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Household Energy Behaviour in Serbia: the Practical Applicability of the Energy Ladder Theory

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Abstract

Around half of households in Serbia depend on inefficient and outdated use of firewood for heating, contributing significantly to air pollution and the irrational use of energy resources. Over three-quarters of residential buildings are in energy classes G and F, with energy consumption surpassing 200 and 250 kWh per m² annually. The Serbian government has emphasized the importance of revitalizing building envelopes and reducing household dependence on conventional energy sources, such as firewood and solid fossil fuels, in line with its commitment to align energy strategies with the goals of the European Green Deal across all sectors. To better understand the current household heating structure, this paper examines the applicability of the energy ladder theory to household energy choices and behaviour in Serbia. A national survey conducted in 2024 within the framework of the FF GreEN Project, supported by the Science Fund of the Republic of Serbia, serves as the foundation for mapping key determinants of household heating. These determinants are included in the approach proposing the calculation of the Energy Ladder Step Index for administrative districts. These patterns are then correlated with influential factors recorded in official statistics. The results suggest that household energy behaviour is significantly influenced by the income level in the municipalities, with households at the bottom of the ladder showing the lowest index values. However, there are also districts where this connection is not as direct, and other factors analysed, such as locally available cheap firewood, lack of district heating infrastructure, and the education level of the population, emerge as significant.

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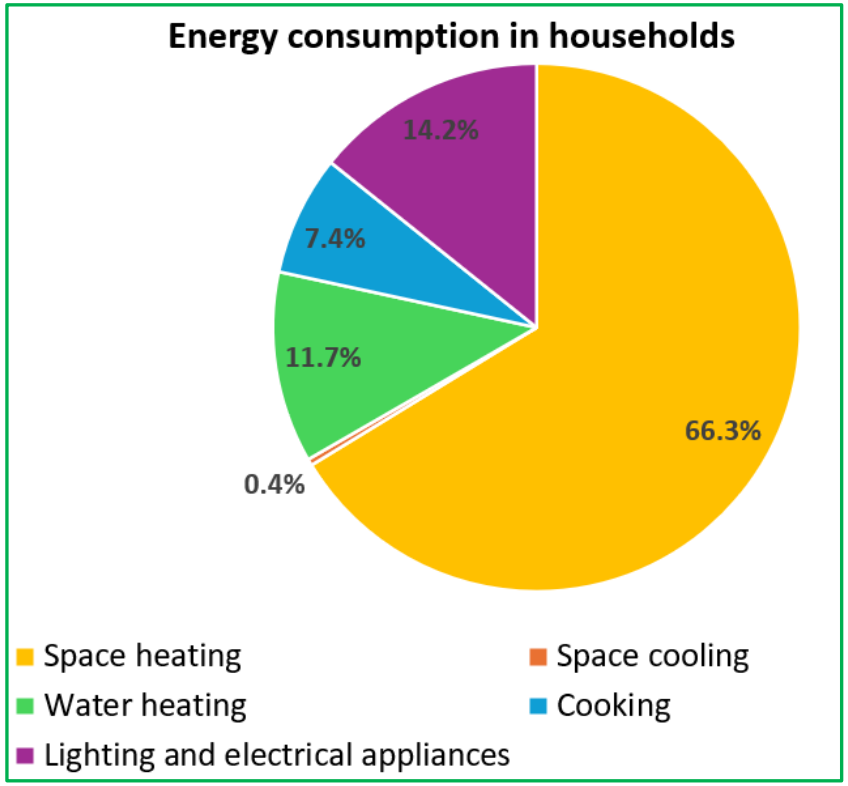
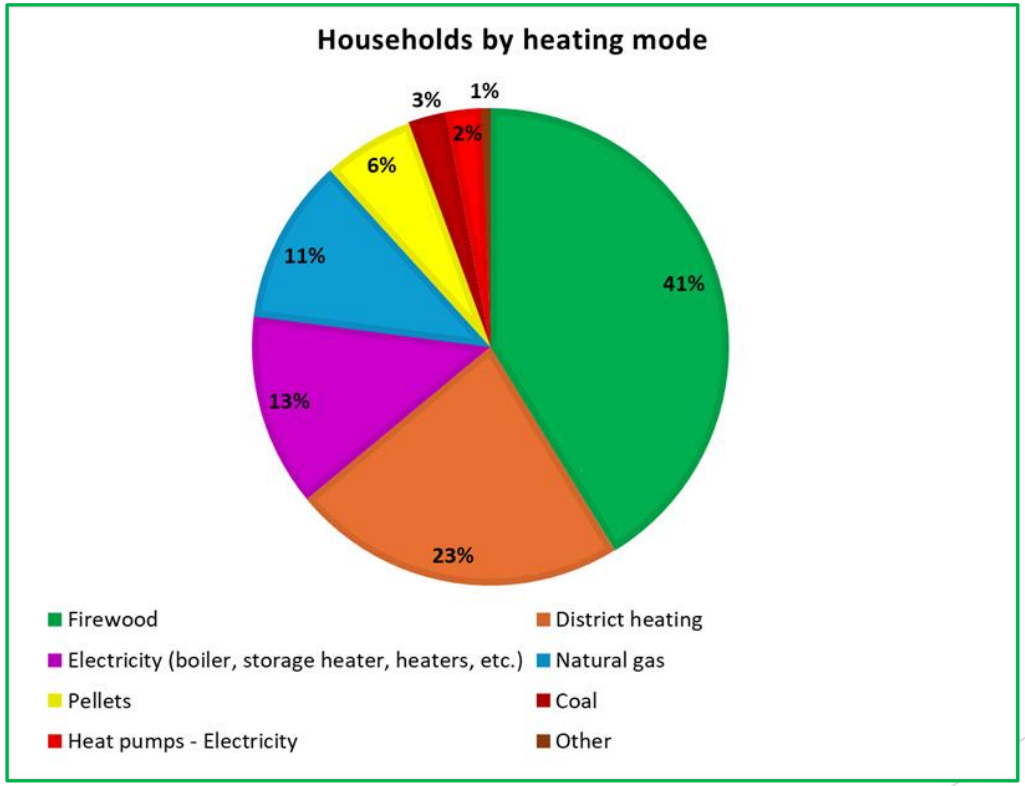
Introduction

- **Household sector** - recognized in the global energy transition as one of the most important and cost-effective areas for reducing energy use and greenhouse gas (GHG) emissions.
- Most changes in household energy use are expected to happen in heating systems.
- **Space heating** remains one of the largest uses of energy and, at the same time, the most varied in terms of fuels and technologies.
- However, transitioning from traditional to modern energy sources and more efficient technologies for heating could be difficult (especially in countries where a large part of the population is energy vulnerable or even energy-poor).

Introduction

- In Serbia, the household sector has a significant share in final energy consumption, often exceeding one-third of total final energy consumption in recent years.





Objective, hypothesis, contribution

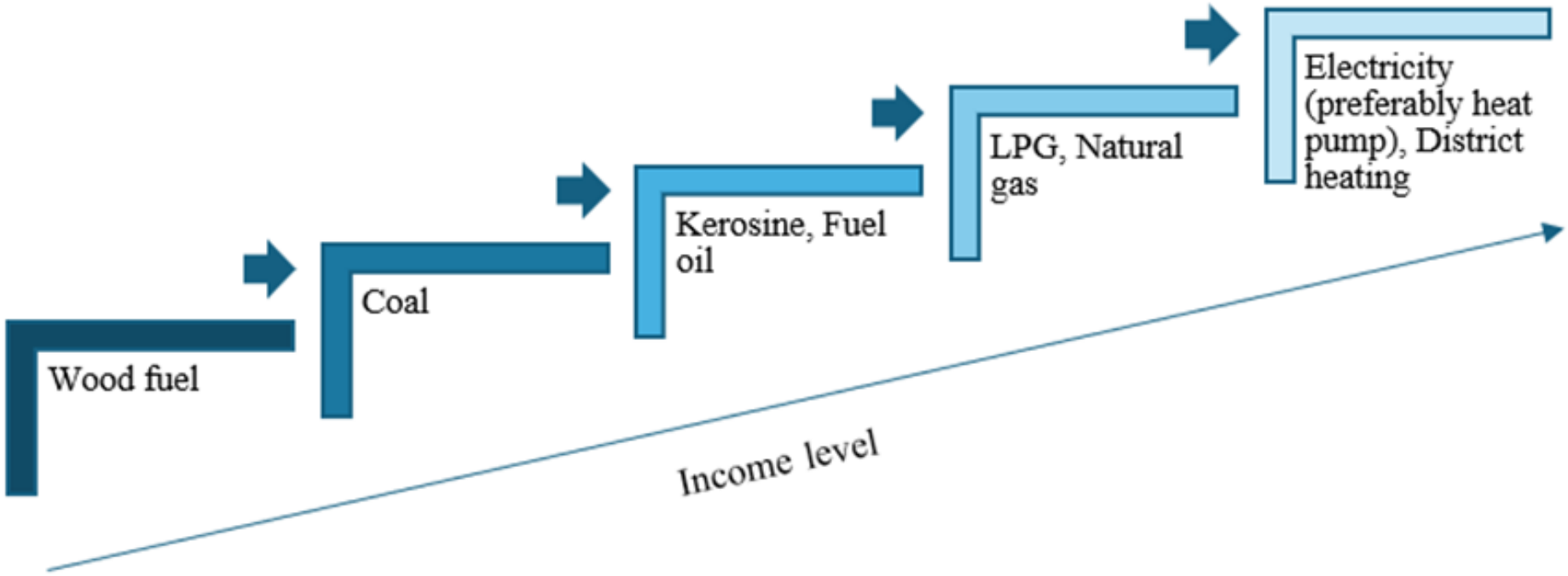
- The main objective of this research is to develop a typology of the "energy ladder steps" for administrative districts within the country, based on a framework using data from a household survey related to energy transition.
- The main hypothesis: The typology of energy ladder steps can help in designing better and more targeted energy policy measures for each administrative district, avoiding general and broad measures at the national level.
- The main contribution of the research:
  - introducing a new framework based on a specialized household survey and proposition of "energy ladder step index" at the administrative district level in order to assess the current level of administrative districts across the country.
  - corelating the obtained index values with influential factors recorded in official statistics.
  - formulating targeted policy measures to facilitate a successful transition in “typical“ administrative districts.

Household survey

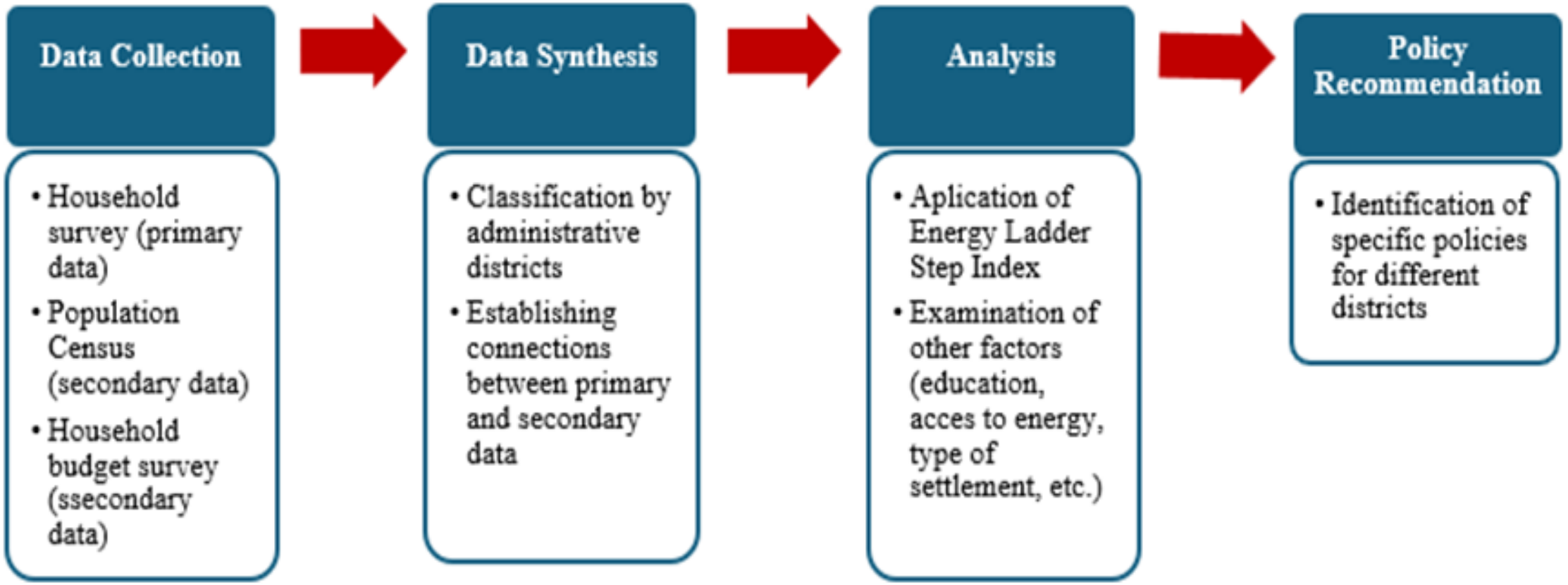
- Goal: gathering detailed information that could be directly linked to each household, allowing for later synthesis at higher administrative levels.
- Survey was conducted from June to October 2024.
- The sample design used was a two-stage stratified sampling method:
  - First stage: census enumeration areas stratified by settlement type (urban and other) and by territory (4 regions) - 8 strata.
  - Second-stage: individual households. A total of approximately 1200 households were selected for the sample, 1033 households were successfully surveyed.
- Telephone surveys were used.
- The results were then classified according to the administrative division of the country, specifically into 25 administrative districts (AD1 – AD25).

Energy ladder theory

- Energy ladder theory - households will move to more advanced energy sources as their income increases.



Methodology



Methodology

ELSI value for each area is calculated based on the next equation

$$ELSI = w_1 \times HM + w_2 \times EE + w_3 \times AS \quad (1)$$

Where:

$\boldsymbol{w_1}$, $\boldsymbol{w_2}$, and $\boldsymbol{w_3}$ are the weights for each parameter,

HM is Heating Method (weight $w_1 = 0.5$),

EE is Investments in energy efficiency in the last 10 years (weight $w_2 = 0.3$), and

AS is Age of current heating system (weight $w_3 = 0.2$).

$$HM = \sum(\%\ of\ Households\ on\ Determinant(HM)_i \times weight\ (HM)_i) \quad (2)$$

$$EE = \sum(\%\ of\ Households\ on\ Determinant(EE)_i \times weight\ (EE)_i) \quad (3)$$

$$AS = \sum(\%\ of\ Households\ on\ Determinant(AS)_i \times weight\ (AS)_i) \quad (4)$$

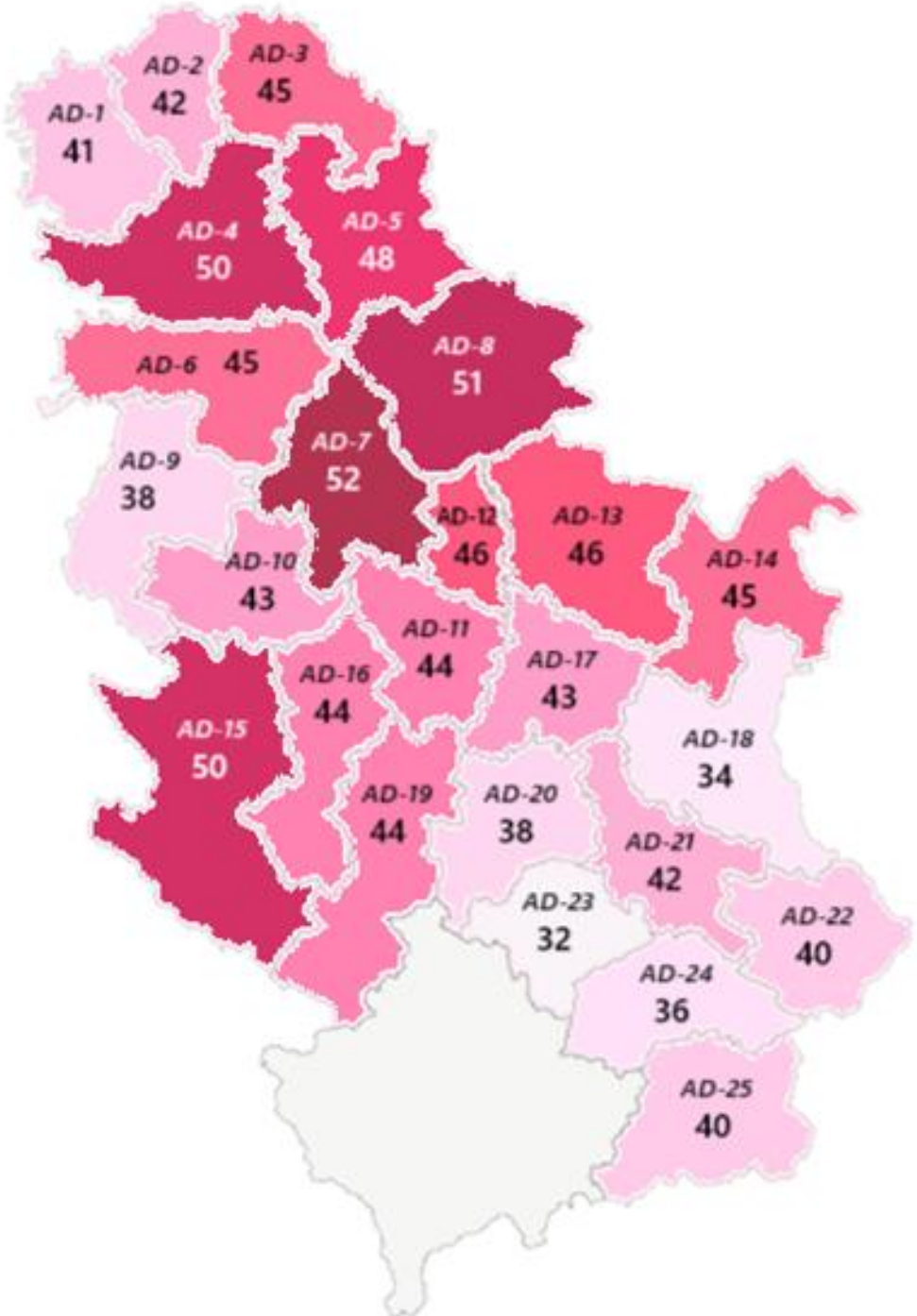
Results and Discussion

- The weights of determinants for each parameter (HM, EE, and AS):

Parameter	Determinants	Weight
HM	Heat pump	1
	District heating	0.9
	Pellets	0.8
	Natural gas	0.7
	Electric heating (boiler, heaters)	0.6
	Fuel oil	0.4
	Coal	0.3
	Firewood	0.1
Parameter	**Determinants**	**Weight**
EE	Window and facade replacement (100%)	1
	Only window or facade replacement (50%)	0.5
	No replacement	0
Parameter	**Determinants**	**Weight**
AS	System up to 5 years	1
	System 6 to 10 years	0.75
	System 11 to 15 years	0.5
	System older than 15 years	0.25

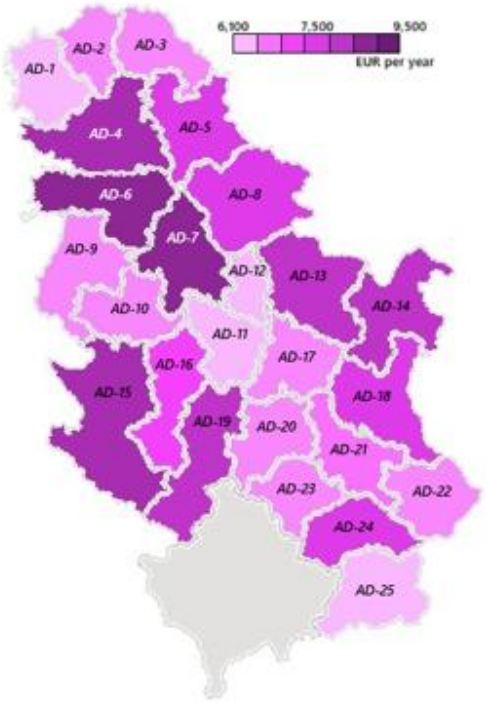
Results and Discussion

- ELSI values by administrative district:

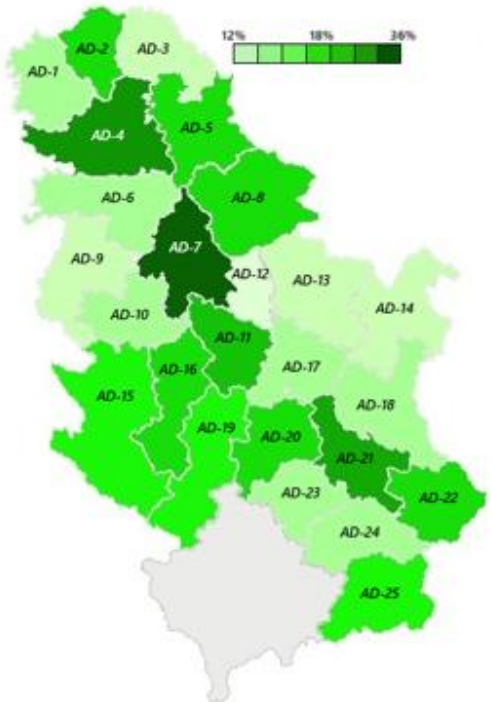


Influential factors

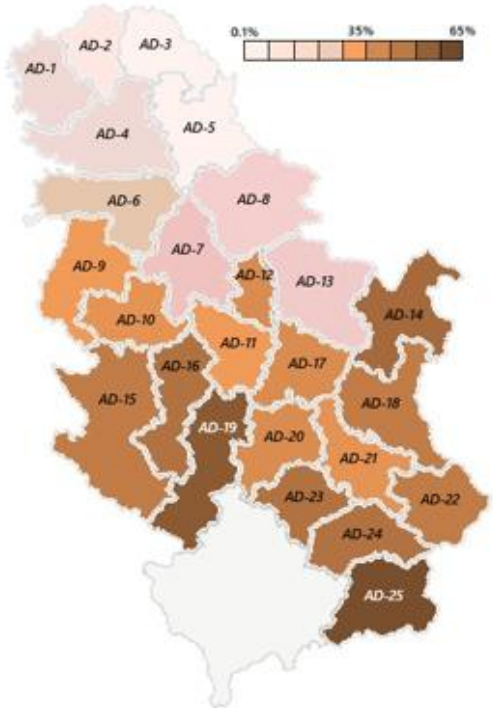
- The values of four influential factors: (a) income, (b) education level, (c) forest share, (d) district heating connections:



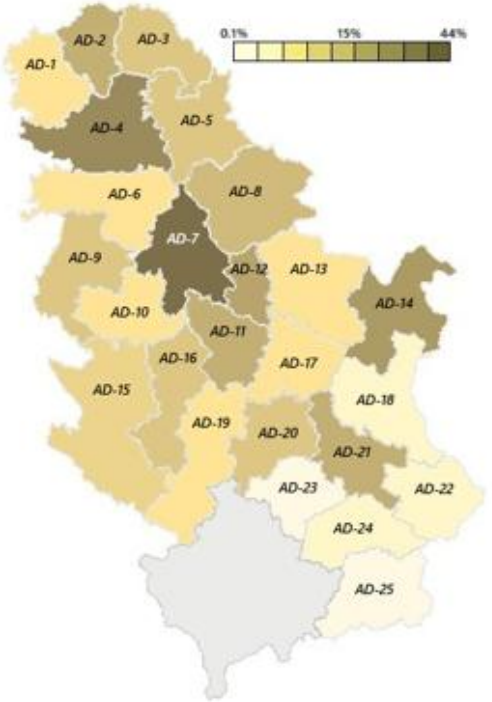
A) Income per year



B) Share of high educated in population



C) Forest share of total area



D) Share of apartments with district heating

Policy implications

- Policy clusters for administrative districts with the lowest ELSI values:

Cluster	Policy recommendations
Districts with high to mid-high income and low to mid education level	Subsidies for modern heating systems like heat pumps or pellet stoves to replace traditional fuels; Invest in educational campaigns on energy efficiency and environmental benefits.
Districts with district heating infrastructure (mid to high) and low to mid income	Expand district heating infrastructure; Offer free connections for households to switch from traditional fuels to district heating; Implement public awareness campaigns about the benefits of district heating.
Districts with low education level and access to forests (cheap firewood)	Promote the switch to more efficient biomass-based heating; Subsidize the production of biomass fuels.
Districts with low income and low education, with underdeveloped district heating infrastructure	Focus on financial support for energy vulnerable consumers; Implement programs to raise awareness on energy efficiency; Offer alternatives in the form of individual heating systems or connections to natural gas if available.

- Methodology grounded in the energy ladder theory and multi-factor analysis.
- Reliable basis: combining primary survey data with secondary statistics.
- District-level insights: avoiding national-level generalizations and enabling region (district)-specific policy recommendations.
- Universal and adaptable methodological approach.

Conclusion

THANK YOU!

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