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Affordability of Electricity to Rural Consumers in Tanzania: An Elephant in the Room?

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Abstract: Affordability of electricity in rural areas has received negligible concern, yet with equivocal information. Thus, this paper extrapolates this disregarded aspect by raising empirical debates on the affordability of electricity connection and consumption while also predicting the factors of domestic electrical appliances among rural consumers. Affordability of electricity connection was measured by a catastrophic approach through the index of utility Price Income Ratio (PIR) at a threshold of 10%. Consumption affordability was estimated through PIR at a 5% share of household income, coupled with a monthly basic electricity consumption of 30 kWh per household. A multiple regression model was adopted to determine electrical appliance ownership in the household. The paper reveals that electricity connection was not affordable to consumers in the lowest income quintile (61.76%), who spent up to 33% of their income. On consumption, electricity was affordable as consumers spent no more than 5% of their household income. Moreover, the paper explains that electricity affordability and the desire for wellbeing motivate consumers to use domestic electrical appliances. Measuring the affordability of energy has a paucity in the energy literature. Thus, the paper provides insight into the present debate regarding affordability measures. Although the paper uniquely uncovers the affordability of electricity connection and consumption as prime factors for policy consideration, energy policy should also consider that affordability does not end at connection; rather, it extends to consumption. Energy policy must prioritise free technical services for rural power connection and subsidise consumption costs for the economically disadvantaged.

Keywords: Rural electricity, electricity connection, consumption affordability, appliances, Tanzania.

1. Introduction

The affordability of electricity, which is considered a top-tier energy source, has been and continues to be crucial for social and economic development for many years (Muhihi, 2024). Affordable electricity has the potential to greatly improve the lives and livelihoods of rural communities by enabling the use of various electrical appliances (Richmond & Urpelainen, 2019). The affordability of electricity not only determines the amount of power consumed at the household level (Trotter, 2019) but also influences the types of electrical appliances that can be utilised. However, it is important to note that affordability does not simply mean low-cost or cheap; rather, it refers to the ability to pay for the necessary level of consumption or connection within normal spending patterns (Trotter, 2019; Bos et al., 2018). The demand for electricity is increasing at the household level due to its importance in providing lighting, powering small businesses, facilitating study time for school children, and operating entertainment appliances (Grimm et al., 2017; Muhihi & Lusambo, 2022a). However, information regarding electricity affordability, especially for rural consumers, is limited.

In 2012, affordability was recognised as essential to achieving Sustainable Development Goal Number Seven (SDG7), which focuses on access to affordable, reliable, and sustainable modern

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energy for all (United Nations, 2016). Okere et al. (2023) highlighted that the affordability of electricity poses a challenge for many developing countries. For example, in the Lao People's Democratic Republic, 20%−40% of households were unable to afford a connection charge of $100 (Oum, 2019). Therefore, if universal access to electricity is to be achieved, affordability is undoubtedly a critical concern (Okere et al., 2023). As rural electrification efforts increase to promote access to clean energy (Odarno et al., 2017), it is imperative to make electricity accessible and affordable in order to alleviate fuel poverty (Garba & Bellingham, 2021).

The strategy to alleviate electricity poverty requires significant effort due to the staggering number of people worldwide who lack access to electricity. According to the International Energy Agency (2019a), approximately 1.3 billion people are in this situation. In Sub-Saharan Africa alone, there are 573 million individuals without electricity (International Energy Agency, 2019b). The region's poverty exacerbates the issue, making it crucial to improve the affordability and reliability of electricity (Taneja, 2018). Halbrügge et al. (2023) argue that the cost of electricity directly impacts access and consumption rates, emphasising the importance of affordable energy for both higher and lower-income earners. For example, the global access rate for urban areas is around 90% for those with higher incomes, while rural areas lag behind at 70% (Curtis et al., 2018). This disparity is also influenced by differences in electricity generation, transmission, and distribution (Kojima et al., 2016).

While urban areas can manage the costs of connection and electricity consumption, rural consumers face significant challenges even at lower costs (Kojima & Trimble, 2016). In countries such as South Sudan and Malawi, limited electricity generation leads to extremely low access rates of approximately 5.2% and 1.6%, respectively (World Bank, 2021). Affordability of connection and consumption is a critical concern in these rural areas. Golumbeanu and Barnes (2013) explain that rural consumers can typically only afford monthly bills ranging from USD $3-7. Consequently, the inability to afford electricity consumption can lead to economic strain (Bezerra et al., 2017), forcing individuals to forsake essential electrical appliances like televisions and cookstoves (Batteiger & Rotter, 2018). All of these factors have a detrimental impact on people's overall livelihood strategies (Avordeh et al., 2022).

International Energy Agency (IEA) (2016) and Lusambo (2009) define electricity poverty as the lack of connection or consuming less than 250 kWh and 500 kWh per year for rural and urban consumers, respectively. This situation negatively impacts asset ownership in households, which is essential for consumer wellbeing (Narasimha & Pachuri, 2017; Lee et al., 2016). Additionally, electricity consumers are burdened by high connection costs, particularly in impoverished countries (Young et al., 2017). For instance, in Kenya, the connection cost was 400 USD, while in Tanzania, it was 297 USD. Other countries, such as the Central African Republic and Burkina Faso, experienced connection costs of 283 USD and 264 USD, respectively (World Bank, 2019). These are the highest connection costs among all regions.

In rural areas of Africa, the high connection costs lead to illegal connections and the sharing of meters among consumers (Kojima et al., 2016). Furthermore, the unaffordability of consumption results in some consumers disconnecting from the grid (Grimm et al., 2016). In Bangladesh, more than 13% of rural power consumers were disconnected, with even higher disconnection rates in certain poorer regions, exceeding 20% (Bangladesh Bureau of Statistics, 2018). Those who lack access to electricity due to the unaffordability of connection and consumption are deprived of a fundamental element for socioeconomic development (Groh et al., 2016) and may face limitations in accessing information and community technology (Muhihi & Lusambo, 2022b). In this regard, van de Walle et al. (2017) argued that rural people cannot seize development opportunities without access to electricity, as efficient lighting and appliances are vital components of such opportunities.

The affordability of public utilities is a challenge for both consumers and suppliers (Prokhorov & Dreisbach, 2022). Affordability is closely tied to poverty (Naumzik & Feuerriegel, 2020; Niëns & Brouwer, 2013) and encompasses Out-of-Pocket (OP) expenses. Various affordability indices have been proposed. Haurin (2016), Renne et al. (2016), Deller (2016), and Betraud (2016) suggest using the residual income ratio of utility prices to household disposable income. Rademaekers et al. (2014) propose income expenditure and consensual approaches, while Niëns and Brouwer (2013) discuss catastrophic and impoverishment measures. The catastrophic approach is based on the Price Income Ratio (PIR) index (Kuhe & Bisu, 2020). In this paper, the affordability of connection is measured using a PIR at a 10% threshold (Lusambo, 2009), while a 5% threshold and the basic need of 30 kWh of electricity are used to gauge the affordability of consumption (World Bank, 2016).

To ensure affordability, various countries have implemented measures. For instance, Senegal has significantly reduced connection and upstream network costs, bringing them down from $725 to $99. They have also provided customers with electrical materials to help reduce installation costs. Similarly, Liberia has lowered the cost of connection and upstream network to $950, and Kenya has introduced subsidies to decrease the upfront cost for rural connections, reducing it from $300. Ethiopia offers financing for up to 80% of connection costs and provides installation materials. In Tanzania, upfront costs for single-phase rural customers have been reduced from $270-1957 to $80. Additionally, residential meter rental charges and connection application fees have been waived, while lifeline tariffs have been increased from 50 to 75 kWh (Energy and Water Utilities Regulatory Authority, EWURA, 2018).

Despite these efforts, the clarity regarding affordability remains limited due to methodological options. For example, Golumbeanu and Barnes (2013) used PIR to assess upfront costs and consumption, but they gave less consideration to technical costs as a significant factor, leading to uncertain conclusions. Similarly, Moss (2018), Naumzik and Feuerriegel (2020), and Kyritsis et al. (2017) focused on the affordability of consumption, providing less information on upfront costs and how electricity can impact domestic appliance purchases. Consequently, there are still ambiguous findings regarding affordability. Richmond and Urpelainen (2019) point out that empirical evidence on the relationship between rural electrification, appliance ownership, and usage is still lacking across different contexts. Therefore, this paper argues that electricity affordability should be measured based on connection and consumption. Hence, this paper aims to:

- Assess the affordability of electricity by considering the combined costs of connection and consumption, with a focus on basic electricity usage of 30kWh.
- Determine how electricity affordability and related factors impact the purchase of domestic appliances.

This paper offers a unique contribution to knowledge by addressing the lack of methodology for measuring the affordability of energy in the existing literature. Unlike previous studies (Best & Burke, 2018; Djeunankan et al., 2023; Reboredo & Ugolini, 2018; Halbrügge et al., 2023), this paper emphasises the importance of considering the affordability of electricity connection and consumption as key factors in consumer wellbeing.

1.1 Energy justice theory and the multi-tier framework

Energy Justice Theory (EJuT) and The Multi-Tier Framework (MTF) were adopted as theoretical frameworks for this study. John Rawls propounded EJuT in the 1970s and drew on various social theories, applying them to the energy context (Sari et al., 2017; Qian et al., 2023). EJuT promotes the fair sharing of benefits and burdens related to energy services, as well as the provision of safe, affordable, and sustainable energy (Jenkins et al., 2018). It emphasises the importance of ensuring that electricity is accessible and that the price of access is affordable for all consumer groups, aiming to eliminate injustice (Jenkins et al., 2021). However, EJuT does not specify the level of consumption or the amount of energy that individuals should consume at a given affordability threshold. To address this lack of clarity, the MTF was adopted as a second theoretical framework for this study (see Table 1).

Table 1: *The Multi-Tier Framework for affordability of electricity*

Attribute of access	**Tier 0**	**Tier1**	**Tier2**	**Tier3**	**Tier4**	**Tier5**
Capacity		Capacity from (3W to above 2kWh) and ability to power appliances (off-grid)				
Duration of supply	NA	> 4 hrs	> 4 hrs	> 8 hrs	> 16 hrs	> 22 hrs
Duration-evening		**> 2 hrs**	**> 2 hrs**	**> 4 hrs**	**> 4 hrs**	**> 5 hrs**
Reliability					**Number of the duration of outages**	
Number of Disruption					Max 14/Week	Max 3/ week, duration of < 2 hours Agg*.
Annual SAIFI* and SAIDI*					< 730	< 156
						< 6 240 mins
Quality	**NA**				**Voltage problems do not affect the use of desired appliances.**	
Affordability				Basic service less than five 5% of a household income for 30 kWh		
Legality	**NA**				**Service provided legally**	
Health and Safety					**Absence of accidents**	

Source: Kojima and Trimbe (2016); **NA=Not Available, and mostly lack access to electricity fuel*

MTF was developed by the World Bank in 2011 to promote sustainable energy for all (SE4ALL) (Kojima & Trimbe, 2016). According to the framework, consumers are categorised into different tiers (ranging from Tier 0 to Tier 5), each requiring a specific amount of electricity and corresponding appliances (World Bank, 2016). The framework also suggests that rural consumers should not spend more than 5% of their household income to consume 30 kWh of electricity per month (Kojima et al., 2016). Additionally, it provides information on the appropriate use of electricity within households and specifies the types of appliances suitable for each tier, such as TV, radio, fridge, and metal iron. Both EJuT and MTF offer clear guidelines for assessing energy affordability and consumption levels, emphasising that connection and consumption costs should be fair for all consumers, regardless of their category, and that the amount of power consumed should be sufficient for sustenance (World Bank, 2015).

2. Methodology and Study Areas

The study was conducted in western Tanzania, specifically in the regions of Kigoma and Tabora. These areas, characterised by low socioeconomic status, were chosen as a priority for assessing the affordability of electricity connections and factors related to electrical appliance ownership (the United Republic of Tanzania-URT, 2022). For instance, statistics show that these regions have the lowest level of human development with a GDP per capita of TZS.1 075 268/= and a localised Human Development Index (HDI) of 0.4 (URT, 2017), which is lower than other regions. Additionally, the areas have a higher Multidimensional Poverty Index (MPI) of 56% for Kigoma and 65% for Tabora (URT, 2017).

The study employed a cross-sectional design, which is suitable for examining ratios and relationships between variables (Capili, 2021; Wang & Cheng, 2020). Cross-sectional designs are also appropriate for exploratory studies with causal relationships (Smith, 2020). Rather than measuring willingness to pay, the study took a retrospective approach to assessing affordability (Yevdokimov et al., 2019). The study included 374 households as participants, which was determined using a formula for finite population sampling. Of these households, 2585 were in the Uyui District, and 3475 were in the Kasulu District, resulting in a total population of 6060 households. The sample size was refined using stratified proportionate sampling, resulting in a representative sample of 214 households in the Kasulu District and 160 households in the Uyui District, with a total sample size of 374 households. In quantitative studies like this one, a sample size of 374 households is considered sufficient for drawing valid inferences with a high level of precision and confidence (Johnson et al., 2018). To minimise selection bias, a simple random sampling technique using a random number table was used to select respondents (Nohr & Liew, 2018).

Data collection focused on households' annual and monthly income, as well as expenditures, to establish affordability thresholds. Qualitative information was obtained through seven participants' gender-sensitive focus group discussions (FGDs) (Nyumba et al., 2018). Additionally, interviews were conducted with five key informants from the energy utility sector to enhance the reliability and validation of certain quantitative estimates. In quantitative studies, the inclusion of qualitative data is important for triangulation, as it provides true perspectives and experiences of participants, particularly in studies dealing with complex and multifaceted phenomena like affordability (Creswell & Creswell, 2017). The additional data were manually organised, and key themes relevant to the objectives of the study were extracted and integrated into the interpretation of the quantitative information.

A catastrophic approach using the utility price-income ratio (PIR) index was employed to measure the affordability of electricity connections. The PIR components included technical and material costs to capture an appropriate level of affordability. Consumption affordability was determined through PIR, with a threshold of 5% of households' income, coupled with an assessment of basic electricity consumption at 30 kWh per month for households in different income quintiles (World Bank, 2016). Therefore, respondents were divided into five income quintiles, as in Adam et al. (2013). The equations for affordability are given in (i) and (ii)

$$AEConnect = \frac{UPC+MTC}{ANHAI} \text{x}100 \quad \text{(i)}$$

Where:

AEConnect = Affordability of Electricity Connection

UPC=Upfront cost payable directly to the utility

MTC=Total material and Technical Cost

ANHAI=Aggregate Net Household Annual Income (from various source)

Decisive threshold =10%

$$AEConsumpt = \frac{UP}{ANHIM} x100 \quad \text{(ii)}$$

Where:

AEConsumpt=Affordability of Electricity Consumption

UP=Utility price for the reference month

ANHIM=Aggregate Net Household Income (for the reference month)

*Decisive threshold is 5% and 30 kWh as basic need electricity

Furthermore, three stages were implemented to evaluate the impact of electricity on domestic electrical appliances. Firstly, descriptive statistics were utilised to determine the number of appliances owned by the household both before and after the electricity connection. Richmond and Urpelainen (2019) employed Ordinary Least Squares (OLS) with binary (dummy) measures of the appliance in India. Therefore, a multiple regression model was utilised to assess the predictive effect of electricity and related factors on domestic appliances (equation iii), with appliances treated as count variables.

$$Y_i = \gamma_{0+}\gamma_1 ec_i^{yrs} + \gamma_2 au_i^k + \gamma_3 pc_i + \gamma_4 la_i^{ap} + \gamma_5 wc_i^{ap} + \gamma_6 a_i^{ap} + \gamma_7 sw_i + \gamma_8 h_i^{inc} + \gamma_9 c_i^{ea} + \gamma_i x_i' + \varepsilon_i \text{......(iii)}$$

Where x_i' represents a vector of demographic variables such as gender, age, level of education and the marital status of the household. Y_i is the number of domestic electrical appliances owned by a household. Most variables are operationalised in the following matrix.

Table 1: *Matrix for definition and measurement of variables*

Variable	Definition	Measurement	Source
Years since electricity connection (ec_i^{yrs})	Number of years elapsed after electricity connection at household	Continuous	Munyanyi & Churchill (2022)
Knowledge on the use of appliance (au_i^k)	Ability to safely operate a domestic electrical appliance	Binary 0= has no knowledge on use of electrical appliances, 1=has knowledge on use of the appliance	Raudeliūnienė et al. (2016)
Power connection (pc_i)	Available electricity connection at the household	Binary, 0=not a factor to consider, 1 =a factor to consider	Raudeliūnienė et al. (2016)
Wattage capacity of the appliance (wc_i^{ap})	The measure at which power is used	Continuous	Bezerra et al. (2017); Munyanyi & Churchill (2022)
Loan ability of the appliance (la_i^{ap})	The ability of the sellers to release appliances on promised payment	Binary, 0=non-loanable appliance, 1=Loanable appliance	Mudi et al. (2019).
Appliance being an asset(a_i^{ap})	A resource that is expected to provide benefit in the future	Binary, 0=Not an asset, 1=Asset	World Bank (2017).
Social wellbeng(sw_i)	Useful and healthier interactions that bring happiness and satisfaction	Categorical	Abendroth (2022)
Income of the household (h_i^{inc})	Total amount of cash made by all family members aged 18 and above	Continuous	Cohen et al. (2023)
Affordability of electricity consumption (c_i^{ec})	The ability to pay for necessary levels of electricity consumption is usually not more than 5% of household income.	Continuous	World Bank (2016), Trotter (2019), Bos, Chaplin & Mamun (2018)
Gender of the household head (x_i')	The socially constructed characteristics of males and females	Binary, 0=Female, 1 Male	Reboredo & Ugolini (2018).

Age of the household head (x_i')	The description of how old a head of household at a particular point	Continuous	Petts (2022)
Level of education (x_i')	Number of years spent in formal education system	Continuous	Petts et al. (2022)
Marital status (x_i')	The legally defined marital state	Categorical	Gerlinde (2023)

3. Results and Discussion

3.1 Affordability of electricity connection at the household

To assess the affordability of electricity for rural consumers, a catastrophic approach (CA) was used, using the PIR (index) at a 10% threshold. The assessment of affordability was conducted step by step, first considering utility upfront costs, then material and technical costs, and finally, the aggregate costs of electricity connection. Respondents were categorised into different income quintiles to ensure a precise articulation of the affordability of electricity. Reporting affordability should be done with reference to the specific group of consumers in order to answer the question, "is it affordable or not, and for whom?" In other words, inferences on affordability are most effective when they are compared to the income group of consumers (see Table 2).

Table 2: *Households' share of expenditure on electricity connection*

Income Quintiles (TZS) AHNI		HHMCI	TEEC	Share on UCEC	Share on MTC	ASEC	%
	Median TZS	Mode	Median TZS	% of mean			
Lowest	1,940,000	2	627,000	13	20	33	61.76
Min	1,000,000	1	327,000	.89	9	13	
Max	3,600,000	4	1,152,000	51	33	64	
Lower	5,080,000	3	797,000	6	9	15	28.07
Min	3,620,000	1	407,000	.44	5	7	
Max	6,200,000	6	1,132,000	11	15	25	
Medium	6,940,000	2	915,000	6	6	12	7.75
Min	6,250,000	1	367,000	.34	5	5	
Max	8,600,000	5	1,452,000	14	9	12	
High	10,150,000	2	720,500	3	5	7	1.06
Min	9,060,000	2	627,000	2	4	6	
Max	11,300,000	4	878,000	4	6	9	
Highest	13,100,000	3	768,000	2	3	6	1.33
Min	12,400,000	2	625,000	1	3	5	
Max	13,400,000	4	885,000	3	4	7	Total.100

Notes: AHNI=Annual household net income, HHMCI=Household members contributing income, TEEC=Total expenditure on electricity connection, UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share on electricity connection

Empirical results show that consumers in the lowest income quintile spent 13% of their household income on upfront costs, while material and technical costs accounted for 20%. Overall, household expenditure on these costs was 33%. Consumers in the lower, medium, and higher income quintiles spent less than 10% of their household income on upfront, materials, and technical costs. For consumers in the lowest income quintile, electricity was not affordable due to high connection costs, which accounted for 33% of their income. This level of expenditure is deemed catastrophic and unbearable. These findings indicate that rural consumers continue to face significant challenges in accessing affordable electricity. The financial burden of spending more on electricity also impacts other aspects of their livelihoods. These results are consistent with previous studies in Bangladesh and Brazil, which found that consumers in these countries spend a considerable portion of their income on connection costs. It is evident that unaffordability issues persist in many different countries and regions, and they should not be neglected.

More than 75% of Tanzania's population resides in rural areas, with a majority of them living in poverty. For example, in Kasulu, the per capita income in 2022 was estimated to be TZS 650,000 (URT, 2022). In 2020 and 2022, Kasulu and Uyui had a GDP per capita of TZS 1,075,268 (URT, 2022). Given these figures, it is clear that consumers in these areas struggle to afford connection costs. According to information from EWURA (2018), the subsidised connection fee for consumers within 30 meters of distribution lines was TZS 180,000, while the unsubsidised fee was TZS 385,682. These costs are paid to the utility company. When additional costs, such as materials and technical expenses, are factored in, affordability becomes a major concern. Rural communities are particularly vulnerable to economic shocks, and consumers with low incomes bear the brunt of these costs, affecting their ability to meet basic household expenses.

Based on the Energy Justice theory, electricity should be affordable to all consumers, regardless of their socioeconomic status. Therefore, social inequalities should not hinder individuals from accessing clean energy services. The high connection costs, which impose a significant financial burden, are seen as an "unjust price" according to the principles of energy justice. The rural population relies on agriculture, which is subject to market uncertainties, adverse weather conditions, and poor transportation systems, all of which exacerbate sporadic incomes. When the high costs of electrical materials are taken into account, the burden becomes even greater (URT, 2022). Consequently, the high cost of electricity connections is considered a contributing factor to the transitory poverty experienced by rural communities. For instance, during focus group discussions, participants expressed their concerns about the high connection costs:

…. there are so many costs for connecting electricity, and you must pay them once. The inspection and upfront costs have no excuse, and it worsens as you stay beyond 30 metres from the power distribution line…

This statement indicates that upfront cost changes with distance from power lines. However, being closer does not imply affordability. In fact, it gets worse as a consumer stays further away from the power line. Cost variations are shown as follows: a single-phase customer within 60 metres costs TZS 337,740.00, while within 90 metres costs TZS 454,654.00 (TANESCO, 2016). These costs pose a challenge for low-income earners. The key informants (Transmission engineers) also stated that some consumers were within 30 metres of the power line but failed to pay the connection fee of TZS 27,000.00. The paper analysed affordability for the population by conducting a clarity-based analysis. The empirical analysis (Table 3) provides inferential statistics on affordability for the pooled sample and population statistics.

Table 3: *Affordability of electricity to consumers of different income quintiles*

Income Quintiles	**Sample statistic**				**Inferential statistic for the population (95% CI)**			
	N=374	**Share on UCEC**	**Share on MTC**	**ASEC**	**Share on UCEC**	**Share on MTC**	**ASEC**	**% of N**
Lowest		**Mean of %**			**Mean of %**			
	231	13	20	33	12-14	19-20.7	32-34	61.76

Lower	105	6	9	15	5.5-6.5	9.4-9.8	15-16	28.07
Medium	29	6	6	12	4.9-6.8	5.9-7.1	11-14	7.75
High	4	3	5	7	0.79-4.5	3.3-6.2	5-11	1.06
Highest	5	2	3	6	1.2-3.7	2.9-3.7	5-7	1.33

Notes: UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share on electricity connection

It is stated that the aggregated connection cost for the population in the lowest quintile, using the PIR at 10%, was found to be between 32-34% at a 95% confidence interval. This represents catastrophic spending and indicates a significant burden ratio of expenditure on electricity connection. The population in the lower and medium income quintiles faced an aggregate power cost burden between 15-16% and 11-14%, respectively (95%, CI). This still highlights an affordability problem, in line with the 10% rule, as also noted by Westskog and Winther (2014), who found that energy affordability remains a challenge for consumers across income thresholds. On the other hand, those in the high- and highest-income brackets had a favourable affordability status, as their electricity expenses rarely exceeded 10% of their income. Nevertheless, the paper provides an in-depth affordability analysis for each stratum and includes inferential checks for robust inference (see Table 4).

***Table 4:** Affordability of electricity across the districts under investigation*

Income Quintiles	Sample statistics				Inferential statistics (95% CI)			
	District	Share on UCEC	Share on MTC	ASEC	Share on UCEC	Share on MTC	ASEC	N
	The mean percentages of expenditure							
Lowest	Uyui	13.7	20.3	34.0	12.2-15.3	19.1-21.6	32-36	94
	Kasulu	12.5	19.8	32.3	11.4-13.6	18.9-20.7	31-34	137
Lower	Uyui	6.1	9.3	15.7	5.3-6.9	8.7-9.9	14-17	51
	Kasulu	5.9	9.5	15.4	5.2-6.7	8.9-10.1	15-16	54
Medium	Uyui	5.7	5.9	11.6	4.9-6.6	4.9-6.9	10-13	11
	Kasulu	6.0	6.9	12.9	4.6-7.5	6.1-7.7	11-15	18
High	Uyui	1.6	4.1	5.7	N.A	N.A	N.A	1*
	Kasulu	2.9	5.0	7.9	-.060-6.0	2.6-7.4	3-13	3
Highest	Uyui	2.7	3.2	5.9	-.14-5.7	2.1-4.3	4-8	3
	Kasulu	1.9	3.3	5.3	-.5.7-9.7	2.1-4.7	-10-12	2

NA=Not applicable,* the stratum of the Quintile has one respondent, inferential cannot be computed.

UCEC=Upfront cost on electricity connection, MTC=Material and technical costs, ASEC=Aggregate share of electricity connection, CI=Confidence Interval.

The results suggest that there are marginal differences in electricity expenditure between different income groups within the stratum. For example, in the Uyui district, the lowest income quintile in the sample had a PIR of 34%, while the inferential statistics showed a range of 32-36% (95% CI) less than their counterparts in Kasulu, who spent a share of 31-34% on electricity. This similarity in affordability issues can be attributed to the fact that most rural areas share similar cultural and economic contexts, relying on agriculture with unpredictable markets and underdeveloped transport infrastructure. These findings are consistent with the findings of Bajwa and Cavicchi (2017), who also reported that electricity access is unaffordable and that countries like the USA are experiencing increasing negative effects of electricity prices among socially disadvantaged consumers, particularly those with low incomes.

3.2 Affordability of electricity consumption at the household

The affordability of electricity extends beyond just the connection itself. It is important to note that connection and consumption are two separate things. This means that even if consumers are connected to the electricity grid, they may still struggle to afford the costs associated with electricity consumption. In other words, they could remain in the dark despite having a connection. Table 5 presents the findings on the affordability of electricity consumption, specifically using the Price Income Ratio (PIR) based index. The threshold for this index is set at 5%, with a basic need of 30 kWh of electricity.

Table 5: *Expenditure on electricity consumption as per consumer category*

Income Quintiles	Sample statistic (median)			Mode	The inferential statistic at 95% CI			% of
	Median expense	Share on electricity/ month	kWh	Consumer Category	Median expenses	Share on electricity	kWh/ month	N
Lowest	9150	4.8	40.9	T1*	8842-9719	4.7-5.4	41.6-45.9	61.76
Lower	15000	3.17	56.3	T1	13654-16541	3.0-3.7	50.0-57.2	28.07
Medium	20000	3.13	56.3	T1	15485-21146	2.8-3.6	44.3-75.1	7.75
High	12500	2.17	48.7	T4*	-3712-32712	-0.04-5.2	25.7-82.8	1.06
Highest	8500	0.93	57.3	T4	6877-10322	-1.1-5.4	24.8-73.2	1.33

T1=Tariff One, T4=Tariff Four/Zero (Highly subsidised power consumers), N=number of observations

Interestingly, the lowest income quintile (61.8%) consisted mostly of middle power tariffs (T1) consumers who spent 4.8% of their income on electricity. This is because most of the lowest-income earners fall into the T1 category, which is partially subsidised. The lower and medium-income quintiles spent 3.1% of their income on electricity, while high- and higher-income quintiles had expenses of 2.2% and 0.9%, respectively. When looking at the inferential statistics, it is clear that all quintiles in the population spent an acceptable and tolerable share of their income on electricity. Even though the lowest, high, and higher quintile consumers spent up to 5.4% of their income on electricity consumption, it still fell within the tolerable range despite a partial deviation. Therefore, the inference about the prevalence of affordability remains valid.

Furthermore, the affordability of consumption was assessed based on the amount of electricity consumed for household sustenance. Table 5 shows that respondents in all income quintiles consumed more than the basic need electricity of 30kWh, as indicated in the multi-tier framework. Based on these findings, we can infer that electricity consumption was affordable for all consumers in all income quintiles. The amount of electricity consumed exceeded the level of electricity poverty, as it was enough to run minimal and basic domestic electrical appliances (Djeunankan et al., 2023). In the context of rural areas in developing nations, it is viable that consumers who have access to electricity are only using it to power lightweight devices that are essential for their wellbeing. The power of light alone can make a significant impact on improving human lives, let alone heavy electrical appliances (Day et al., 2016).

Although Winkler et al. (2011) argued that spending a very small percentage of income on electricity could indicate unaffordability and economic stress, the findings indicate that the amount of share spent in this study is sufficient to meet the basic need for electricity. The theory of energy justice also emphasises the importance of affordability in power consumption, and it applies strongly in this case. The amount of kWh consumed (40-57) was enough to operate domestic appliances and provide sufficient lighting for households. This aligns with the findings of Carranza and Meeks (2016), who showed that a reasonable amount of kWh can power several Compact Fluorescent Lamps for efficient lighting, which in turn can extend study hours for children at home and contribute to small business growth as well. Furthermore, the current results support the findings from URT (2017) that regardless of whether households are in Dar es Salaam city of Tanzania or in other regions of the country, poor urban households use an average of 51 kWh per month or 620.4 kWh per year.

Furthermore, Table 5 shows inferential statistics (95% C.I) indicating that respondents in the lowest income quintile consumed between 41.6 to 45.6 kWh. These findings align with Sankhyayan and Dasgupta (2019), who found that in India, electricity consumption averaged at 10-50 kWh per month with a guaranteed power supply of 6-10 hours per day. Similarly, in rural Brazil, the share spent on electricity consumption was 3.2, South Africa 5.9, and Bangladesh 5 (Winkler et al., 2011). Togo had a share of 4.1, Uganda 3.1, Angola 4.2, Rwanda 3.3, while Sierra Leone had 13.2 (Golumbeanu & Barnes, 2013). Although the specific amount of power consumed was not revealed, the share spent on electricity indicates affordability. The expenditure on electricity among rural consumers is further exacerbated by the high demand for domestic electrical appliances and school children who spend extra hours studying at night (Moors, 2015). Moreover, the availability of small businesses at home premises and the low cost of electricity per kWh make power consumption economically viable. For instance, one key informant explained that lower tariff (D1 or T4) consumers paid TZS 122.00 per kWh, while middle tariff (T1) consumers paid TZS 356.00 per kWh, inclusive of taxes. The affordability of electricity consumption for residential customers suggests that electricity fuel poverty is near its end, as agreed upon during the focus group discussions (FGD).

> *"The price of electricity is cheaper; nobody can sleep in darkness for failure to buy power units; for example, TZS.1,000.00 can buy 8 units of electricity."*

This statement highlights the affordability and efficiency of electricity consumption. With just TZS 1,000.00, one can earn up to 8 kWh of electricity, which is enough to power essential household appliances for several days. Additionally, households that have access to electricity benefit from extended hours of interaction and increased study time for school children. The power of light plays a significant role in these advantages (Boemi & Papadopoulos, 2019).

3.3 Electricity connection versus ownership of domestic electrical appliance

The household's electricity connection is assumed to have various effects, one of which is the use of electrical appliances for wellbeing. In this paper, we aim to evaluate the impact of utility connection and affordability on these desired effects. The primary objectives of this study are: first, to assess the number of appliances acquired before and after electricity connection, and second, to identify the factors that determine appliance ownership at the household level (Table 6).

Table 6: *Ownership of domestic electrical appliances among residential consumers*

Pre-electrification appliances	domestic	electrical	Usability status %		Post-electrification electrical appliances		Usability status %	
Name of appliance	**Frequency**	**% of purchase**	**FR**	**OCC**	**Frequency**	**% of purchase**	**FR**	**OCC**
Radio	292	78.1	60	40	145	38.8	75	25
Solar lamp	158	42.2	90	10	142	37.8	30	70

Mobile Phone	318	85.0	95	5	275	68.7	100	0
TV/VIDEO	31	8.2	65	35	224	59.8	70	30
Iron metal	13	3.5	15	85	185	49.5	40	60
Electrical fan	12	3.2	20	80	113	30.2	15	85
Dry cell lamp/Torch	183	48.9	56	44	85	14.0	45	55
Rechargeable lamp	10	2.7	30	70	94	25.1	26	74
Water heater	0	0	0	0	10	2.6	5	95
Electrical jug	0	0	0	0	44	11.7	20	80
Fridge	0	0	0	0	38	10.0	70	30
Blender	0	0	0	0	85	14.0	15	85
DVD/CD player	15	4	0	0	189	50.5	72	28
Home theatre	16	4.2	0	0	151	40.4	85	15
Electric cookstove	0	0	0	0	33	8.8	40	60
Rice cooker	0	0	0	0	31	8.2	30	70
Computer	3	0.8	100	0	10	2.6	100	0
Oven	1	0.3	100	100	5	1.3	55	45

*FR=Frequently, OCC=Occasionally

The summary of the results shows that the post-utility connection was accompanied by an increase in the ownership of domestic electrical appliances among rural consumers. For instance, the ownership of TV/VIDEO saw a noticeable improvement, increasing from 9% to 59.8%, and 68.7% of the respondents purchased new mobile phones. However, this does not mean that ownership decreased. Some respondents continued to use the same mobile phone even after connecting to electricity. The mobile phones owned after connecting to electricity were of a type and quality that supported internet access (Smartphones).

The shift in ownership and purchase of smartphones was influenced by the availability of a reliable electricity supply. It was challenging to maintain smartphones without a reliable source of electricity (Best & Burke, 2018). Some appliances, such as electric irons, were used infrequently in households due to concerns about high power bills. Adult members of the household took care of these appliances to prevent excessive power consumption. The ownership of mobile phones increased in the post-electrification era because a reliable source of power was available to run them. Moreover, it is expected that the trend of appliance ownership will continue to evolve, with households potentially purchasing more useful appliances to support small-scale industrial or entrepreneurial activities (Dey et al., 2023).

Generally, mobile phones and radios are commonly used because they play a significant role in accessing news and communication. Before utility connections were available, private generators, solar power, and dry cells were used as sources of energy to operate appliances, but these options had cost implications for consumers. Those who owned mobile phones had to pay out-of-pocket (OP) fees of TZS. 300.00-500.00 at phone charging centres. However, after electricity connections were established, the appliances purchased were based on the capacity to use electricity. For example, government employees and businessmen and women had heavier electrical appliances compared to others, including rice cookers (8.2%), electric cook stoves, fridges, and electric irons (49.5%).

The findings on increased electrical appliance ownership are consistent with those of Debnatha et al. (2015) who reported an increase in TV/VIDEO ownership in rural Bangladesh from 24% to 48% and electrical fan ownership from 45.1% to 56.92%. In rural Kenya, Lee et al. (2016) found an 82% increase in TV ownership, a 34% increase in electric iron ownership, and a 38% increase in DVD/CD player ownership. TV/VIDEO was the most desired electrical appliance that households struggled to purchase. An assured supply of efficient energy from utility companies, a sense of social wellbeing, and access to information through watching TV news, entertaining programs, and education (Munyanyi & Churchill, 2022) also contributed to the increased rate of TV purchases. Therefore, the increased rate of purchasing appliances went hand in hand with the willingness to pay higher power costs for consumption (Sievert & Steinbuks, 2019).

3.4 Determinants for purchase of domestic electrical appliances

In spite of the increasing rate of electrical appliances, after households gain access to electricity, it cannot be inferred that this is the sole cause. Therefore, a multiple regression model was employed to statistically determine the factors contributing to the increase in appliance usage despite the prevalence of electricity. The results of the multiple regression can be found in Table 7.

Table 7: *Factors influencing ownership of domestic electrical appliances*

Regressed variables	*B*	St. Error	*Β*	Sig.	Tolerance	VIF
(Constant)	**35.657**	**1.605**		**.0001**		
Year of power connection	.306	.157	.085	.0520	.865	1.156
Knowledge on the use	1.894	.291	.293	.0001	.808	1.238
Power connection	.483	.099	.215	.0001	.844	1.185
Wattage capacity	.089	.104	.039	.3930	.775	1.291
Loanability	.005	.115	.002	.9620	.687	1.455
Appliance being an asset	-.165	.098	.079	.0920	.744	1.344
Social wellbeing	.550	.135	.201	.0001	.666	1.502
Income of the household	.243	.000	.170	.0010	.661	1.513
Affordability of EC	.174	.064	.137	.0060	.657	1.521
Gender	.844	.346	.105	.0150	.882	1.134
Age of household head	-.055	.017	.144	.0010	.854	1.172
Level of education	.503	.149	.148	.0010	.850	1.176
Marital status	-.502	.355	.062	.1570	.862	1.161

Durbin -Watson 1.387, R^2 = 0.410, $R^2_{Adjusted}$ = 0.389, ANOVA model significant $p < 0.01$, EC=Electricity Consumption

On the assumptions and robustness check of the model, multicollinearity (< 0.6) and collinearity diagnostics indicated tolerance values of variables were > 0.10, while VIF for variables were < 10. The goodness fit of the model indicated acceptability as ANOVA ($p < 0.01$) and Durbin-Watson value >1 but < 2. The R2 was 0.410, meaning that the model explained 41% of the variance. This is common in social sciences, where calibrating precise variables that show great model explanatory power differs across the context (Field, 2009; Pallant, 2007).

The results, considering the β values, indicated that predictors had a significant contribution to domestic electrical appliance ownership, except for some variables such as loanability, wattage capacity, appliance as an asset, and marital status. However, the wattage capacity of an appliance was found to be practically significant, as it influences consumption capacity. Household preference tends to prioritise electrical appliances that do not substantially increase electric bills (Lee et al., 2016). Additionally, knowledge of how to use appliances was found to be significant ($p < 0.01$). In rural areas, individuals are particularly interested in appliances that are easy to use or can be easily learned, given the higher risks associated with electricity. For example, it was found that 58% of respondents expressed fear of cooking on an electric stove due to the risk of electric shocks. Winther (2012) also highlighted similar concerns, with rural residents expressing a deep fear of electric stoves due to the risk of shocks. These findings contradict those of Ganesan and Vishnu (2014), who reported religious affiliation with appliances, as the assessment of the quality of food is also influenced by the tools used for its preparation.

Nonetheless, the predictor of wellbeing was found to be significant ($p < 0.01$). This is because happiness and a sense of success associated with electricity access and its related appliances play a crucial role. People's subjective wellbeing is often influenced by material success, which is supported by the capability approach, as explained by Broderick (2018). Appliances such as televisions, radios, and refrigerators are directly associated with happiness and overall life comfortability. Entertainment and educational programmes on television contribute significantly to wellbeing at the household level. Furthermore, the importance of household cohesion through shared time spent watching television cannot be overlooked. Efficient power supply from the utility ($p < 0.01$) has also led to an increase in appliance ownership. The burdensome costs associated with charging mobile phones and running private generators have made it unreliable for households to purchase hard and sophisticated appliances. However, upon efficient power connection, Batteiger and Rotter (2018) reported a notable increase in household appliance ownership, particularly in rural areas where TV usage doubled. For example, the percentage of households with mobile phones rose from 2% to 90%, and refrigerator ownership increased from 3% to 12%. The availability of electricity provides households with greater freedom to purchase appliances without concerns about power efficiency. In some cases, households even started buying electrical appliances like TVs and home theatres before completing the installation of electricity. This is because TVs were considered valuable and highly desired (Lee et al., 2016).

The affordability of electricity consumption ($p < 0.01$) and the economic status of the household ($p < 0.01$) have had distinct influences on the dependent variables. The affordability of power consumption directly impacts the purchase of appliances. The number of appliances purchased is determined by the "just price," which is sensitive to the annual or monthly income of the household. In Tanzania, like many other countries, there is a growing trend of counter-urbanisation. This means that economically well-off individuals, including government workers, are moving to rural areas, leading to a mix of people with varying economic capabilities.

The 75kWh lifeline tariff for lower power users in Tanzania makes it easier for them to assess which appliances are within their purchasing power. Additionally, the gender of the household head has a significant impact ($p < 0.05$), indicating that male-headed households tend to have a greater number of male-controlled appliances and vice versa. Winther (2012) supports this argument, stating that electric irons, fridges, home theatres, water heaters, electric cookstoves, and TVs are influenced by gender and education. In fact, men prefer appliances that are clean and have lower greenhouse gas emissions (Banday & Aneja, 2019). As the dominant heads of households, men exert influence over the types and nature of appliances that are purchased. Therefore, domestic appliances are important, as they can also be used for running small enterprises within the home.

4. Conclusions and recommendations

The study explains that the affordability of electricity connection for rural consumers has not been improved compared to that of consumption. The amount of household income spent on electricity connection is alarming. Therefore, the cost of electricity connection should be improved before focusing on consumption. Additionally, factors such as electricity connection, the affordability of electricity consumption, the economic status of the household, and the desire for social wellbeing significantly influence the purchase of domestic electrical appliances. These results align with the assumptions of EJUT and MTF. It is recommended that an instalment payment method be devised due to the irregular income of consumers, as the current lump-sum payment places a heavy burden on them. Future studies on clean energy should prioritise measuring affordability, as it is still a disputed topic requiring clear scholarly debate.

5. Theoretical, practical and policy implications

With reference to the main findings, the Energy Justice and Multi-Tier Frameworks are relevant to the issues at hand. Firstly, since energy is an important resource in the human environment, it should be affordable to everyone. All human beings deserve to equally benefit from the products of the environment, including through state subsidies for energy utilities. Secondly, the multi-tier framework is validated in the sense that consumers of electricity are always influenced by their ability to afford the appliances they purchase for their households. On a practical note, this study sheds light on electricity consumers, indicating that affordability continues to be a challenge that requires special attention. The amount of electricity consumed, as a result of affordability, is sufficient for basic domestic activities and operations. Policy reviews should take into consideration the improvement of affordability by addressing two aspects: the affordability of connection (including material and technical costs) and consumption. Utility suppliers should ensure that they provide free technical services to consumers who wish to be connected.

6. Declarations

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