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Energy Accessibility: Strategies for Equitable Energy Access in Georgia



Abstract: - Energy accessibility is a crucial issue that impacts the lives of individuals and communities across the globe. Access to affordable and reliable energy is crucial for economic and social development. While global access to electricity has increased, disparities persist between urban and rural areas, particularly in developing nations. This paper examines energy accessibility in Georgia, analyzing the relationship between household income, energy expenditure, and perceived challenges related to electricity access. Despite Georgia's progress in electrification, research reveals that high electricity tariffs significantly impact Georgian households, particularly those with lower incomes. This study employed a mixed-methods approach, combining analysis of global energy consumption trends with data from a field study involving 1200 households across Georgia. The study highlights that a considerable proportion of households, especially in lower income brackets, are forced to reduce energy consumption or adopt energy-saving measures to manage costs. For instance, 77.8% of respondents identified electricity tariffs as a major challenge, with 786 resorting to energy-saving lamps and 598 reducing energy use. This situation underscores the need for targeted strategies to mitigate the financial burden of energy on vulnerable populations and promote equitable energy access in Georgia.

Keywords: energy accessibility, energy poverty, energy affordability, Georgia, energy equity.

I. INTRODUCTION

Access to affordable and reliable energy is a fundamental prerequisite for sustainable economic and social development. Unfortunately, many regions in Georgia continue to face significant challenges in providing equitable energy access to all citizens.

This paper examines the issue of energy accessibility in Georgia and explores strategies to promote more equitable energy access. According to the International Energy Agency, approximately 789 million people worldwide lacked access to electricity in 2020 [1]. The majority of these individuals reside in sub-Saharan Africa and developing Asia, with rural populations disproportionately affected. Georgia has made significant strides in improving overall energy access in recent decades. The country's electrification rate reached 100% in 2020 [2]. However, this aggregate figure masks persistent disparities in energy access, with rural and low-income areas continuing to experience higher rates of energy poverty [3].

One of the primary challenges to energy accessibility in Georgia is the uneven distribution of energy resources and infrastructure. Rural areas, in particular, often lack the necessary grid connectivity and suffer from higher energy costs and lower reliability. Furthermore, potential consumers in remote areas may have limited awareness and knowledge of modern energy technologies and their benefits [4],[5]. Additionally, potential consumers in remote areas may have limited awareness and knowledge of modern energy technologies and their benefits [6].

To address these challenges, a multifaceted approach is required that combines targeted infrastructure investments, innovative financing mechanisms, and public awareness campaigns [7]. One key strategy for enhancing energy accessibility is the deployment of renewable energy technologies, particularly solar photovoltaic systems. Solar power offers a decentralized, sustainable, and cost-effective solution for providing electricity to remote and marginalized communities. Several interconnected factors contribute to the complexity of energy accessibility in

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Georgia. Policymakers should prioritize grid extension and decentralized renewable energy solutions to reach unserved communities. Subsidies, low-interest loans, and pay-as-you-go models can help improve affordability [8]. Furthermore, public education and capacity-building initiatives can empower local communities to understand and adopt clean energy technologies [9].

Overall, achieving equitable energy access in Georgia will require a comprehensive and coordinated effort involving the government, private sector, and civil society. By leveraging renewable energy solutions and addressing the socioeconomic barriers to access, Georgia can ensure that the benefits of modern energy services are more equitably distributed across all regions and populations.

II. LITERATURE REVIEW:

The issue of energy accessibility is a global challenge that has received significant attention in the academic literature. Several studies have examined the relationship between energy access, economic development, and social well-being.

One study on energy access and sustainable development [10], highlights the critical role of decentralized energy solutions, such as solar photovoltaic systems, in addressing the needs of underserved communities.

Several studies have explored the relationship between energy access, economic development, and social well-being. One study on energy access and sustainable development highlights the critical role of decentralized energy solutions, such as solar photovoltaic systems, in addressing the needs of underserved communities [11].

The authors argue that off-grid renewable energy technologies can provide cost-effective and reliable electricity to remote areas, thereby catalyzing economic and social progress [4]. Another study on the potential of solar power in Ghana emphasizes the importance of addressing affordability and awareness barriers to promote more equitable energy access [2].

In the case of Georgia, the existing research suggests that a multifaceted approach is needed to address the complex and interconnected challenges of energy accessibility [12]. By leveraging renewable energy solutions and addressing the socioeconomic barriers to access, Georgia can work towards a more equitable and sustainable energy future. The challenges of energy accessibility in Georgia are not unique to the country but rather reflect a broader global concern. A review of the existing literature on energy access in developing countries provides valuable insights for the Georgian context [13].

Several studies have examined the multifaceted barriers to energy access, including infrastructure gaps, affordability constraints, and awareness/knowledge barriers [14].

In summary, the existing literature underscores the multifaceted nature of the energy accessibility challenge and the need for a comprehensive, context-specific approach to addressing it. By leveraging renewable energy solutions and addressing the socioeconomic barriers to access, Georgia can work towards more equitable energy distribution and improved social and economic outcomes.

III. METHODOLOGY

This study investigates energy accessibility in Georgia through a mixed-methods approach, integrating quantitative and qualitative data to provide a comprehensive understanding. Secondary data analysis underpins the quantitative approach, focusing on **energy availability indicators and descriptive statistics**.

To complement secondary data analysis and gain deeper insights into factors influencing energy accessibility, a large-scale survey was conducted. A structured questionnaire, ensuring anonymity and confidentiality, was developed to gather data on **household energy access, socioeconomic factors, Perceptions and Attitudes**, Perceptions of energy security and satisfaction with energy services.

A representative sample of 1,200 respondents was selected from all regions of Georgia using a stratified random sampling method, ensuring proportional representation across urban and rural areas and different income levels. Data were collected through both online questionnaires and face-to-face interviews. Collected survey data were processed and analyzed using SPSS software. Frequency distributions and cross-tabulations were used to examine the relationships between energy access, socioeconomic factors, and perceptions. Chi-square tests and t-tests were employed to determine the statistical significance of observed relationships.

To provide further context and depth to the quantitative findings, qualitative data were collected through **semi-structured Interviews and thematic analysis**. In-depth interviews were conducted with three key stakeholders: a government official responsible for energy policy, a researcher specializing in renewable energy in Georgia, and a resident from a rural community facing energy access challenges. Thematic analysis, involving the systematic

coding and categorization of data, was employed to identify recurring themes and patterns within the interview transcripts, interpreting the findings in relation to the research questions.

Findings from the quantitative and qualitative analyses will be triangulated to provide a comprehensive understanding of energy accessibility in Georgia. Qualitative data will be used to contextualize and provide nuanced insights into the quantitative results.

IV. FACTORS AND TRENDS AFFECTING ENERGY ACCESSIBILITY

Energy accessibility stands as a critical global challenge. In 2023, 746 million people lacked access to electricity, with hundreds of millions more facing energy scarcity². This challenge is compounded by the global effort to transition towards a secure and affordable energy infrastructure while reducing reliance on fossil fuels. Despite their detrimental environmental impact and contribution to air pollution, fossil fuels retain a significant share in electricity production (see Table I). Globally, coal dominates electricity production at 10,467.93 terawatt-hours, followed by gas at 6,622.93 TWh. Hydropower (4,211.01 TWh), nuclear (2,685.74 TWh), wind (2,304.44 TWh), solar (1,629.90 TWh), oil (788.55 TWh), and bioenergy (678.74 TWh) constitute the remaining share.

Table I: Electricity production by sources in the world 2010-2023 (terawatt-ours)

	gas	hydropower	wind	oil	coal	nuclear	solar	bio energy	Other renewables
2023	6,622.93	4,211.01	2,304.44	788.55	10,467.93	2,685.74	1,629.90	678.74	89.81
2020	6,332.21	4,344.05	1,590.68	773.00	9,417.44	2,648.37	853.37	609.27	86.43
2015	5,553.96	3,884.00	829.57	1,118.41	9,281.27	2,532.93	256.00	476.55	73.10
2010	4,816.71	3,428.38	345.92	1,069.20	8,459.82	2,725.91	32.20	325.41	59.72

Source: <https://ourworldindata.org/electricity-mix>

In Georgia, electricity production relies on gas, hydro resources, and wind (see Table II). Hydropower leads with a 75.8% share, followed by gas at 23.6%, and a minor contribution from wind at 0.6%.

Table II: Electricity production by sources in Georgia 2010-2023 (terawatt-ours)

	electricity generated by gas	electricity generated by hydropower	electricity generated by wind	electricity generated by oil
2023	3.44	10.85	0.09	-
2020	2.82	8.25	0.09	-
2015	2.38	8.37	-	-
2010	0.65	9.27	-	0,03

Source: <https://ourworldindata.org/electricity-mix>

Energy accessibility, often measured by per capita energy consumption, varies significantly across regions and income levels. GDP per capita is a key determinant of energy accessibility. Generally, countries with higher GDP per capita tend to have higher per capita energy consumption (see table III). For instance, the United States, with a GDP per capita of US\$48,866.60, exemplifies this trend. Its per capita energy consumption surpasses Brazil's by 4.3 times, India's by 11 times, and Georgia's by 4 times. Notably, India's GDP per capita is 12 times lower than the USA's, while Georgia's is 6 times lower.

Table III: Primary Energy Use Per Person (kWh)

²<https://www.statista.com/statistics/829803/number-of-people-without-access-to-electricity-by-region/>

Countries	GDP per capita 2023 (current US\$) ³	Household electricity prices worldwide 2023, (in U.S. dollars per kilowatt-hour) ⁴	Primary Energy Use Per Person (kWh)			
			2010	2015	2020	2023
Brazil	10 043.62	0.15	16,221	17,140	15,921	17,806
China	12 614.06	0.08	21,552	25,210	29,120	33,267
France	44 460.82	0.28	48,062	44,229	37,859	37,164
Georgia	8 120.36	0,09	14,790	18,088	18,697	18,898
Germany	52 745.76	0.4	47,306	46,067	41,329	38,052
India	2 484.85	0.08	5,039	5,994	6,322	7,586
South Africa	6 253.16	0.18	28,271	25,372	23,688	22,314
United Kingdom	81 695.19	0.4	39,533	34,977	29,395	28,501
United States	48 866.60	0.16	83,403	79,319	73,294	77,028
World	13138.33	-	20,250	20,472	20,108	21,394

Source: <https://ourworldindata.org/energy>

Historically, developed countries have exhibited higher per capita energy consumption compared to developing countries. However, recent trends indicate a decrease in developed countries and an increase in developing countries.

Within countries, household income significantly shapes energy accessibility. High-income households typically display higher energy consumption, while low-income households often experience limitations. Energy tariffs can significantly impact affordability, particularly for low-income households. Government subsidy programs, targeting high tariffs or vulnerable populations, can help mitigate these disparities and improve energy access. The United Kingdom and Germany, for example, have relatively high electricity tariffs at US\$0.4. However, their high GDP per capita helps offset the burden on their populations, ensuring access to sufficient energy. Conversely, India's seemingly low electricity tariff of US\$0.08, coupled with a significantly lower GDP per capita, places a considerable strain on its population and limits energy accessibility.

A population survey in Georgia revealed that 52% and 66% of respondents cited tariffs as a major factor affecting the availability of sufficient electricity and natural gas, respectively (see Figure 1). This highlights the importance of addressing affordability barriers to enhance energy access in Georgia.

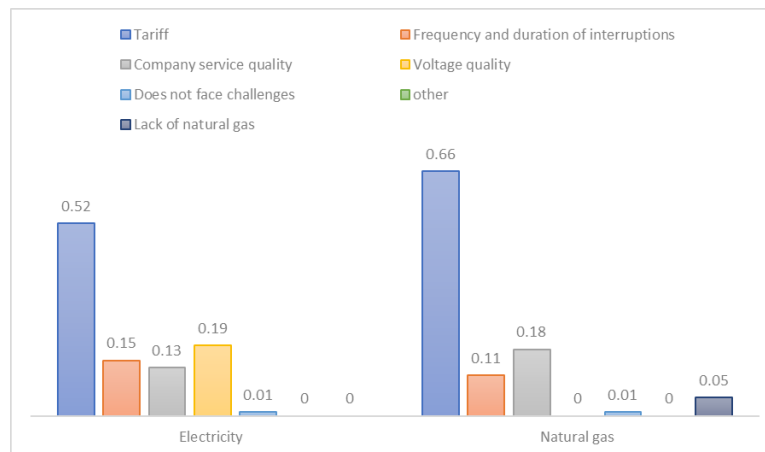


Fig 1. Factors influencing the availability of electricity and natural resources in Georgia (%) source: authors

³https://databank.worldbank.org/reports.aspx?source=2&series=NY.GDP.PCAP.CD&country=&_gl=1*1xhuuqd*_gcl_au*MTMxMTMwMDMyMS4xNzI0MDk0NDM4#

⁴<https://www.statista.com/statistics/263492/electricity-prices-in-selected-countries/>

Energy accessibility also varies geographically within countries. Urban areas generally experience higher per capita energy consumption compared to rural areas. This disparity often stems from differences in infrastructure development, economic activities, and population density.

Energy accessibility is a multifaceted issue influenced by a complex interplay of global trends, national policies, and socioeconomic factors. Addressing this challenge requires a comprehensive approach that considers economic development, affordability, infrastructure development, and public awareness. By understanding these factors and implementing targeted interventions, nations can strive towards a future where energy access is equitable and sustainable for all.

V. ENERGY ACCESSIBILITY SURVEY IN GEORGIA

During the research process of energy availability in Georgia, the following findings were identified: **H1: Monthly household income has a significant effect on the consumption of electricity and natural gas in Georgia, as measured by monthly energy bills, during both winter and summer months.**

To examine the relationship between monthly household income and energy consumption, we conducted a cross-tabulation analysis and employed the chi-square test. The results of this analysis are presented in Tables 1 and 2. Table 1 displays the frequency distribution of monthly energy bill ranges (e.g., "0-50 GEL," "51-100 GEL") across different monthly household income categories. For instance, during the winter months, the most common electricity bill range for low-income families was "0-50 GEL" (53.2%), while high-income families most frequently reported bills in the "51-100 GEL" range (42.3%).

Table 1: Monthly household incomes impact on energy consumption

		Q11 Monthly family income (column %)				
		0-1000	1001-2000	2001 - 5000	5001 - 10000	> 10000
Q12 Bill of electricity consumed in winter	0-50	53.2%	48.6%	31.5%	24.4%	26.9%
	51-100	34.0%	36.0%	39.2%	42.3%	19.2%
	101-200	10.6%	10.7%	20.9%	17.9%	19.2%
	201-300	1.8%	4.7%	6.9%	14.1%	19.2%
	> 300	0.4%	0.0%	1.5%	1.3%	15.4%
Q13 Bill of electricity consumed in summer	0-50	73.8%	67.5%	54.4%	44.9%	30.8%
	51-100	20.2%	26.4%	33.5%	39.7%	23.1%
	101-200	4.6%	4.7%	11.6%	15.4%	23.1%
	201-300	1.4%	0.9%	0.2%	0.0%	7.7%
	>300	0.0%	0.5%	0.2%	0.0%	15.4%
Q14 bill for natural gas consumed in winter	0-50	28.4%	16.0%	9.6%	10.1%	3.8%
	51-100	31.6%	22.5%	20.4%	19.1%	11.5%
	101-200	30.5%	46.0%	40.9%	36.2%	42.3%
	201-300	8.5%	8.3%	19.2%	23.1%	7.7%
	>300	1.1%	7.2%	9.9%	11.5%	34.6%
Q15 Bill for natural gas consumed in summer	0-50	70.6%	70.8%	59.6%	55.1%	50.0%
	51-100	22.7%	24.3%	32.5%	34.6%	23.1%
	101-200	6.4%	4.0%	6.9%	7.7%	11.5%
	201-300	0.4%	0.5%	0.7%	2.6%	3.8%
	>300	0.0%	0.5%	0.2%	0.0%	11.5%

Source: authors

As shown in Table 2, there is a statistically significant relationship ($p < 0.01$) between monthly household income and energy bills. The strength of this association is indicated by the chi-square values. The strongest relationship was observed for summer electricity bills (Q13, Chi-square=182.792), followed by winter electricity bills (Q12, Chi-square=142.979), winter natural gas bills (Q14, Chi-square=86.609), and finally, summer natural gas bills (Q15, Chi-square=96.678). As a result, the truth of H1 was confirmed.

Table 2: Pearson Chi-Square Tests

	Q11 Monthly family income	
Q12 Bill of electricity consumed in winter	Chi-square	142.979
	df	16
	Sig.	.000

Q13 Bill of electricity consumed in summer	Chi-square	182.792
	df	16
	Sig.	.000
Q14 bill for natural gas consumed in winter	Chi-square	137.308
	df	16
	Sig.	.000
Q15.bill for natural gas consumed in summer	Chi-square	96.678
	df	16
	Sig.	.000

Source: authors

H2: Region of residence significantly affects energy consumption in Georgia.

To test this hypothesis, we again employed cross-tabulation analysis and the chi-square test. The results are presented in Tables 3 and 4.

Table 3 reveals that higher frequencies of both electricity and natural gas charges were observed in Tbilisi compared to other regions, across all income categories and in both winter and summer.

Table 3: Influence of the region/city on the bill for consumed energy

category	Q3 Region	Q3 Region										
		1 Tbilisi	2 Achara	3 Guria	4 Imereti	5 kacheti	6 Mtskheta-Mtianeti	7 Racha-Lechkhumi and kvemo kartli	8 samegrelo-Semoplisti	9 Imereti	10 Kvemo Kartli	11 Shida Kartli
Q12 Bill of electricity consumed in winter	0-50	19.3%	6.8%	9.0%	12.1%	16.2%	6.6%	5.7%	9.2%	5.3%	4.1%	5.7%
	51-100	25.3%	7.6%	1.3%	10.3%	11.9%	3.8%	7.6%	11.9%	6.0%	7.6%	6.7%
	101-200	40.0%	5.0%	1.7%	7.8%	8.3%	8.3%	2.8%	11.1%	4.4%	6.1%	4.4%
	201-300	36.2%	8.7%	1.4%	8.7%	7.2%	11.6%	4.3%	7.2%	4.3%	5.8%	4.3%
	> 300	25.0%	8.3%	0.0%	0.0%	16.7%	0.0%	0.0%	25.0%	8.3%	16.7%	0.0%
Q13 Bill of electricity consumed in summer	0-50	22.3%	6.3%	7.1%	10.5%	14.8%	5.9%	6.6%	9.1%	6.4%	5.7%	5.3%
	2 51-100	31.5%	5.8%	.6%	11.4%	11.1%	6.1%	3.8%	12.2%	3.8%	6.7%	7.0%
	3 101-200	31.6%	10.2%	0.0%	9.2%	7.1%	7.1%	8.2%	15.3%	1.0%	4.1%	6.1%
	4 201-300	18.2%	36.4%	0.0%	0.0%	0.0%	9.1%	0.0%	0.0%	18.2%	18.2%	0.0%
	5 > 300	14.3%	42.9%	0.0%	0.0%	0.0%	0.0%	0.0%	28.6%	14.3%	0.0%	0.0%
Q14 Bill of natural gas in winter	1 0-50	12.4%	13.9%	15.4%	9.0%	8.5%	3.5%	13.4%	13.4%	5.5%	3.0%	2.0%
	2 51-100	25.0%	8.4%	3.2%	11.7%	9.7%	1.3%	5.2%	17.5%	6.2%	4.9%	6.8%
	3 101-200	32.7%	5.1%	3.3%	11.3%	14.1%	4.9%	3.8%	7.5%	3.5%	7.3%	6.6%
	4 201-300	27.1%	3.0%	0.0%	8.4%	18.7%	14.5%	3.0%	4.8%	7.8%	5.4%	7.2%
	<5 300-	18.5%	3.3%	0.0%	9.8%	17.4%	18.5%	6.5%	5.4%	7.6%	9.8%	3.3%
Q15 Bill of natural gas in summer	1 0-50	24.1%	6.8%	6.6%	11.4%	13.9%	4.3%	6.9%	10.5%	5.0%	5.5%	5.1%
	2 51-100	27.3%	6.0%	.6%	9.3%	12.6%	8.7%	4.2%	11.7%	6.3%	6.9%	6.3%
	3 101-200	34.7%	11.1%	1.4%	6.9%	6.9%	11.1%	2.8%	2.8%	4.2%	6.9%	11.1%
	4 201-300	22.2%	22.2%	0.0%	11.1%	0.0%	33.3%	0.0%	11.1%	0.0%	0.0%	0.0%
	< 300	16.7%	16.7%	0.0%	0.0%	0.0%	0.0%	0.0%	33.3%	33.3%	0.0%	0.0%

Source: authors

Table 4 confirms a statistically significant relationship ($p < 0.01$) between region of residence and energy bills. The strongest association was found for winter natural gas bills (Q14, Chi-square=258.649).

Table 4: Pearson Chi-Square Tests

		Q3 Region
Q12 Bill of electricity consumed in winter	Chi-square	109.221
	df	40
	Sig.	.000*, b,c
Q13 Bill of electricity consumed in summer	Chi-square	108.373

	df	40
	Sig.	.000*, b,c
Q14 Bill of natural gas in winter	Chi-square	258.649
	df	40
	Sig.	.000*
Q15 Bill of natural gas in summer	Chi-square	90.097
	df	40
	Sig.	.000*, b,c

Source: authors

These findings support our hypothesis, indicating that energy consumption patterns differ significantly between Tbilisi and other regions of Georgia. Specifically, energy availability, as reflected in higher consumption levels, appears to be greater in Tbilisi.

H3: Government tax subsidy programs significantly affect energy affordability in Georgia.

To investigate this hypothesis, we again utilized cross-tabulation analysis and the chi-square test. The results are presented in Tables 5 and 6.

Table 5: Impact of state subsidy programs on energy availability

		\$Q26. government tax subsidy programs					
		Q26.1 Tax subsidy by the state	Q26.2 Partial tax subsidy by the state	Q26.3 Semek's help	Q26.4 City hall assistance	Q26.5 Tax allocation	Q26.6 Exemption from tax
Q12 Bill of electricity consumed in winter	0-50	39.5%	32.3%	20.0%	45.2%	40.6%	14.3%
	51-100	40.7%	44.6%	60.0%	38.1%	31.3%	42.9%
	101-200	12.8%	13.8%	10.0%	11.9%	12.5%	14.3%
	201-300	5.8%	6.2%	10.0%	2.4%	6.3%	14.3%
	300>	1.2%	3.1%	0.0%	2.4%	9.4%	14.3%
Q13 Bill of electricity consumed in summer	0-50	64.0%	63.1%	70.0%	69.0%	65.6%	57.1%
	51-100	22.1%	21.5%	10.0%	23.8%	18.8%	14.3%
	101-200	10.5%	9.2%	20.0%	4.8%	3.1%	14.3%
	201-300	2.3%	3.1%	0.0%	0.0%	6.3%	0.0%
	300>	1.2%	3.1%	0.0%	2.4%	6.3%	14.3%
Q14 Bill of natural gas in winter	0-50	15.1%	20.0%	10.0%	31.0%	25.0%	42.9%
	51-100	34.9%	23.1%	20.0%	26.2%	21.9%	14.3%
	101-200	29.1%	27.7%	50.0%	31.0%	31.3%	14.3%
	201-300	10.5%	16.9%	10.0%	7.1%	9.4%	14.3%
	300->	10.5%	12.3%	10.0%	4.8%	12.5%	14.3%
Q15 Bill of natural gas in summer	0-50	69.8%	61.5%	70.0%	76.2%	68.8%	57.1%
	51-100	20.9%	23.1%	20.0%	21.4%	15.6%	14.3%
	101-200	8.1%	10.8%	10.0%	0.0%	9.4%	14.3%
	201-300	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%
	300>	1.2%	3.1%	0.0%	2.4%	6.3%	14.3%

Source: authors

Table 6 demonstrates a statistically significant relationship ($p < 0.01$) between government tax subsidy programs (Q26) and energy bills. The strongest association was observed for summer natural gas bills (Chi-square=99.925), followed by summer electricity bills (Q13, Chi-square=96.684), winter natural gas bills (Q14, Chi-square=86.609), and lastly, winter electricity bills (Q12, Chi-square=60.447).

Table 6: Pearson Chi-Square Tests

		\$Q26
Q12 Bill of electricity consumed in winter	Chi-square	60.447
	df	32
	Sig.	.002
Q13 Bill of electricity consumed in summer	Chi-square	96.684
	df	32
	Sig.	.000
Q14 Bill of natural gas in winter	Chi-square	86.609
	df	32

	Sig.	.000
Q15 Bill of natural gas in summer	Chi-square	99.925
	df	32
	Sig.	.000

Source: authors

H4: Region of residence significantly affects the energy efficiency of housing in Georgia.

To test this hypothesis, we again employed cross-tabulation analysis and the chi-square test. The results are presented in Tables 7 and 8.

Table 7 displays the frequency distribution of housing energy efficiency by region. Notably, the highest frequency of energy-efficient housing (91.10%) is found in Tbilisi.

Table 7: Influence of the region on the energy efficiency of housing
Q7 residential energy efficiency

Q3 region		1 yes	3 not
	1 Tbilisi	91.10%	8.9%
	2 Achara	89.40%	10.6%
	3 Guria	76.30%	23.7%
	4 Imereti	68.80%	31.3%
	5 Kakheti	74.70%	25.3%
	6 Mtskheta-Mtianeti	79.70%	20.3%
	7 Racha-Lechkhumi and Kvemo Svaneti	66.20%	33.8%
	8 Samegrelo-Zemo Svaneti	72.70%	27.3%
	9 Samtskhe-Javakheti	77.30%	22.7%
	10 Kvemo Kartli	77.80%	22.2%
	11 Shida Kartli	77.20%	22.9%

Source: authors

Table 8 confirms a statistically significant relationship ($p < 0.01$) between region of residence and housing energy efficiency, as evidenced by the high chi-square value (57.603). This finding supports our hypothesis, indicating that the energy efficiency of housing varies significantly depending on the region in Georgia.

Table 8: Pearson Chi-Square Tests

		Q7 residential energy efficiency
Q3 regions	Chi-square	57.603
	df	20
	Sig.	.000*

Source: authors

H5: Energy affordability and housing energy efficiency are positively correlated with household income.

To examine this hypothesis, we used Spearman's rank correlation coefficient due to the non-parametric nature of our data. Our analysis revealed a strong positive correlation between household income and housing energy efficiency ($\rho = 0.829, p < 0.01$). This suggests that higher-income households in Georgia tend to have more energy-efficient homes (see table 9).

Table 9: Spearman's rho

			housing energy efficiency	Monthly family income
Spearman's rho	housing energy efficiency	Correlation Coefficient	1.000	.829
		Sig. (2-tailed)	.	.000
		N	1220	1220
	Monthly family income	Correlation Coefficient	.829	1.000
		Sig. (2-tailed)	.000	.
		N	1220	1220

Source: authors

Furthermore, we found a strong positive correlation between housing energy efficiency and energy affordability. Specifically, higher energy efficiency was associated with lower summer electricity bills ($\rho = 0.929, p < 0.01$) and lower winter natural gas consumption ($\rho = 0.940, p < 0.01$) (see table 10).

Table 10: Impact of income and energy efficiency of housing on energy availability.

		housing energy efficiency	Bill of electricity consumed in winter	Bill of electricity consumed in summer	Bill of natural gas consumed in summer	Bill of electricity consumed in summer
housing energy efficiency	Correlation Coefficient	1.000	.492	.929	.940	.790
	Sig. (2-tailed)		.000	.000	.000	.000
	N	1220	1220	1220	1220	1220
Bill of electricity consumed in winter	Correlation Coefficient	.492	1.000	.602	.374	.408
	Sig. (2-tailed)	.000		.000	.000	.000
	N	1220	1220	1220	1220	1220
Bill of electricity consumed in summer	Correlation Coefficient	.929	.602	1.000	.293	.492
	Sig. (2-tailed)	.000	.000		.000	.000
	N	1220	1220	1220	1220	1220
Bill of natural gas consumed in winter	Correlation Coefficient	.940	.374	.293	1.000	.407
	Sig. (2-tailed)	.000	.000	.000		.000
	N	1220	1220	1220	1220	1220
Bill of natural gas consumed in summer	Correlation Coefficient	.790	.408	.492	.407	1.000
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	1220	1220	1220	1220	1220

** . Correlation is significant at the 0.01 level (2-tailed).

Source: authors

These findings indicate that energy-efficient homes are associated with reduced energy consumption, leading to lower energy bills for residents, particularly during periods of high energy demand (summer and winter).

Our research on energy consumption patterns in Georgia yielded several important insights:

- **Income and Energy Consumption:** A strong positive correlation exists between household income and energy consumption. While higher-income households tend to consume more energy overall, this relationship is nuanced.
- **Urban-Rural Disparities:** Energy consumption is significantly higher in urban areas, particularly in Tbilisi, compared to other regions of Georgia. This difference likely stems from factors such as higher population density, greater economic activity, and variations in housing stock.
- **Impact of Subsidy Programs:** Government subsidy programs appear to have a positive effect on energy affordability, potentially leading to increased energy consumption. Further investigation is needed to fully understand the relationship between subsidies, affordability, and consumption patterns.
- **Energy Efficiency and Location:** Energy-efficient dwellings are more prevalent in urban areas, especially Tbilisi, compared to other regions. This difference could be attributed to factors like stricter building codes, greater awareness of energy efficiency, and more opportunities for retrofitting existing buildings.
- **Interplay of Income, Efficiency, and Consumption:** Higher-income households are more likely to reside in energy-efficient housing, which can offset their higher overall energy consumption. This finding highlights the complex interplay between income, housing choices, and energy use patterns.

VI. CONCLUSION

This study underscores the multifaceted nature of energy accessibility in Georgia, revealing a complex interplay between global trends, national policies, and socioeconomic factors. Our findings highlight that while Georgia benefits from a relatively clean energy mix led by hydropower, ensuring equitable access to affordable and sustainable energy remains a critical challenge.

The strong correlation between income and energy consumption, coupled with significant urban-rural disparities, underscores the need for targeted interventions. While higher-income households tend towards greater energy use, their adoption of energy-efficient housing mitigates this impact. This suggests that promoting energy efficiency,

particularly in existing building stock across all regions, is crucial. Furthermore, the concentration of energy-efficient dwellings in urban areas like Tbilisi highlights the need for policies that incentivize similar upgrades in other regions, ensuring a more geographically balanced approach to energy efficiency.

The positive impact of government subsidy programs on energy affordability is promising, though further research is needed to understand its full implications on consumption patterns. This underscores the importance of designing well-structured subsidy programs that balance affordability with responsible consumption.

Addressing energy accessibility in Georgia requires a multi-pronged approach. Prioritizing policies that:

- **Promote energy efficiency:** Incentivize energy efficiency upgrades, particularly in existing buildings and across all regions, not just urban centers.
- **Ensure affordability:** Develop targeted subsidy programs that consider regional disparities and income levels, ensuring equitable access to affordable energy.
- **Invest in infrastructure:** Address infrastructure gaps between urban and rural areas to ensure reliable energy access for all.
- **Raise public awareness:** Promote energy conservation and educate the public about energy efficiency measures and available support programs.

By understanding the complex interplay of factors influencing energy accessibility and implementing targeted interventions, Georgia can move towards a future where sustainable and affordable energy is a reality for all its citizens.

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