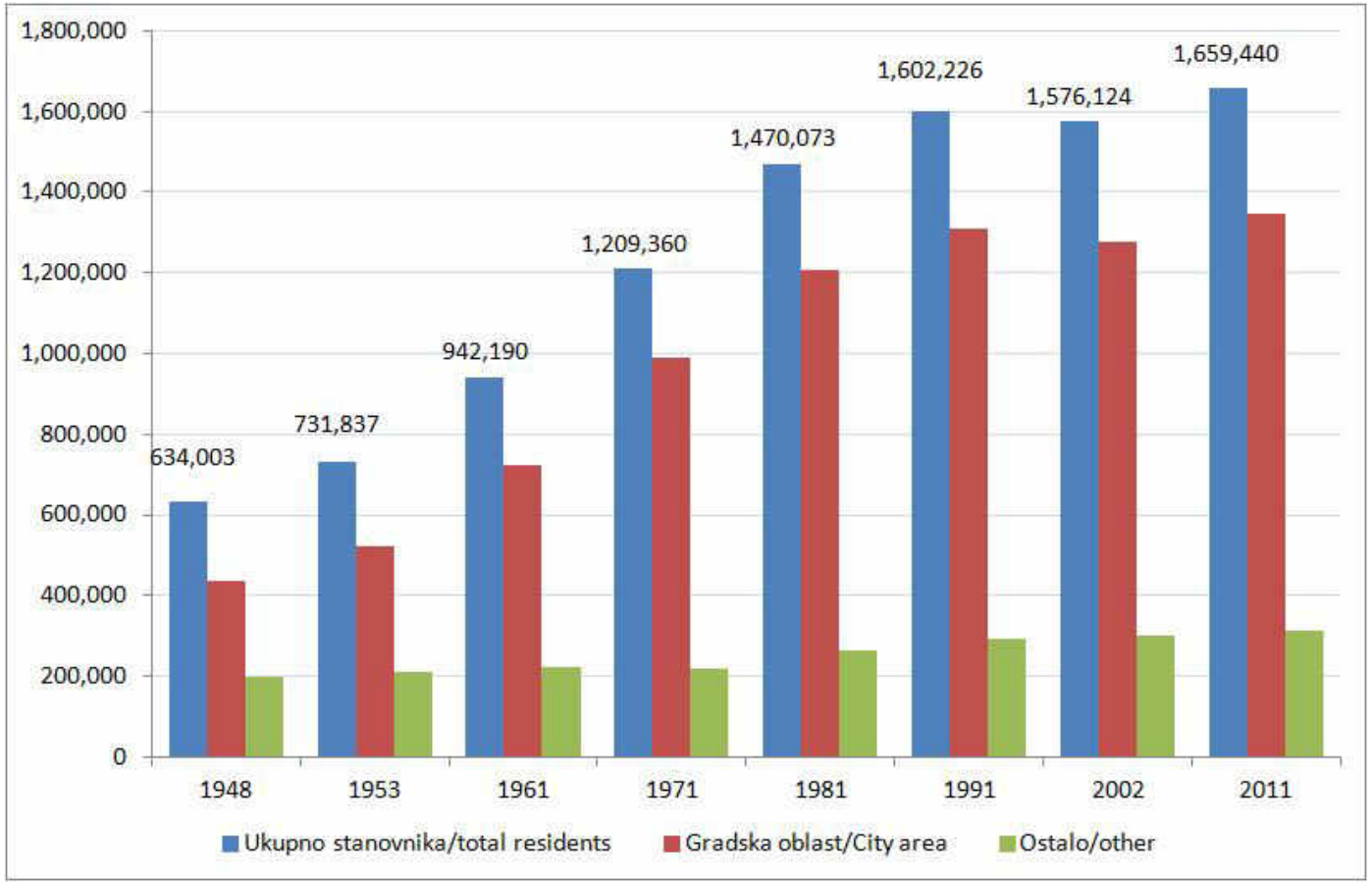
University of Belgrade
Faculty of Architecture

Belgrade, 31.10.2016.

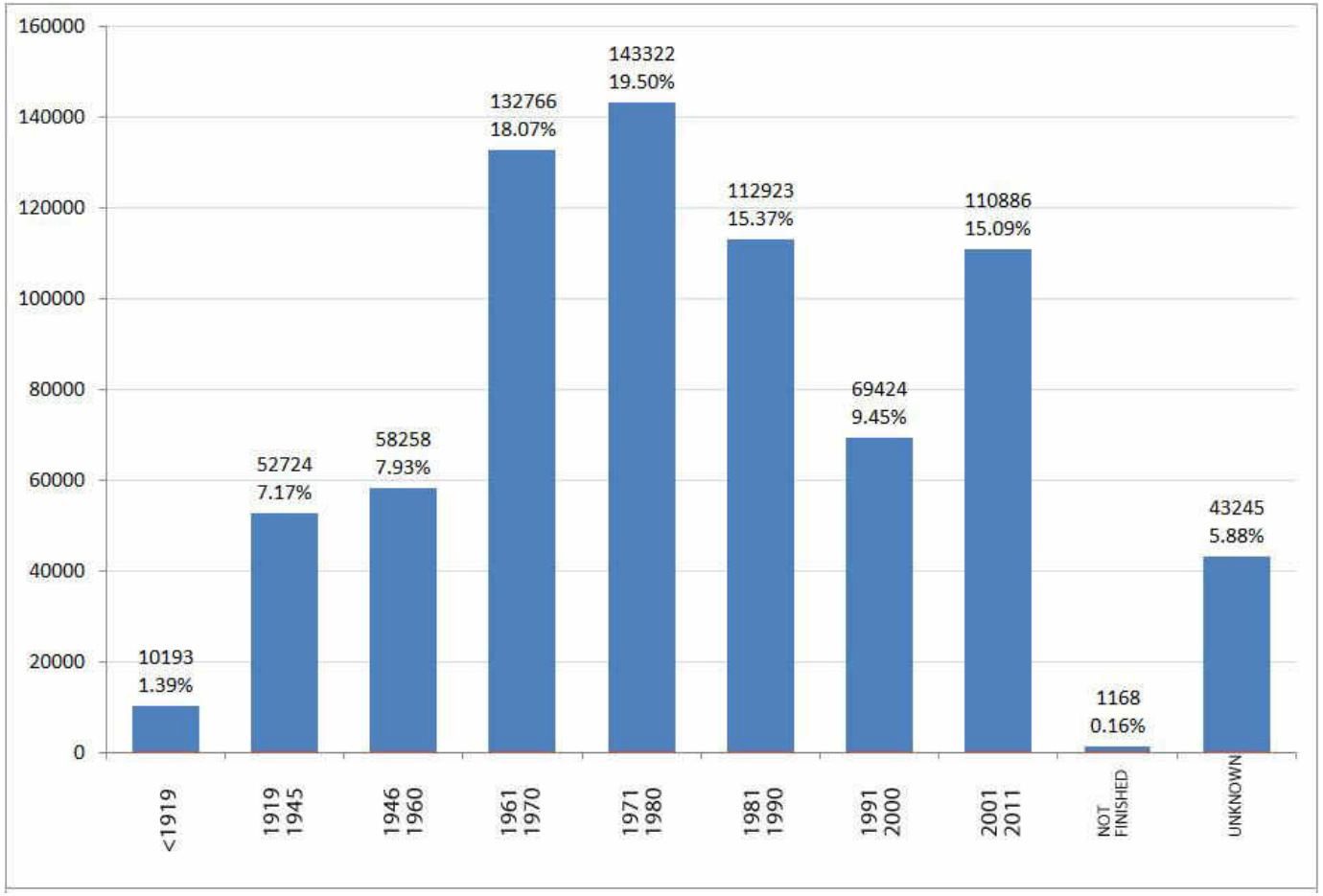
City of Belgrade



Population of Belgrade, 2011.
1.659.440

Source: Statistical Office of the Republic of Serbia

City of Belgrade

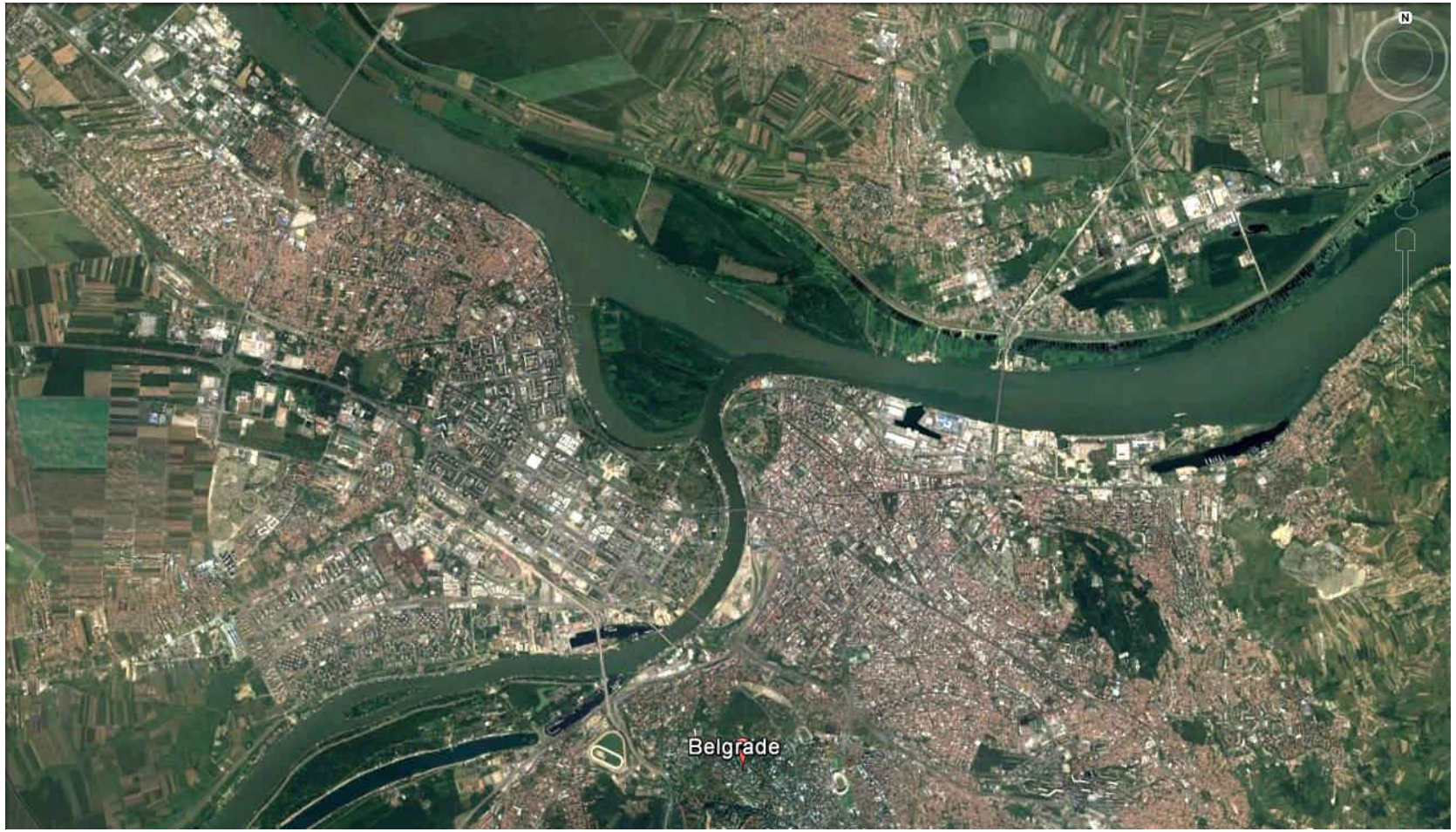


Constructed flats by periods
Total 734.909 flats, 48.620.227 m^2

Average flat size 63.44 m^2

Source: Statistical Office of the Republic of Serbia

City of Belgrade



City area	322.268 ha
Inner city area	35.996 ha

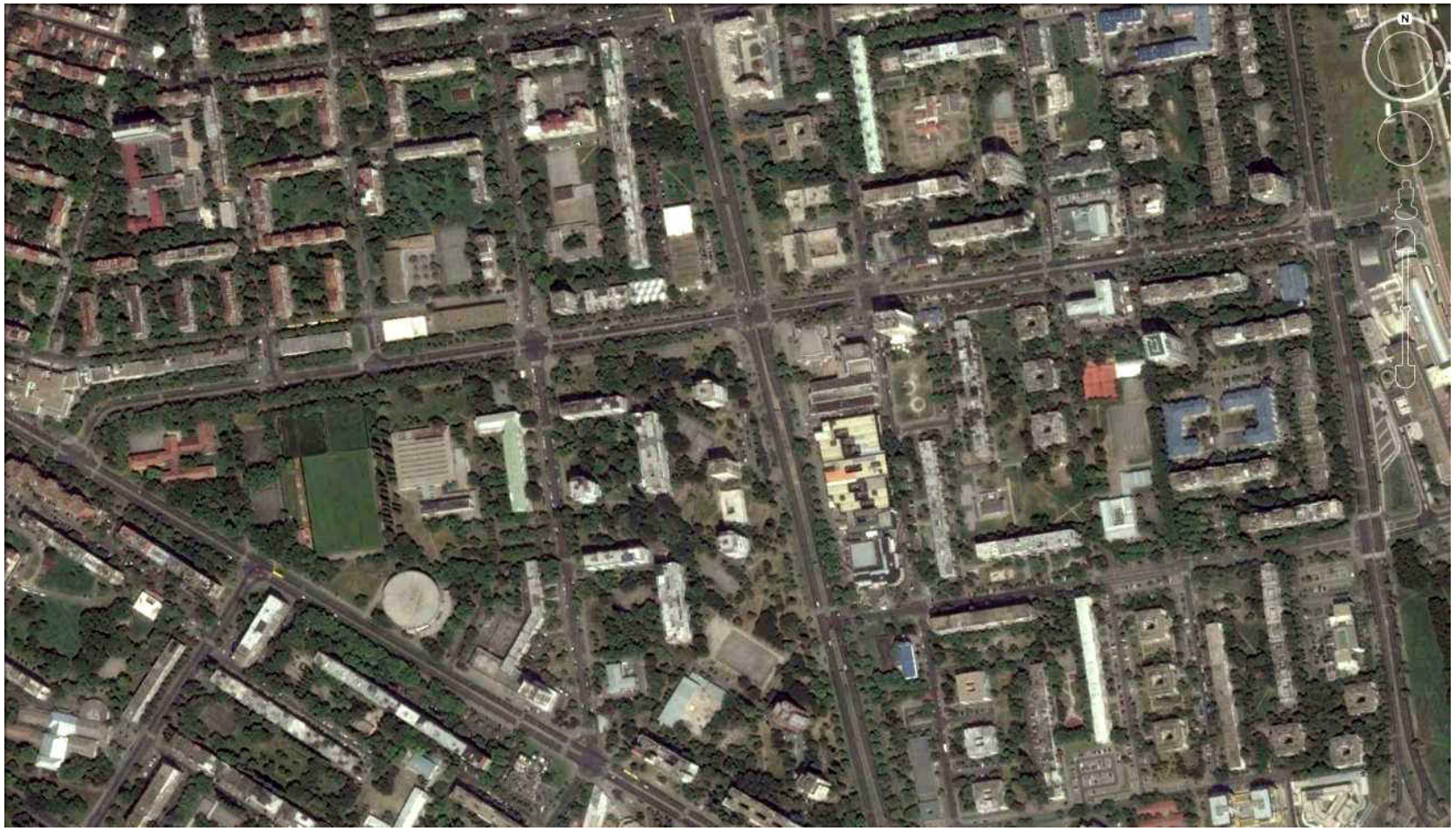
Source: Google earth

City of Belgrade

Inner city

Source: Google earth

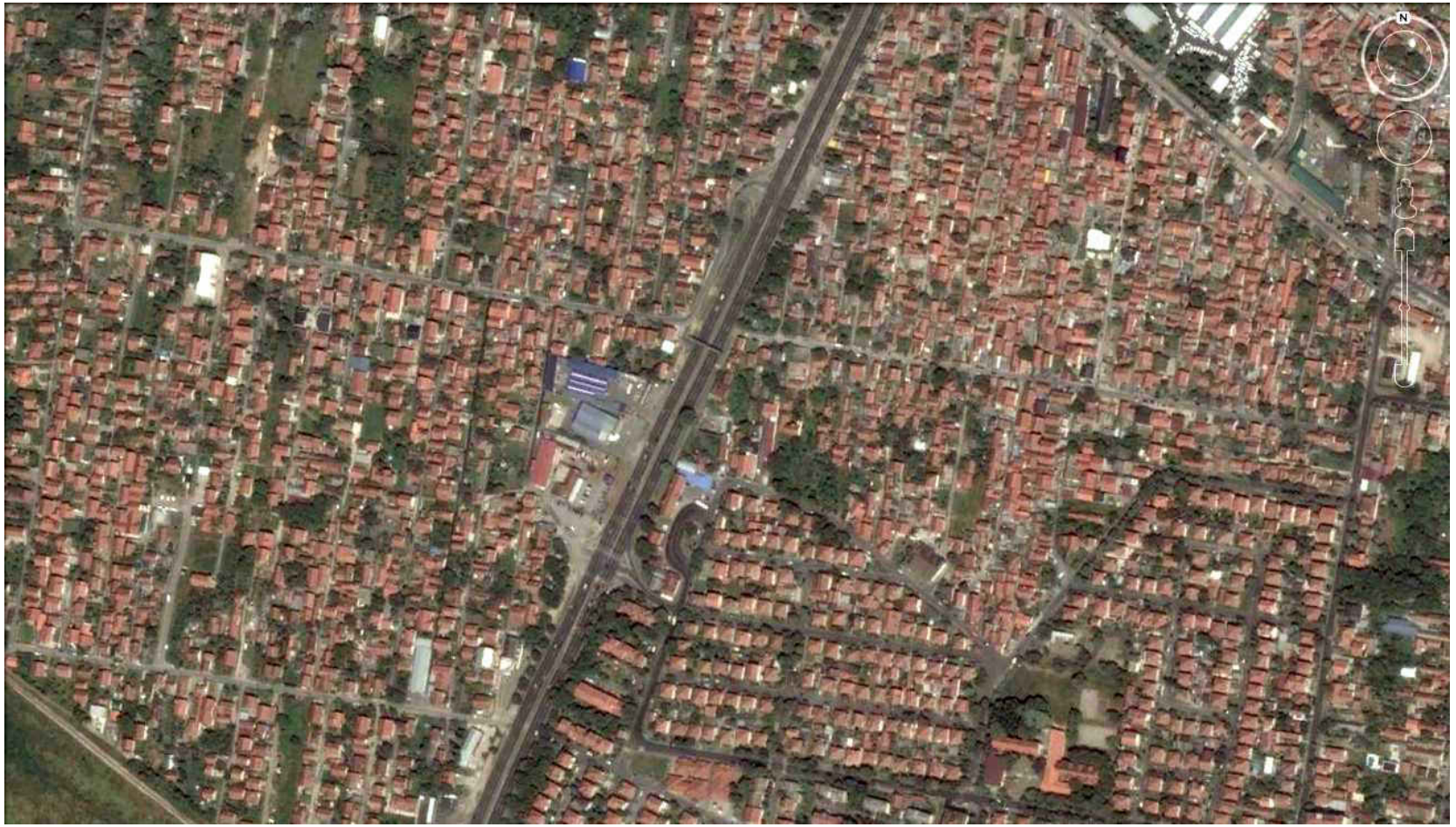
City of Belgrade



New Belgrade

Source: Google earth

City of Belgrade



Outer city

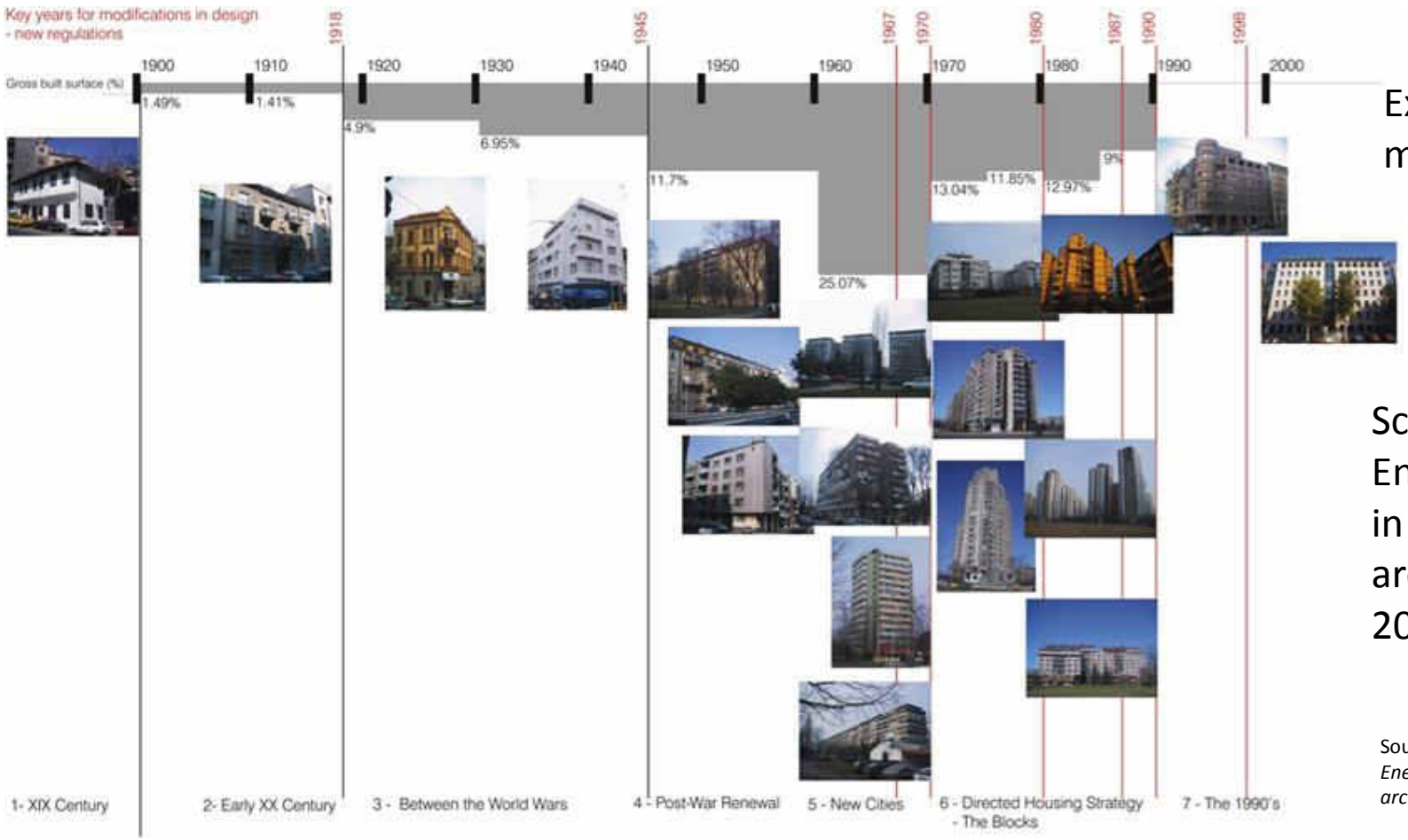
Source: Google earth

City of Belgrade – building fund

Main questions:

- How does the building fund of Belgrade look like?
- What are material characteristics of buildings?
- What is the current state (level of deterioration) of the buildings?
- How much energy buildings consume (in total)?
- What is the potential for improvement?
- How can we estimate the potential investment?
- What are the possible savings in energy and CO2?
- …

City of Belgrade – building fund



Expert estimation of building fund multifamily buildings

Scientific project:
Energy optimization of buildings in context of sustainable architecture (NSP 283)
2002-2005.

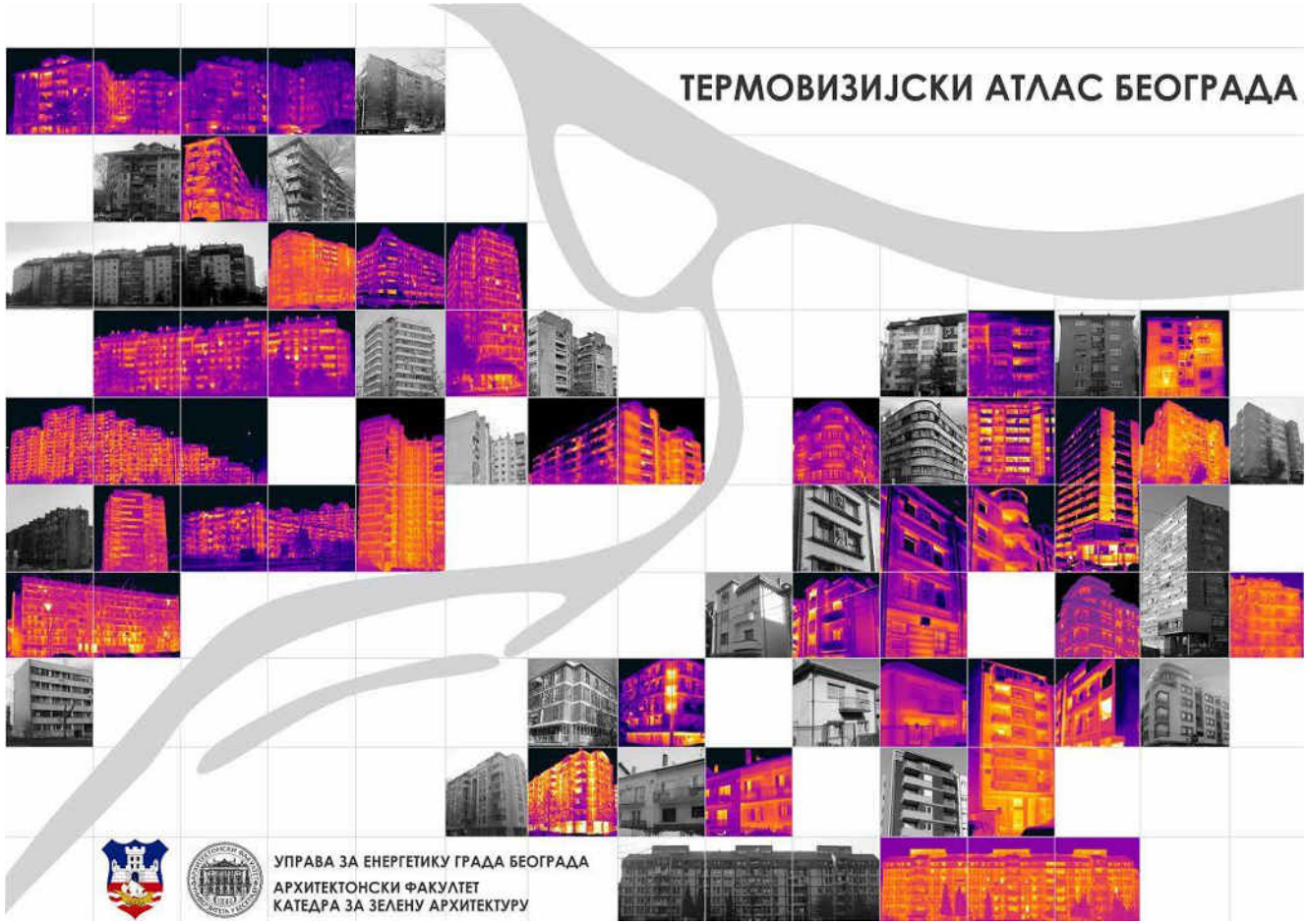
Source: Јовановић-Поповић, M. (ed) (2003)
Energy optimization of buildings in context of sustainable architecture - part 1,Belgrade, Faculty of Architecture, (in Serbian)

City of Belgrade - Building fund

Awareness campaign 2010-2011.

Source: Faculty of Architecture, exhibition material

City of Belgrade - Building fund



"IR Atlas of Belgrade"
Research project,
Faculty of Architecture,
Supported by

Beograd
www.beograd.rs

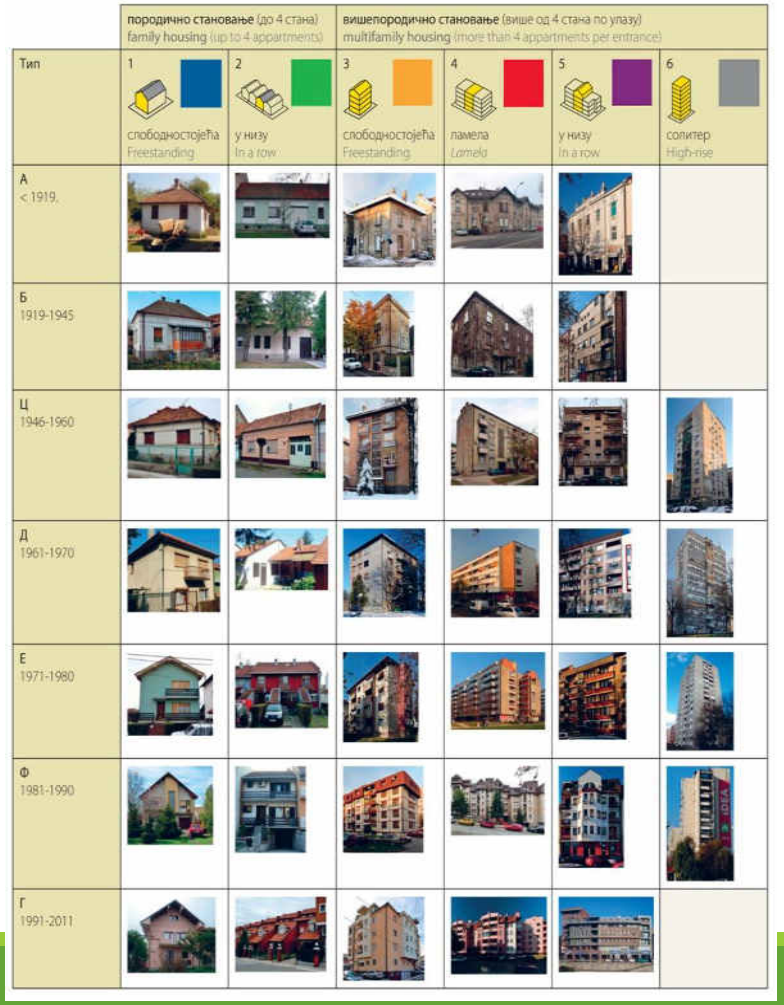
2010-2012.

Expert analysis of 32 representative Building types
(30 multifamily and 2 single family)

- Performance calculation
- Improvement potential calculation
- Investment and payback calculation

Source: Ignjatović, D. Ćuković Ignjatovicć, N. (2012)
Atlas of Belgrade buildings envelope energy characteristics,
Belgrade, Faculty of Architecture, project report (in Serbian)

National typology of Residential buildings in Serbia - Building fund



Research project - National level
EU TABULA* project, Serbia only non EU participant
Faculty of Architecture
Supported by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
2011-2013.

Census of 22 000 buildings
Development of methodology
Identification of model buildings
Calculation of performance (new regulations)
Improvement potential
Energy and CO^2 savings potential

* http://episcope.eu/building-typology/

Source: Јовановић Поповић М., Игњатовић Д. (ур), (2013).
National Typology of Residential Buildings in Serbia, Београд: Архитектонски факултет

National vs. Local typology of Residential buildings

Problem of local relevance and implementation possibilities of methodology developed for the National typology

Implementation on the particular building type level
Improvement by packages as defined by TABULA project
No financial aspect of refurbishment analyzed

Municipal level implementation depends on the local building fund characteristics
Need for estimation of single measure impact
Need for estimation of investments and pay back

Building fund of City of Belgrade – performance levels

What are material and energy performance levels of Belgrade buildings?

Calculated consumption: $Q_{h,\,nd} = 252$ [kWh/m^{2}a], upper floor not heated

Source: Ignjatović, D. Ćuković Ignjatovicć, N. (2012) „Atlas of Belgrade buildings envelope energy characteristics", Belgrade, Faculty of Architecture, project report (in Serbian)

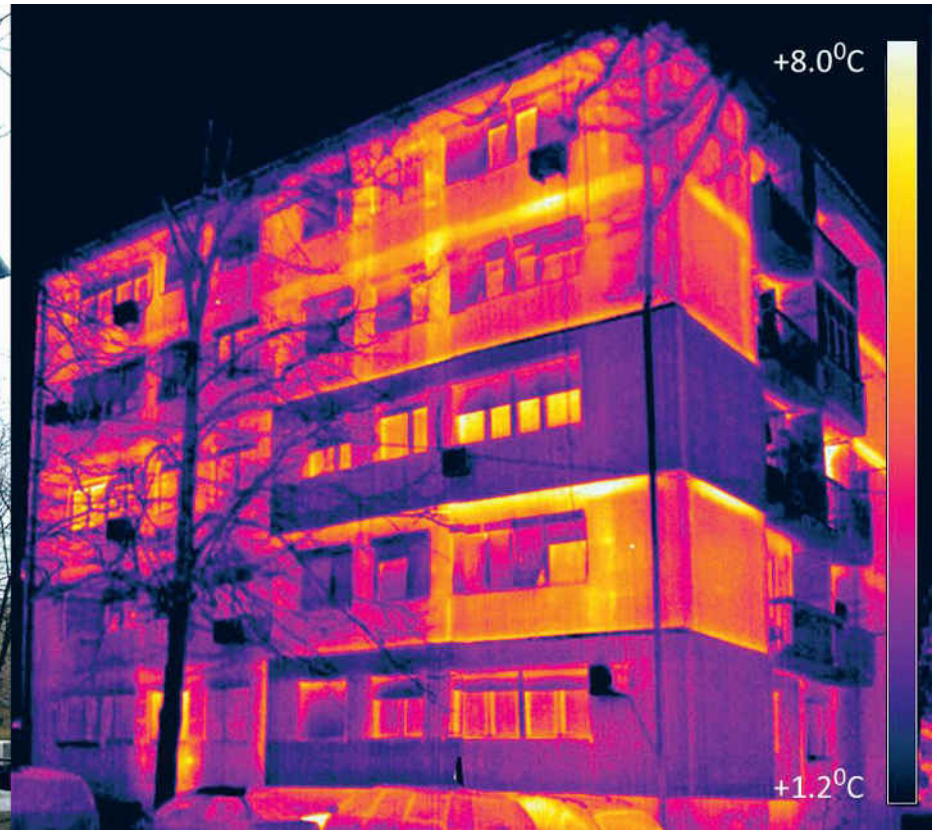
Building fund of City of Belgrade – performance levels

What are material and energy performance levels of Belgrade buildings?

Calculated consumption: $Q_{h,nd} = 172$ [kWh/m^{2}a], Some flats not heated

Source: Ignjatović, D. Ćuković Ignjatovicć, N. (2012) „Atlas of Belgrade buildings envelope energy characteristics", Belgrade, Faculty of Architecture, project report (in Serbian)

Building fund of City of Belgrade – performance levels



Performance? Individual initiative

Source: Јовановић Поповић М., Игњатовић Д. (ур), (2013).
National Typology of Residential Buildings in Serbia, Београд: Архитектонски факултет

City of Belgrade – Conserve energy

Source: Ignjatović, D. Ćuković Ignjatovicć, N. *Conserve energy,* working material

Based on
"IR Atlas of Belgrade"

Expert analysis of 10 representative Building types – multifamily
Supported by giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

- Performance calculation – new regulations
- Improvement potential calculation – single measure and package of measures impact
- Investment and payback calculation

10 steps to refurbishment

City of Belgrade – Conserve energy – example

Building 02

Number of floors: B+GF+5
Construction year: 1953.
Gross area: 4180m2
Heated area: 2182m2
National typology type: C4
TABULA type: 3_AB

Source: Ignjatović, D. Ćuković Ignjatovicć, N. *Conserve energy,* working material

City of Belgrade – Conserve energy

Façade segment 2: Original segment of thermally non- isnsulated façade
Сегмент фасаде 2: Сегмент оригиналне термички неизоловане фасаде

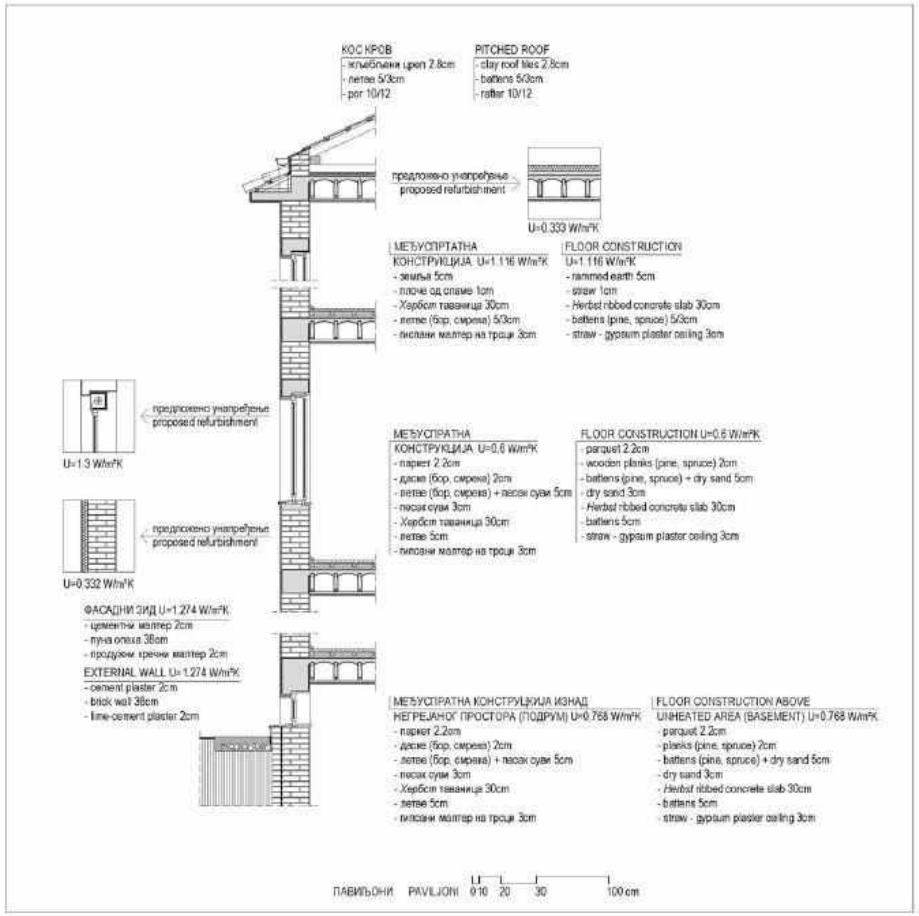
Typical segment of masonry façade wall constructed without thermal insulation.
Reinforced concrete ring beams and window lintels are zones of the wall that are characterized by highest thermal losses, on thermogram, with temperature difference of almost 3°C compared to masonry infill.
Thermogram also illustrates that building has been constructed without vertical reinforcements.

Карактеристични сегмент фасаде зиданих објеката без термоизолације.
Термограм илуструје изразите губитке у зонама хоризонталних армирано-бетонских серклажа и натпрозорних греда са температурном разликом од 3°C у поређењуса зиданим делом.
На термограму се може уочити да објекат нема вертикалне армирано-бетонске елементе.

Source:
Ignjatović, D. Ćuković Ignjatovicć, N. „Conserve energy", working material

City of Belgrade – Conserve energy

FAÇADE DETAILING
ДЕТАЉ ФАСАДЕ



Source:
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City of Belgrade – Conserve energy

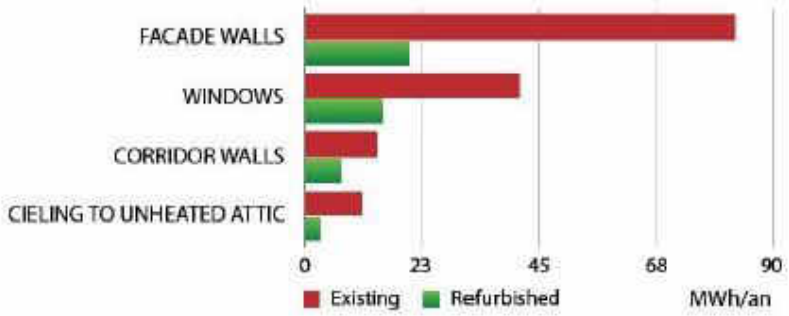
REVIEW OF MAIN ENERGY EFFICIENCY MEASURES
ПРЕГЛЕД ОСНОВНИХ МЕРА УНАПРЕЂЕЊА ЕНЕРГЕТСКЕ ЕФИКАСНОСТИ

Pos.	Necessary repairs and/or renovation	Share in heat transm. losses	Area	Energy efficiency improvement measures	Unit price	Total	Qh,an	EPC	Energy saving	Annual savings	Payback
		[%]	[m2]		[€/m2]	[€]	[kWh/m2an]		%	[€/an.]	[years]
FACADE WALLS	☐	54	955	8cm of thermal insulation + new facade	27	25.775	145,70	F	13	2313	11
WINDOWS	☑	26	192	PVC windows U= 1,3	160	30.720	129,11	F	23	4054	8
CORRIDOR WALLS	☐	9	412	4cm EPS + new paint	14	5.764	161,58	F	4	647	9
CEILING TO UNHEATED ATTIC	☐	7	205	8cm of thermal insulation	12	2.463	161,38	F	4	668	4
COMBINED MEASURES						64.722	69,62	C	58	7683	8

ESTIMATED INVESTMENT
ПРОЦЕЊЕНА ИНВЕСТИЦИЈА

Total for the building	Per m2 of heated surface	Per flat
64.722 €	53 €	2697 €

HEAT LOSSES RELATED TO THERMAL ENVELOPE ELEMENTS
ТОПЛОТНИ ГУБИЦИ КРОЗ ЕЛЕМЕНТЕ ТЕРМИЧКОГ ОМОТАЧА

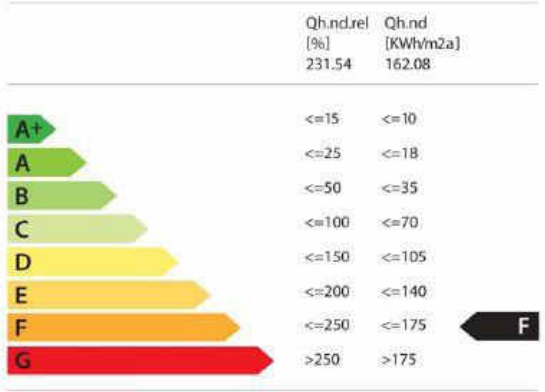


Source:
Ignjatović, D. Ćuković Ignjatovicć, N. „Conserve energy", working material

City of Belgrade – Conserve energy

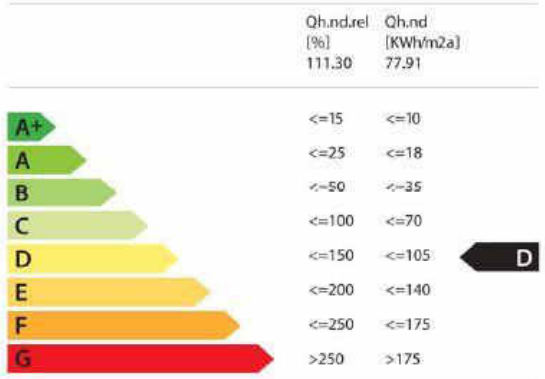
EPS RATING
ЕНЕРГЕТСКИ РАЗРЕД

Original state
Оригинално стање



Current state $Q_{h,nd} = 162.08$ [kWh/m²a]

Refurbished state
Санирано стање



Improved state $Q_{h,nd} = 77.91$ [kWh/m²a],

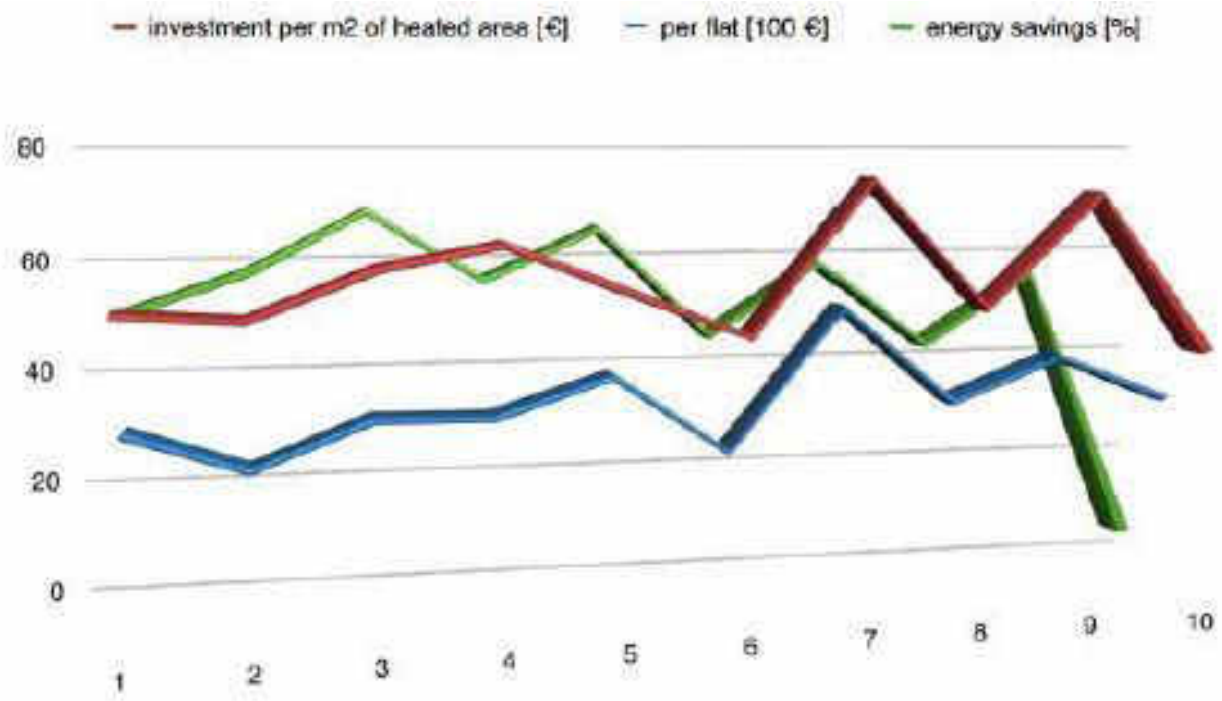
QH.nd [kWh/(m2a)] Specific yearly building energy need for heating

QH.nd.rel = (QH.nd / QH(nd,max)) x 100% Relative value of Specific yearly building energy need for heating (ratio between calculated value of specific yearly building energy need for heating and maximal value set by the regulations for certain type of building)

Source:
Ignjatović, D. Ćuković Ignjatovicć, N. „Conserve energy", working material

City of Belgrade – Conserve energy – summary

	Investment		energy savings [%]	annual savings [100 €]	payback
	per m2 of heated area [€]	per flat [100 €]			[years]
1	54	34	52	27	7
2	53	27	58	77	8
3	61	35	69	115	6
4	64	35	57	358	8
5	57	41	66	473	7
6	49	27	46	85	11
7	74	52	59	337	10
8	53	35	44	95	10
9	72	43	56	90	12
10	45	35	7	7	121



Source: Ignjatović, D. Ćuković Ignjatovicć, N. „Conserve energy", working material

City of Belgrade – needed next steps

?

Building fund :

- Belgrade building fund – Typology
- Other building typologies (educational, health, public, administrative…)

Refurbishment process:

- Procedures explained – manual and guidebook
- Financial modalities and support for improvement (funding)

Pilot projects:

- Illustrative projects with good practice case explained
- Pre and post refurbishment monitoring

Thank you for the attention

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