Rooftop Solar as a Tool for Mitigating Energy Poverty

A Feasibility Assessment in Social Housing in Čačak, Serbia

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Why energy poverty matters

- **Limited household income**
  Low-income households are more vulnerable to energy costs.
- **High energy burden**
  Electricity and heating expenses account for a significant share of household budgets.
- **Need for sustainable solutions**
  Affordable energy and residential decarbonisation are interconnected challenges

9.3%

of the population unable to keep home adequately warm

17.3%

of the population with arrears on utility bills

10.4%

of the population living in dwelling with presence of leak, damp and rot

≈ 1/3

of Serbia’s total final energy consumption goes to the residential sector

Research aim

Assess the techno-economic feasibility and household savings potential of rooftop PV in social housing.

Expand renewable generation

Rooftop PV adds clean local electricity

Reduce tenants’ expenditure

Lower electricity bills for low-income households

Inspiration

Agra do Amial neighborhood (Porto, Portugal)

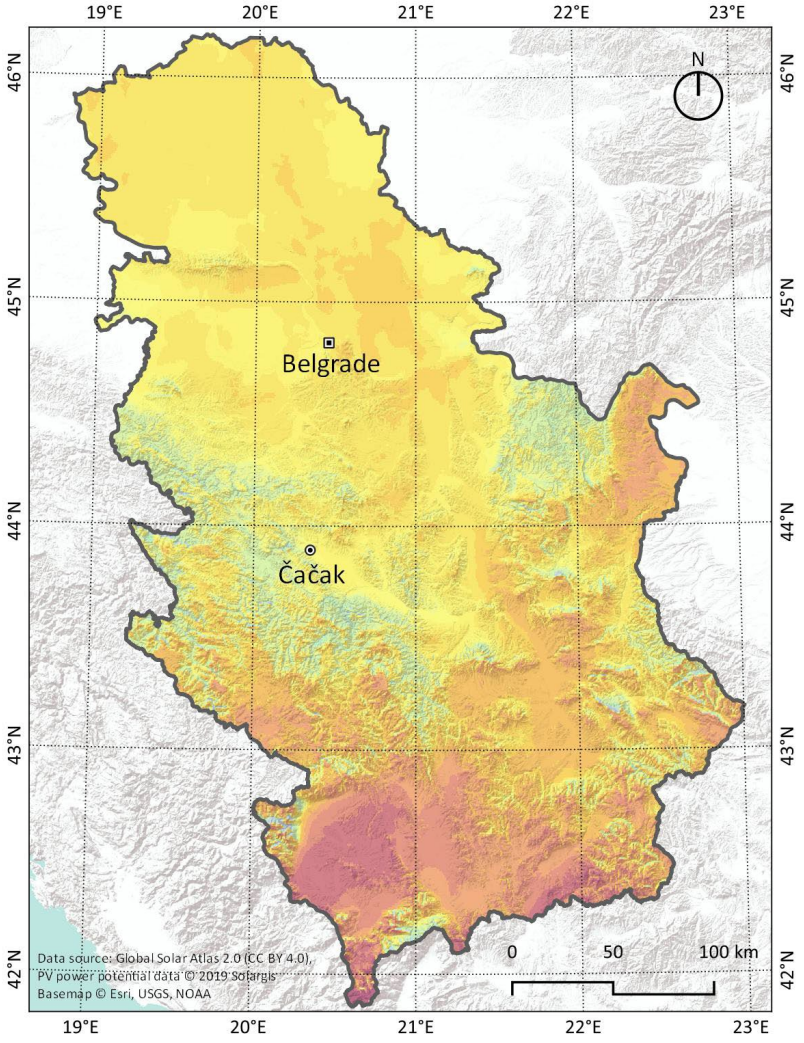


Photo © João Ferrand

Source: Domus Social

- First social housing energy-sharing initiative in Portugal
- Involving vulnerable, low-income social housing residents
- Municipal public investment
- Approx. 127 kWp PV system on residential and school buildings
- 40% of electricity consumption covered by solar energy
- 168 € annual savings per typical household

PV potential in Serbia



Legend

Photovoltaic power potential of 1 kWp freestanding PV system with cSi modules inclined at optimum tilt (kWh/kWp)

- <=1100
- 1100–1150
- 1150–1200
- 1200–1250
- 1250–1260
- 1260–1270
- 1270–1280
- 1280–1290
- 1290–1300
- 1300–1325
- 1325–1350
- 1350–1375
- 1375–1400
- > 1400

Čačak

43.891433°N, 20.349162°E

		Per year	
Direct normal irradiation	DNI	**1245.0**	kWh/m²
Global horizontal irradiation	GHI	**1346.4**	kWh/m²
Diffuse horizontal irradiation	DIF	**625.3**	kWh/m²
Global tilted irradiation at optimum angle	GTI opta	**1556.2**	kWh/m²
Optimum tilt of PV modules	OPTA	**34 / 180**	°
Air temperature	TEMP	**11.4**	°C
Terrain elevation	ELE	**243**	m

Monthly averages

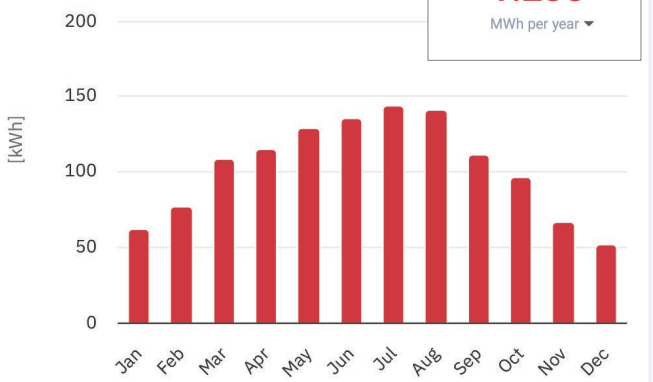
Total photovoltaic power output

Annual averages

Total photovoltaic power output

1.235

MWh per year



Sources: Solar database and PV software © 2026 Solargis

Study area: five social housing developments in Čačak

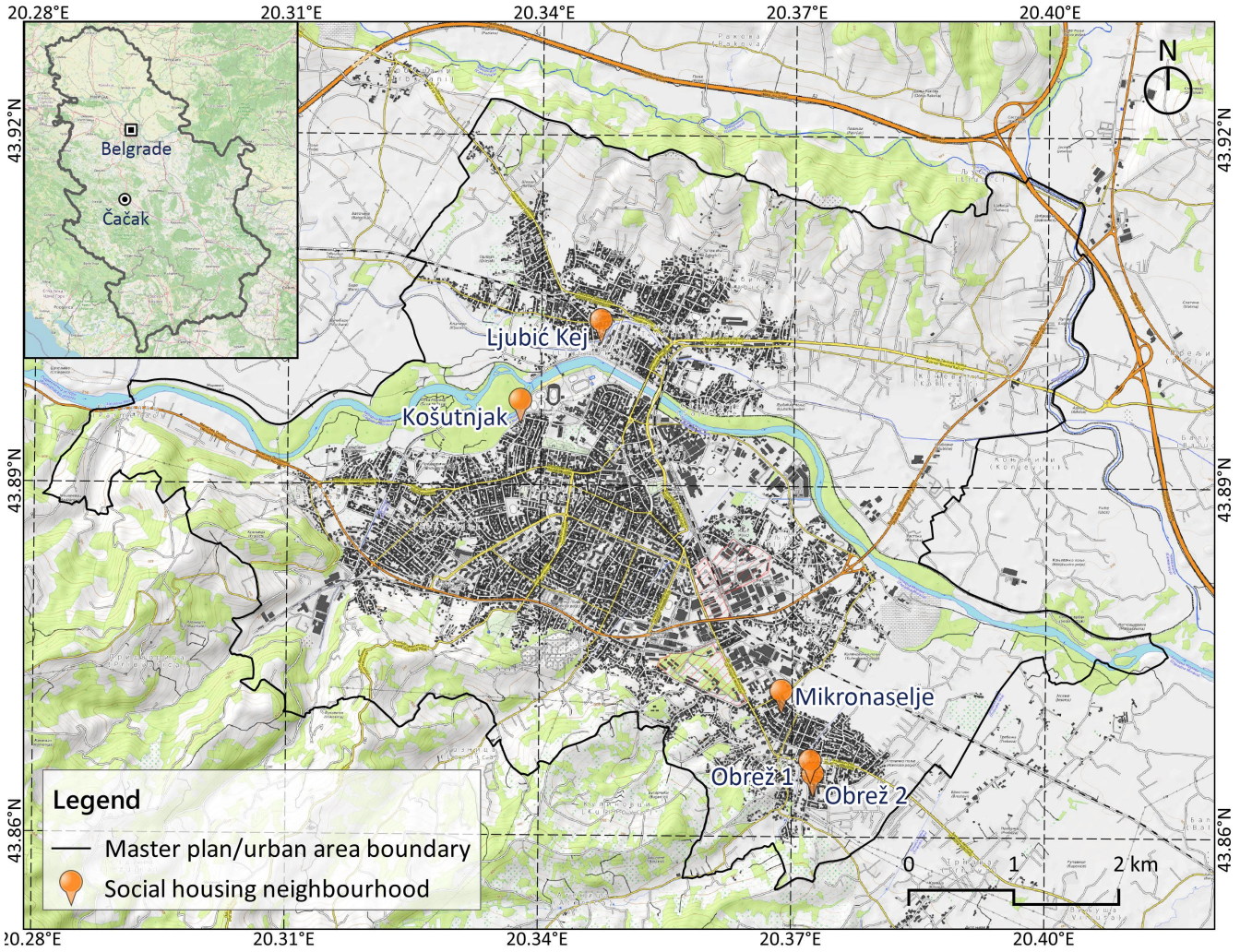


Photo © Zlata Vuksanović-Macura



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Method: four consecutive steps

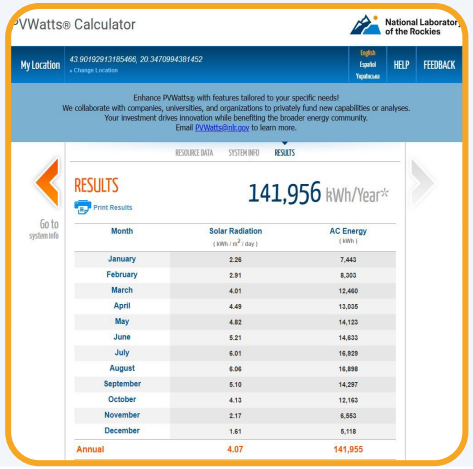
1 Roof survey

Area, pitch and orientation from Google satellite and Street View imagery



2 Generation model

NREL PVWatts: monthly and annual output (kWh) with system losses



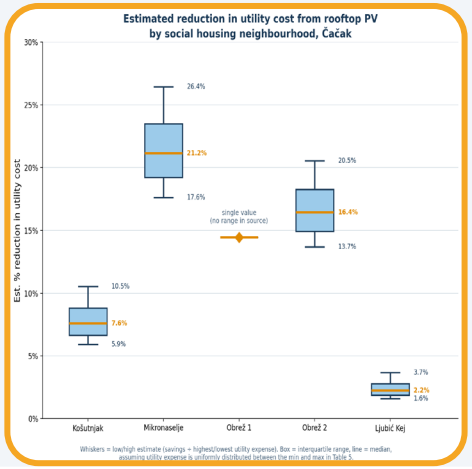
3 Monetary value

Output priced at residential tariffs, minus installation costs and municipal co-financing



4 Household savings

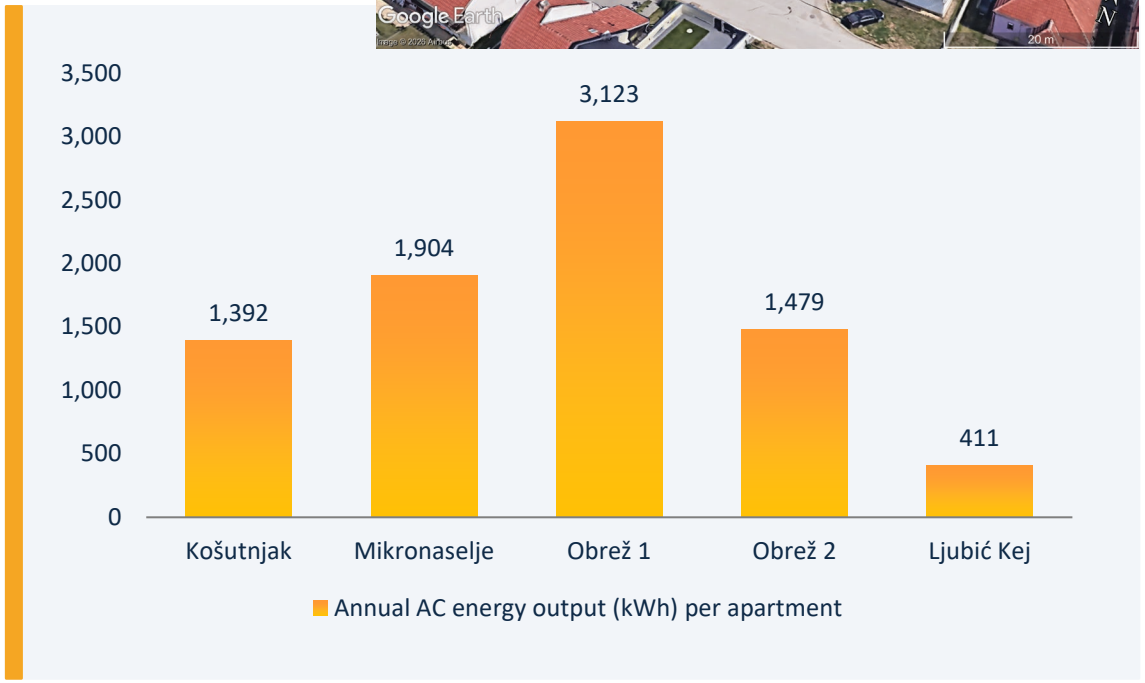
Savings allocated to test feasible cuts in reported utility expenses

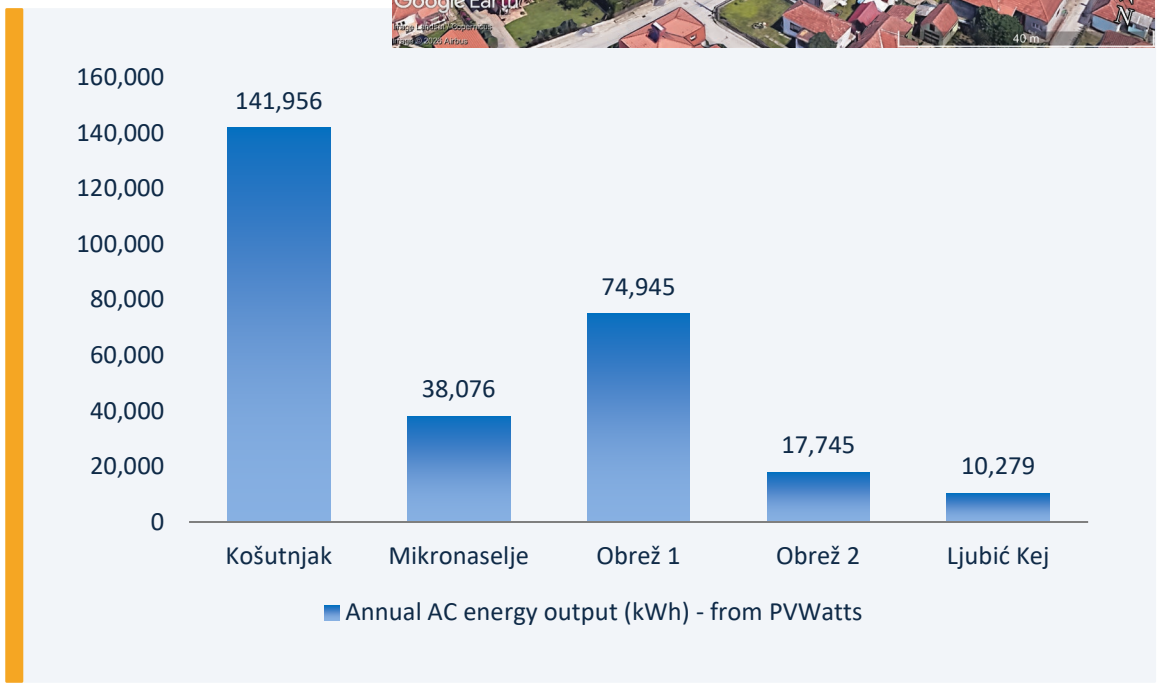


Results

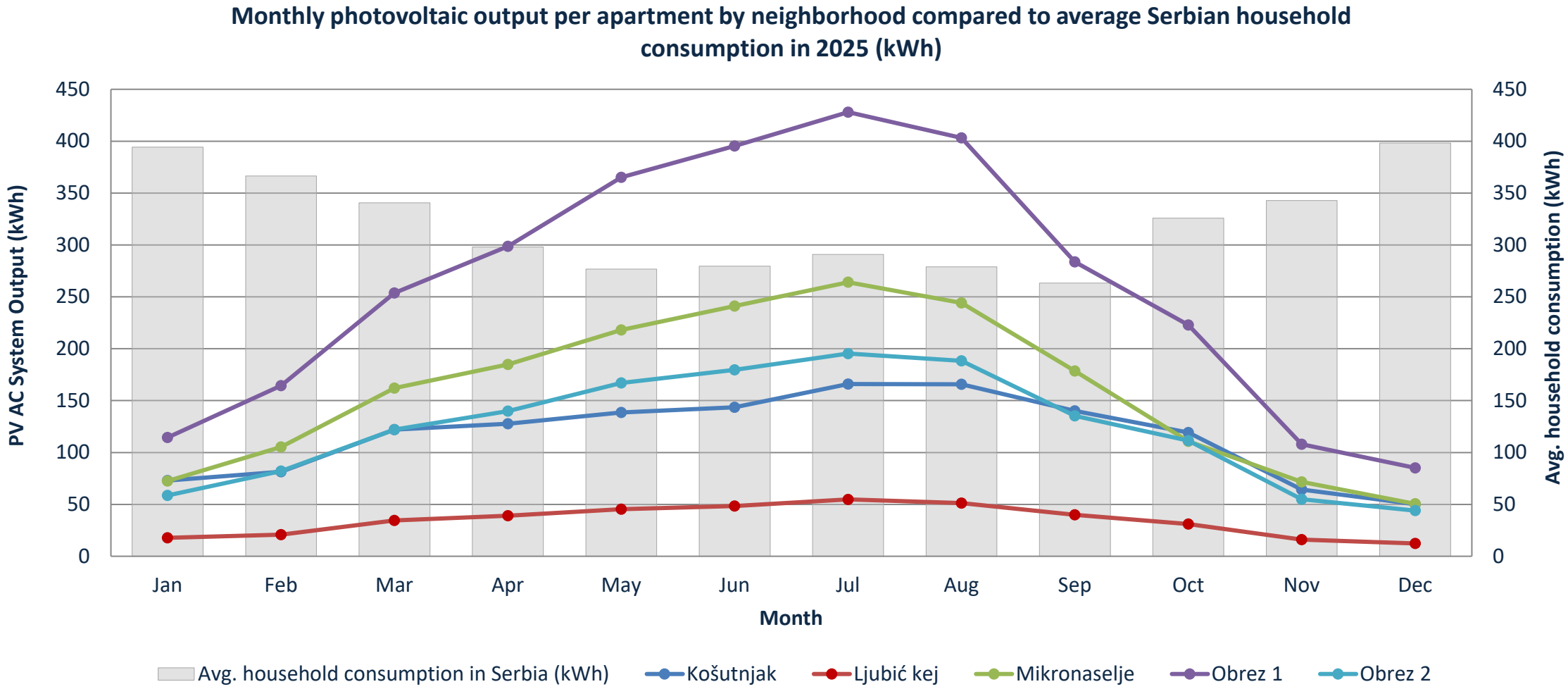

Obrež 1
Google Earth
20 m


Košutnjak
Google Earth
40 m


3,500
3,000
2,500
2,000
1,500
1,000
500
0
1,392
1,904
3,123
1,479
411
Košutnjak
Mikronaselje
Obrež 1
Obrež 2
Ljubić Kej
Annual AC energy output (kWh) per apartment

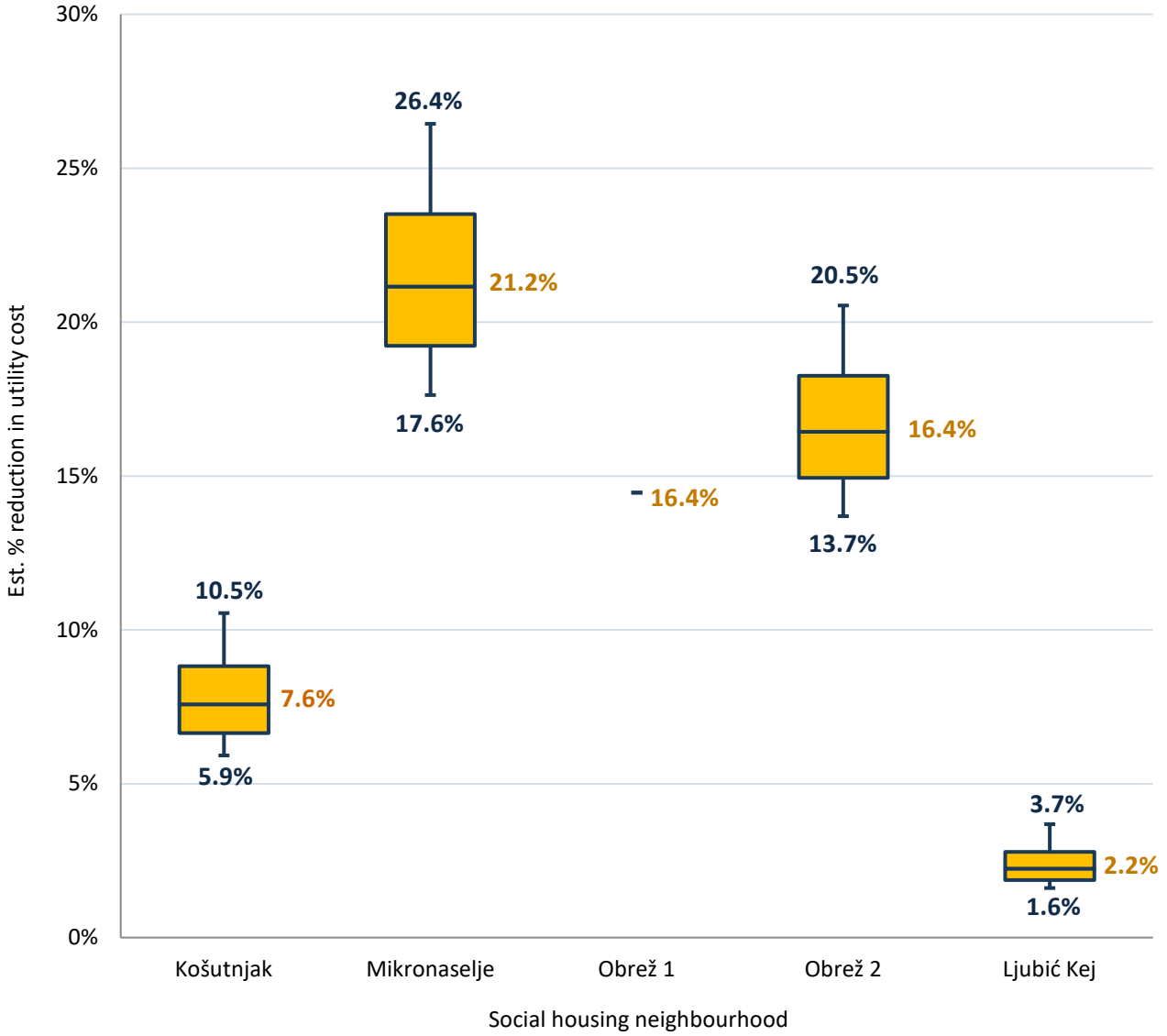

160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
141,956
38,076
74,945
17,745
10,279
Košutnjak
Mikronaselje
Obrež 1
Obrež 2
Ljubić Kej
Annual AC energy output (kWh) - from PVWatts

Results


Monthly photovoltaic output per apartment by neighborhood compared to average Serbian household consumption in 2025 (kWh)
PV AC System Output (kWh)
Avg. household consumption (kWh)
0
50
100
150
200
250
300
350
400
450
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Avg. household consumption in Serbia (kWh)
Košutnjak
Ljubić kej
Mikronaselje
Obrez 1
Obrez 2

Results

- 183 apartment included
- 283 MWh annual PV energy generation
- 155 € average annual savings per apartment
- 10.7–15.1% arevarge estimated cost reduction per apartment



Results

≈ 40%

of average annual household energy consumption in Serbia matched by PV output per household

≈ 26%

potential cut in utility spending (electricity and gas), at best

Reductions are best-case estimates.

Practical implications of the results

- **Prioritize buildings for investment**—rank buildings by output and savings per apartment, so public funds go where they help most.
- **Develop an investment and financing plan**—combine installation costs, municipal co-financing and external funding to identify projects that fit the municipal budget.
- **Design a model that delivers savings to tenants**—explore options such as energy sharing or collective self-consumption.
- **Quantify social and economic**—go beyond estimated bill savings; measure comfort, arrears and health.
- **Establish a pilot project and monitor results**—select a suitable building for a pilot and compare real data with the model.

Conclusions

- Rooftop PV can supply about 40% of household consumption
- Utility bills could fall by up to about 26%, at best
- The “City Housing Agency” Čačak can use PV for social equity and to mitigate energy poverty

Thank you

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