Facilitating Energy Transition in Borsod County: Current Situation and Possible Transition Pathways

Mohammad Jaber
Institute of World and Reginal Economics
University of Miskolc
Miskolc, Hungary
regjaber@uni-miskolc.hu

***Abstract*— In recent years, the transition towards a more sustainable energy system has become the center of the global community focus. This paper examines the current energy situation in Borsod-Abaúj-Zemplén county in Northern Hungary. The Gini index is calculated on residential gas and electricity consumption for the sixteen districts in the county. Furthermore, energy consumption trends are analyzed, and the differences based on income are highlighted. Results indicate that although the county's population has declined through the past years, the electricity consumption trend is slightly inclining. In contrast, gas consumption patterns are declining. Gini index results indicated that energy inequality has varied throughout the years. Districts with high industrial activities show more energy consumption and income than poorer districts, where the consumption varies between low and high. To facilitate energy transition in the region, further analysis is needed to understand better energy poverty and the possible local renewable energy resources.**

Keywords- Borsod County; Energy Inequality; Energy Poverty; Energy Transition; Hungary

I. INTRODUCTION

In recent years, the transition towards a more sustainable energy system has become the center of the global community focus. Societies struggle with environmental and social issues such as climate change, biodiversity loss, poverty, inequality, and discrimination [1]. Additionally, changing the energy system through transition involves energy technologies and prices and extends to the social and economic spheres built around energy production and consumption [2]. For instance, the energy transition from coal to natural gas can, on the one hand, improve the air's status and reduce air pollution; on the other hand, it would increase the rates of energy poverty [3]. However, as energy transition will benefit the environment and society in the long term, but in the shorter term, it will increase the energy poverty problem [4]. A low-carbon energy transition must be facilitated to prevent further temperature increases and the effects of climate change. All stakeholders should be involved in this shift, but in practice, this is much more difficult due to the problem of energy or fuel poverty [5]. Investments in renewable energy are growing globally. Governments and, as a response to environmental justice movements, are working on finding solutions to climate change. For instance, in Hungary, installed solar energy capacity reached 2.13 gigawatts (GW) in 2021 compared to less than 0.01 GW ten years earlier. Moreover, renewables' per capita energy consumption has grown considerably since the early 2000s to reach 1,982 kWh in 2021 [6].

Because of the centrally planned economy emphasis on manufacturing and the county's abundance of brown coal, Borsod-Abaúj-Zemplén (B-A-Z county) has developed into one of the leading industrial districts of the nation [7]. The county also has one of Hungary's largest biomass power plants, the Borsod Power Station has an installed heat capacity of 140 MW and an electric capacity of 40 MW.

B-A-Z has evolved as an industrial center due to coal mining after the end of World War II. Due to their distinct conditions, the various areas of the country experienced the regime change that followed the fall of socialism in different ways. These qualitative and quantitative changes affected the political, economic, and social systems. The mining company's mines in the county shut down one after another [8], [9]. Coal production in the region peaked in 1969, it exceeded 6000,000 tons per year, but after that, the production continued to decline to barely 600,000 tons per year in 2011 [8]. The trend of coal

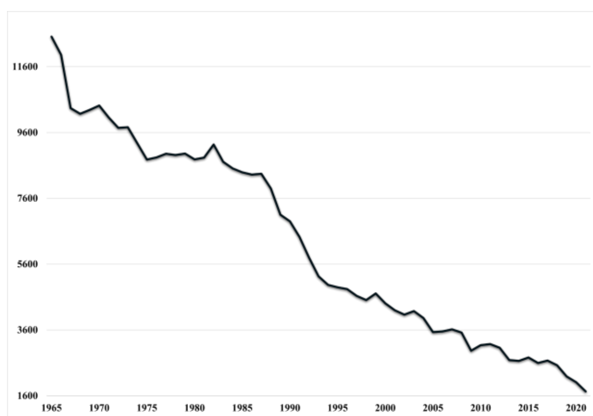

Figure 1. Per capita coal consumption in Hungary (kWh).
Source: [9]

consumption all over Hungary has declined during the last years; figure 1 shows the trend of per capita coal consumption in Hungary from 1965 to 2021 in kWh. The figure shows that per capita coal consumption has declined from over 12,500 kWh in 1965 to almost 1,500 kWh in 2021, indicating that the country is on track to phase out coal before 2030 if all conditions in the regions become favorable.

Still, until recently, in some regions where poverty is high, the government announced the reopening of lignite coal mines in the region [9]. The small, opened coal mines bring pollution, cracked houses, deterioration of health and environment damage, and falling real estate prices. This case is shown in Sajókápolna village. In 2011, a company started opencast coal mining in the region despite the opposition movement led by the locals. Later, with the noise, and other environmental impacts, the municipality donated coal to the energy poor during the heating season, which resulted in declining in the opposed voices among the locals [9]. In a study done by a local non-governmental organization, samples from the free coal distributed in the villages and other samples were bought to be analyzed. Due to its low calorific value, high ash content, and sulfur content, the samples' results demonstrate that the lignite sold and distributed to the general population as fuel is unfit for use in residential fires [10].

This study analyzes the territorial residential energy consumption and inequality in B-A-Z county and the possible links to the energy transition. The following sections discuss a brief literature review, followed by the methodology and data used, a presentation of the results, and finally, conclusions.

II. Literature Review

Energy poverty has emerged as a significant social issue that is thought to affect up to 11% of Europeans [11]. In the European Union, energy poverty is defined as "the inability to afford basic energy services (heating, cooling, lighting, mobility, and power) to guarantee a decent standard of living due to a combination of low income, high energy expenditure, and low energy efficiency of homes" [12]. According to the EU Energy Poverty Observatory (EPOV) and compared to the EU average, Hungary's performance in population-reported indicators is inconsistent. 6.1% of Hungarians reported insufficient home heating in 2018, less than the EU average of 7.3%. Nonetheless, a more significant percentage of the population—11.1%—than the EU average of 6.6%—could not pay their power bills on time due to financial issues. On the other side, Hungary outperforms the EU average in metrics that are based on expenditures. With 9.0%, fewer households than the EU average spend a substantial percentage of their income on energy. This may yet burden household budgets and point to subpar building energy efficiency. The fact that only 9.3% of households in Hungary spend unusually little money on energy may mean they are not getting enough of it [13].

In fact, the literature defines five pillars that form "low carbon societies," namely: energy efficiency, renewable energy resources, buildings as active consumers, electromobility, and developing smart cities where local resources are harnessed [14]. Cities consume a sizeable amount of the world's energy, and it is predicted that metropolitan areas will continue to be the main factor in the growth of energy use. So, for well-informed energy policy decisions, recognizing and assessing urban energy use and addressing social and spatial inequities are essential. Furthermore, implementing a decentralized energy policy needs a clear road plan. In light of this, research was done by [15] to look at household energy use in 23 Hungarian municipalities with county rights and Budapest. Detailed statistical indices were produced to determine the spatial distribution of energy use and regional differences in urban energy consumption. The results indicate that although territorial differences across the cities under study diminished between 2010 and 2015, there were no appreciable differences in urban energy use among them. In order to maintain sustainable and equitable energy use, it is crucial to recognize and rectify spatial disparities in urban energy consumption.

A study by [16] examined how energy prices in the EU's 27 member states affected territorial disparity in household energy use from 2010 to 2020. The Gini and Hoover indices were used to gauge inequality, and multiple linear regression (MLR) was utilized to determine how energy prices affected income distribution. According to the Hoover and Gini indices' downward trends, the study demonstrated a drop in territorial inequality. While gas prices showed a negligible link, MLR analyses demonstrated a substantial correlation between inequality and electricity prices. In the same context, [17] examined the connection between household energy consumption inequality and human development in the EU-27 Member States from 2010 to 2018. The study employed the Gini coefficient, and the least squares dummy variable (LSDV) model to examine the effect of the Human Development Index (HDI) and its components, life expectancy, education, and gross national income (GNI), on energy consumption. The results showed that territorial energy consumption inequality would decrease if all member states had the same HDI score. Furthermore, it was discovered that life expectancy harmed energy consumption, but GNI had a positive correlation, and the education index had none. The study, which classified member nations as having high, low, and medium energy efficiency, also underlined the enormous impact of energy efficiency on human development.

III. Data and Methodology

In this study, the Gini index is calculated based on data related to residential energy consumption collected from the Hungarian Statistical Office database. As mentioned in the literature review section, the Gini index was used in previous studies to measure the territorial disparities in energy consumption in the EU.

$$\text{Gini} = 1 - \sum i \left[xi \times \left(yi + 2 \times (1 - Cyi) \right) \right] \tag{1}$$

The analysis covers the sixteen districts in B-A-Z county from 2000-2021. The sixteen districts are Cigánd, Edelény, Encs, Gönc, Kazincbarcika, Mezőcsát, Mezőkövesd, Miskolc, Ózd, Putnok, Sárospatak, Sátoraljaújhely, Szerencs, Szikszó, Tiszaújváros, and Tokaj.

The following annual data, obtained from the Hungarian Central Statistical Office (KSH), are used in the calculations: the number of household electricity consumers, the volume of electricity supplied to households (thousand kWh), of the total volume of gas supplied, the volume of gas supplied to households(not recalculated) (thousand m3); of household gas consumers, and the number of those using gas for heating. Following the work of [15], the data mentioned was used to estimate the following indicators: 1) of the total volume of gas supplied, the volume of gas supplied to households (not recalculated) per rate of household gas consumers number using gas for heating referred as residential gas consumption per household (m^3); and 2) the volume of electricity supplied to households per number of household electricity consumers referred as residential electricity consumption per household (kWh).

IV. Results and Discussion

Besides analyzing the Gini index of residential electricity and gas consumption per household, the consumption trends were also analyzed. The results of the consumption trends are represented in figure 2. While residential electricity consumption per household shows a slightly inclining trend over the year, residential gas consumption shows the opposite. Additionally, the results show that comparing the declining population in B-A-Z county, people tend to consume more electricity in their daily lives. The findings suggest that the county's energy consumption patterns may be changing. A greater reliance on electric technologies and home appliances may cause an upward trend in electricity use. In the meantime, a shift toward more energy-efficient appliances or a preference for alternate energy sources could be to blame for the downward trend in gas consumption, which could be attributed to a drop in the use of gas for cooking or heating.

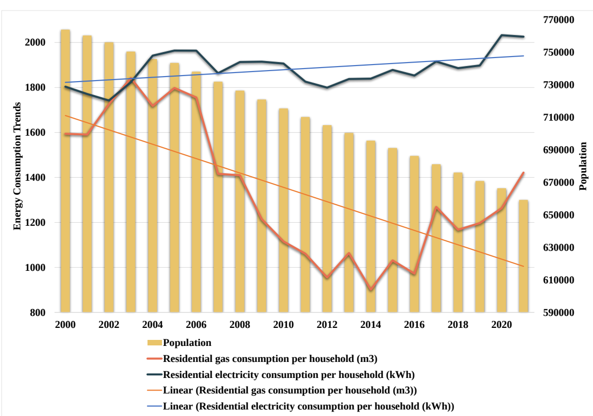

Figure 2. Energy consumption vs. population in B-A-Z county.

Based on the Gini index analysis findings, it can be shown that the Gini index for electricity consumption, which ranges from 0.054 to 0.079, has mainly remained consistent between 2000 and 2021. However, the Gini index for energy consumption rose significantly in 2021, indicating more inequality in household electricity usage.

However, the Gini index for gas use has been inconsistent throughout time, ranging from 0.044 to 0.124. It seems to have reached its apex in 2006 and 2016, reflecting more significant levels of gas consumption inequality in those years. With a value of 0.044 in 2020 and 0.044 in 2021, the Gini index for gas consumption has typically decreased since 2006 and has stayed consistent over the past several years.

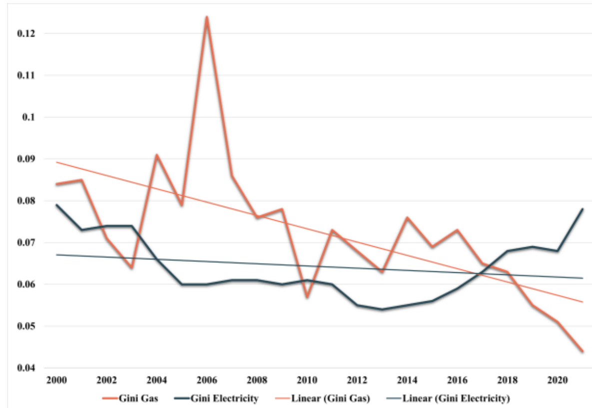

Figure 3. Gini Index results (2000-2021).

Overall, these findings imply that, with variations in the Gini index over time, there may be some inequality in-home gas and electricity usage.

In figures 4 and 5, the vertical and horizontal lines refer to the arithmetic mean of the sixteen districts under study related to the selected indicators, indicating whether the district under examination has a value below or above average. In each figure, the districts are divided into four distinct groups: Cities in the upper right quarter have incomes and energy usage that are above average. The residents of the higher-income cities in the lower right corner tend to be more environmentally conscientious, as seen by the lower home energy consumption (low average). The income is below average, and household energy use is above average in the top left quarter, making this situation unsustainable. Cities in the lower-left quarter have below-average income and energy use.

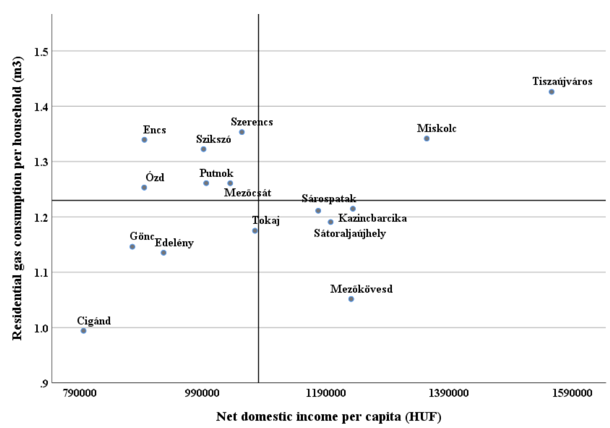

Figure 4. Status of B-A-Z districts in terms of per-capita income (HUF) and residential gas consumption (m^3).

Regarding the residential gas consumption per household, as shown in figure 4, most districts are located on the left side of the income average level. Cigánd district has the lowest value in terms of income and consumption (19 percent lower than the consumption average), where most people tend to use firewood and coal for heating in winter which does not appear in the numbers of the statistical office. The same can be noticed in other districts such as Gönc and Edelény. The upper left quarter represents those who spend more of their income on gas, whereas Szerencs district has the highest share of gas consumption compared to income. On the other hand, Tiszaújváros seems to have the best condition in terms of income level and gas consumption, followed by Miskolc. These two districts are mainly characterized as industrial areas. Finally, four districts are in the lower right quarter, indicating low consumption levels compared to high income.

The situation in the districts in terms of electricity consumption is different. The distribution of the districts is concentrated in the chart's left half and the lower right quarter. This may indicate a higher electricity consumption inequality, where districts are divided between high consumption and low income (falling into the energy poverty trap). On the other hand, districts where high income is associated with low consumption (high energy efficiency equipment and better life standards). The left lower quarter shows that four districts suffer from problems related to low income and low electricity consumption, which may refer to using other energy resources or that these households adapted to low consumption patterns to deal with poverty or other daily life hardships. The results show that while Tiszaújváros net income per capita is the highest in the county, the electricity consumption is the lowest. On the other hand, Encs has the highest share of consumption compared to low-income districts in the same quarter.

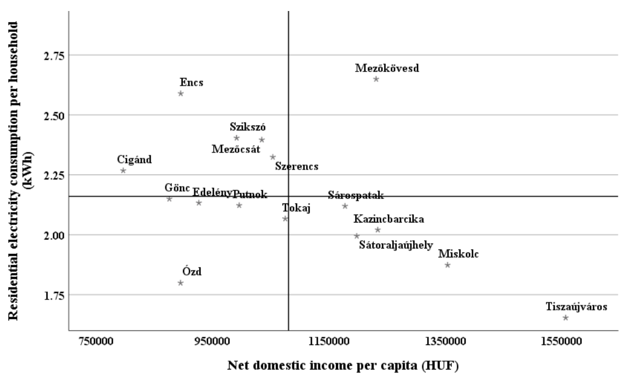

Figure 5. Status of B-A-Z districts in terms of per-capita income (HUF) and residential electricity consumption (kWh).

V. Conclusions

This study aimed to examine residential energy consumption patterns and disparities in Borsod-Abaúj-Zemplén county, Hungary, from 2000 to 2021. Data on residential electricity and gas consumption were gathered and analyzed, and the Gini index was used to evaluate the differences in energy consumption between the districts. The study also examined changes in energy usage and revealed that while domestic gas consumption per home has declined, residential electricity consumption per household has a slightly growing tendency. The results indicate that gas use has decreased due to a shift toward more energy-efficient equipment and alternative energy sources for cooking and heating.

From 2000 until 2021, the Gini index for energy consumption stayed stable, but it markedly increased in 2021, showing growing inequality in household power usage. While the Gini index for gas consumption has fluctuated over time, ranging from 0.044 to 0.124, it has generally dropped since 2006, suggesting some degree of inequality in household gas usage.

The study results showed the differences in residential gas and electricity consumption against the income level in the B-A-Z districts. These differences result from each districts and the region's industrial nature.

As energy transition is vital in decarbonization to achieve sustainable development in cities and communities, it must address energy poverty and inequality to ensure a just transition.

The study suggests that governments concentrate on boosting energy efficiency in homes and alternate energy sources for cooking and heating based on the findings. To lessen the disparity in energy usage, measures could also be developed to increase low-income households' access to affordable and efficient energy. Overall, the study offers insightful information about the patterns of energy consumption and inequality in B-A-Z county, which should guide the development of policies to create a more just and sustainable energy transition.

VI. Acknowledgment

„This project is funded by the European Union's Horizon Europe programme under grant agreement No. 101079354."

References

[1] P. García-García, Ó. Carpintero, and L. Buendía, "Just energy transitions to low carbon economies: A review of the concept and its effects on labour and income," *Energy Res. Soc. Sci.*, vol. 70, p. 101664, Dec. 2020, doi: 10.1016/j.erss.2020.101664.

[2] C. A. Miller, A. Iles, and C. F. Jones, "The Social Dimensions of Energy Transitions," *Sci. Cult.*, vol. 22, no. 2, pp. 135–148, Jun. 2013, doi: 10.1080/09505431.2013.786989.

[3] T. Szép, M. Jaber, and M. Kashour, "Changing European Energy Policy – The Challenge of the Energy Price Storm," *Theory Methodol. Pract. - Rev. Bus. Manag.*, vol. 18, no. 02, Art. no. 02, Dec. 2022, doi: 10.18096/TMP.2022.02.04.

[4] L. Middlemiss, P. Mulder, M. Hesselman, M. Feenstra, S. T. Herrero, and K. Straver, "Energy Poverty And The Energy Transition," p. 38, 2020.

[5] A. Chapman and S. Okushima, "Engendering an inclusive low-carbon energy transition in Japan: Considering the perspectives and awareness of the energy poor," *Energy Policy*, vol. 135, p. 111017, Dec. 2019, doi: 10.1016/j.enpol.2019.111017.

[6] "Hungary," *Our World in Data*, 2023. https://ourworldindata.org/country/hungary (accessed Mar. 05, 2023).

[7] "Borsod-Abaúj-Zemplén County," *Wikipedia*. Jan. 30, 2023. Accessed: Feb. 24, 2023. [Online]. Available: https://en.wikipedia.org/w/index.php?title=Borsod-

Aba%C3%BAj-
Zempl%C3%A9n_County&oldid=1136557892

[8] Z. Dabasi-Halász, K. Lipták, A. S. Gubik, and B. Varga, “Human resources requirements for reindustrialisation in Borsod-Abaúj-Zemplén county,” *Stud. Mundi - Econ.*, vol. 8, no. 4, pp. 55–71, Dec. 2021, doi: 10.18531/Studia.Mundi.2021.08.04.55-71.

[9] L. Pusztai and A. Botar, “Can Borsod county escape the coal mine curse?,” *Just Transition*, 2018. https://www.just-transition.info/can-borsod-county-escape-the-coal-mine-curse/ (accessed Feb. 24, 2023).

[10] “A lignit alkalmatlan lakossági tüzelésre,” *Zöld Kapcsolat Egyesület*, Nov. 10, 2019. https://zoldkapcsolat.hu/a-lignit-alkalmatlan-lakossagi-tuzelesre/ (accessed Mar. 01, 2023).

[11] S. Bouzarovski and S. Tirado Herrero, “The energy divide: Integrating energy transitions, regional inequalities and poverty trends in the European Union,” *Eur. Urban Reg. Stud.*, vol. 24, no. 1, pp. 69–86, Jan. 2017, doi: 10.1177/0969776415596449.

[12] M. Stevens *et al.*, “A comprehensive urban programme to reduce energy poverty and its effects on health and wellbeing of citizens in six European countries: study protocol of a controlled trial,” *BMC Public Health*, vol. 22, no. 1, p. 1578, Aug. 2022, doi: 10.1186/s12889-022-13968-2.

[13] “EPOV Member State Report - Hungary,” *Energy Poverty Advisory Hub*, 2020. https://energy-poverty.ec.europa.eu/discover/practices-and-policies-toolkit/publications/epov-member-state-report-hungary_en (accessed Feb. 26, 2023).

[14] Z. Morvaj, L. Lugari, and B. Morvaj, “Smart Energy Cities - Transition Towards a Low Carbon Society,” in *Energy Efficiency - A Bridge to Low Carbon Economy*, Z. Morvaj, Ed. InTech, 2012. doi: 10.5772/39512.

[15] Z. Nagy, T. S. Szép, and D. Szendi, “Regional Inequalities in Residential Energy Use of Hungarian Urban Areas,” *Trends Econ. Manag.*, vol. 13, no. 33, p. 59, Jun. 2019, doi: 10.13164/trends.2019.33.59.

[16] M. Kashour, “How natural gas and electricity prices influence the consumption patterns of European households’ energy,” presented at the Conference of Hantos Elemér Business and Regional Sciences Doctoral School, University of Miskolc, Faculty of Economics, Jan. 2023.

[17] M. Kashour, “Interlinkages between human development, residential energy consumption, and energy efficiency for the EU-27 Member States, 2010-2018,” *Reg. Stat.*, vol. 13, no. 1, pp. 36–54, 2023, doi: 10.15196/RS130102.