Household Expenditure Pressure and Electricity Access in Rural Kitui County, Kenya

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ABSTRACT

Electricity infrastructure can be physically available while remaining financially inaccessible to rural households whose budgets are dominated by essential consumption. This study examines household expenditure as a demand-side determinant of electricity access in rural Kitui County, Kenya. It isolates the household-expenditure objective from a wider study of socioeconomic factors and asks whether expenditure pressure and household budgeting capacity are associated with the ability to connect to and sustain electricity services. An explanatory cross-sectional design was used, drawing on 380 usable household questionnaires from a target population of 262,942 rural households. Household expenditure was measured using ten Likert-scale items capturing essential-needs spending, expenditure pressure, budgeting capacity and electricity-related affordability. The expenditure construct recorded a high composite mean ($M = 4.3221$, $SD = 0.40607$). Principal component analysis produced a Kaiser-Meyer-Olkin value of .905 and a significant Bartlett's test ($\chi^2 = 1261.606$, $df = 45$, $p < .001$). Two components with eigenvalues above one jointly explained 55.758% of the variance, indicating that expenditure constraints contain both a broad affordability-pressure dimension and a more immediate essential-expenditure burden. In the multivariate model, household expenditure had a positive and statistically significant association with electricity access ($B = .041$, $\beta = .266$, $t = 6.270$, $p < .001$), controlling for household access to credit and living conditions. A supplementary PROCESS Model 4 analysis showed that poverty did not significantly mediate this relationship because the bootstrapped indirect-effect interval included zero ($a \times b = -.0043$; 95% Boot CI [-.0106, .0010]). The findings suggest that rural electricity access is shaped by immediate household resource-allocation and affordability conditions that are not reducible to poverty status alone. Policy should therefore combine infrastructure expansion with payment flexibility, connection-cost relief and household affordability measures.

Keywords: Household expenditure; electricity access; affordability; energy poverty; rural electrification; household budgeting; socioeconomic determinants

INTRODUCTION

Electricity access remains a fundamental component of sustainable development because it influences household welfare, economic opportunities, education outcomes, health services, communication, and productive activities. Access to electricity allows households to adopt modern technologies, improve living standards, and participate more effectively in economic activities. However, global evidence shows that increasing electricity infrastructure coverage does not automatically translate into meaningful household access. Many households, particularly in rural and low-income settings, continue to experience energy exclusion because affordability, reliability, connection costs, and the ability to sustain electricity consumption remain major barriers (Blimpo et al., 2020; World Bank, 2021; International Energy Agency [IEA], 2024).

In rural communities, electricity access involves more than the physical availability of transmission lines or connection points. Households must finance connection fees, internal wiring, appliances, prepaid electricity tokens, monthly bills, and maintenance costs. These expenses compete with other essential household needs,

including food, healthcare, education, housing, and transportation. Consequently, household financial capacity and expenditure patterns influence whether households can transform electricity availability into actual and sustained use (Poblete-Cazenave & Pachauri, 2021; Pelz et al., 2022).

The challenge is particularly relevant in Sub-Saharan Africa, where electricity expansion has improved over recent decades, but many rural households remain unable to achieve reliable and affordable access. Recent studies emphasize that demand-side constraints, including low household purchasing power, affordability challenges, and limited ability to pay for electricity services, continue to slow progress toward universal energy access (Blimpo et al., 2020; Egli et al., 2023). Therefore, understanding household-level socioeconomic factors is essential for designing electrification strategies that move beyond infrastructure expansion toward meaningful energy inclusion.

Kenya provides an important context for examining these challenges. Although national electrification programmes have significantly increased electricity availability, rural households continue to face barriers related to affordability, service reliability, and socioeconomic inequality. Evidence from Kenya indicates that households' willingness and ability to connect to electricity depend not only on network availability but also on household income conditions, expenditure priorities, and perceptions of the value of electricity services (Bajo-Buenestado, 2021; Dominguez et al., 2021; Zuch, 2025). Rural counties such as Kitui experience additional challenges because many households depend on limited and irregular income sources while allocating substantial resources toward basic consumption needs.

This study focuses specifically on household expenditure as a socioeconomic determinant of electricity access in rural Kitui County. Unlike poverty, which reflects a broader condition of deprivation, household expenditure captures how available resources are allocated among competing needs. A household may not necessarily be classified as poor but may still experience expenditure pressure that limits its ability to finance electricity connection or maintain consumption. Examining expenditure therefore provides a more direct understanding of the household budgeting decisions that shape electricity access outcomes (Poblete-Cazenave & Pachauri, 2021; IEA, 2024).

Existing electricity-access research has largely emphasized supply-side factors such as grid expansion, generation capacity, and infrastructure investment. While these factors remain important, they do not fully explain why some households remain disconnected or unable to sustain electricity use despite infrastructure availability. This manuscript contributes to the literature by examining the household financial dimension of electricity access and by demonstrating how expenditure conditions influence the ability of rural households to participate in modern energy systems.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Household expenditure and the household electricity decision

Household expenditure represents the allocation of limited financial resources among competing consumption and investment needs. In the context of electricity access, expenditure decisions influence both the initial decision to connect and the ability to maintain electricity consumption after connection. Households may need to finance connection charges, wiring, appliances, and recurring electricity payments, all of which compete with essential expenditures such as food, education, healthcare, and housing (Poblete-Cazenave & Pachauri, 2021; World Bank, 2021).

Energy-access research increasingly recognizes affordability as a central dimension of meaningful electricity access. Physical connection alone does not guarantee that households can use electricity at levels that generate welfare improvements. Households experiencing high expenditure pressure may reduce consumption, delay connection, or continue relying on traditional energy sources despite the availability of electricity infrastructure (Blimpo et al., 2020; Pelz et al., 2022). This suggests that household expenditure conditions represent an important demand-side determinant of electricity access.

Energy ladder theory and expenditure capacity

The energy ladder theory proposes that households tend to move from traditional energy sources toward more modern energy carriers as economic circumstances improve. (Lee et al., 2020; Koomson & Danquah, 2021) Electricity is commonly positioned near the upper end of this transition because it is versatile, efficient at the point of use and compatible with a wide range of household technologies. The theory therefore provides a useful starting point for understanding why household economic capacity can influence electricity adoption.

From an expenditure perspective, movement toward electricity requires more than an increase in nominal income. Households must have sufficient discretionary resources after meeting essential needs. A household with income above a poverty threshold may still face binding expenditure commitments that delay electricity investment. The expenditure variable therefore adds a resource-allocation dimension to the energy ladder: the ability to move toward electricity depends on what remains financially feasible after competing needs are met.

The theory also helps explain why electricity access and electricity consumption should be distinguished. Connection can require a lump-sum investment, whereas consumption requires recurring payments. Expenditure pressure can affect both stages differently. A household may obtain a connection but restrict usage because monthly resources are uncertain, or it may delay connection despite anticipating future benefits because current essential spending is more urgent.

Sustainable livelihoods and competing household claims

The sustainable livelihoods framework views households as combining financial, physical, human, natural and social resources to pursue livelihood outcomes. (Natarajan et al., 2022) Household expenditure is closely related to the financial-capital component because it reflects the claims placed on available resources. Electricity can strengthen other livelihood assets, but acquiring electricity also requires households to commit resources that could be used elsewhere.

In rural Kitui, this trade-off is important because households may simultaneously face school costs, food insecurity, health expenditures and housing needs. Under such conditions, the relevant question is not simply whether electricity has benefits, but whether those benefits can be financed within the household's current expenditure structure. This framework supports the expectation that expenditure conditions will be significantly associated with electricity access.

Empirical evidence on affordability and rural electricity access

The literature reviewed in the broader study consistently identifies affordability as a major demand-side constraint. Lee et al. (2020) show that rural electrification outcomes depend on household economic capacity and readiness, while Poblete-Cazenave and Pachauri (2021) model energy poverty and electricity demand in relation to household resources and appliance ownership. More recent Kenyan evidence cited in the project also links willingness to pay for electricity access to household expenditures and other socioeconomic characteristics (Zuch, 2025).

The empirical implication is that infrastructure expansion can coexist with low household uptake. Where households cannot finance connection or recurrent use, additional infrastructure may improve geographic availability without eliminating economic exclusion. Expenditure therefore deserves analysis as a distinct household-level determinant rather than being absorbed into a broad poverty or income category.

The affordability problem also extends beyond the initial connection decision. Households need appliances to convert electricity access into lighting, refrigeration, communication, education, and productive services. Recent regional analysis shows that appliance affordability and low consumption can constrain the benefits obtained from electrification even after a grid connection becomes technically feasible. Egli et al. (2023) similarly demonstrate that electrification costs and demand assumptions vary substantially across Sub-Saharan Africa, strengthening the case for planning approaches that match technology and service levels to realistic

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household demand and payment capacity. Therefore, household expenditure is best understood as part of a continuing affordability pathway from connection to sustained and productive electricity use.

Kenyan evidence further demonstrates that households evaluate electricity not only according to whether a network is available but also according to service quality, price, and expected usefulness. Bajo-Buenestado (2021) finds that blackouts discourage household connections and appliance purchases in Kenya, while Dominguez et al. (2021) show that electricity prices and unreliable service reduce the probability of grid-electricity adoption among rural Kenyan households. The implication is that expenditure decisions are shaped by the expected value of electricity: households facing tight budgets may be less willing to allocate scarce resources to a service perceived as costly or unreliable.

Evidence from Sub-Saharan Africa also shows that the demand side of electrification cannot be separated from household economic circumstances. Blimpo et al. (2020) find that demand-side factors account for a substantial share of the electricity-access deficit across African countries, indicating that infrastructure provision alone cannot guarantee household uptake. Similarly, Moshi (2024), examining rural electricity consumers in Tanzania, reports that connection costs can impose a particularly heavy burden on low-income households even where subsequent electricity consumption appears more affordable. These findings support the argument that the timing and concentration of electricity costs matter alongside total household resources.

Recent evidence reinforces the need to treat affordability as a multidimensional component of electricity access rather than as a secondary issue after physical connection. The Multi-Tier Framework defines meaningful access in terms of capacity, availability, reliability, quality, affordability, legality, and safety. Under this approach, a household can be connected to the grid and still experience inadequate energy access when the cost of a basic electricity service absorbs an excessive share of household resources. This distinction is particularly relevant for rural households because connection costs and recurrent payments are incurred within budgets already committed to food, education, health care, transport, housing, and other necessities (World Bank, 2021; IEA, 2024).

H01: Household expenditure has no significant effect on electricity access in rural Kitui County.

RESEARCH METHODOLOGY

Research design and study area

The study adopted an explanatory cross-sectional design. This design was appropriate because the analysis sought to estimate the statistical relationship between household expenditure conditions and electricity access using household-level data collected at one point in time. The unit of analysis was the rural household in Kitui County, Kenya.

The target population comprised 262,942 households. The wider study targeted 400 households using the sampling procedure described in the broader study, and 380 usable questionnaires were available for analysis. This produced a usable response rate of 95.0%. The analysis reported in this manuscript uses the same validated dataset but narrows the empirical focus to the household-expenditure objective.

Measurement of household expenditure

Household expenditure was measured using ten statements on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The items captured essential-needs expenditure, survival prioritization, spending on food, health care and education, financial-resource constraints, expenditure management, poverty-related reallocation and the ability to finance reliable energy solutions. The construct therefore represents expenditure pressure and household capacity to allocate resources toward electricity rather than a simple accounting total of household spending.

Table 1: Household expenditure measurement items

No.	Household expenditure item
1	Higher household expenditure on essential needs limits funds available for electricity access.
2	Poverty-driven expenditure patterns prioritize basic survival over investing in electricity.
3	Increased spending on food, health care and education reduces the ability to afford electricity connections.
4	Limited financial resources due to high expenditure on necessities impact electricity access.
5	Households in poverty must allocate most income to immediate needs, hindering electricity investments.
6	Effective management of household expenditure can improve access to electricity.
7	High essential expenditure leaves little room for electricity-related expenses.
8	Reducing household poverty is crucial for reallocating expenditure towards electricity access.
9	Financial constraints caused by high expenditure on basics prevent upgrading to reliable energy solutions.
10	Addressing poverty can enable households to better manage expenditure and improve electricity access.

Source: Field data (2026)

Data analysis

Data analysis combined descriptive statistics, principal component analysis and multiple regression. Descriptive statistics summarized respondents' agreement with the expenditure items. Factorability was assessed using the Kaiser-Meyer-Olkin measure and Bartlett's Test of Sphericity. Communalities, eigenvalues, percentage variance explained and component loadings were then examined to evaluate the internal structure of the expenditure scale.

The main hypothesis was tested using multiple linear regression in which electricity access was modeled as a function of household access to credit, household expenditure and household living conditions. The expenditure coefficient therefore represents the unique association between household expenditure and electricity access after holding the other socioeconomic predictors constant. The broader model reported $R = .913$, $R^2 = .834$ and Adjusted $R^2 = .833$.

A supplementary simple mediation analysis from the wider project was retained because it provides a useful mechanism check. Hayes' PROCESS Macro v4.2, Model 4, was used to test whether poverty statistically transmitted the relationship between household expenditure and electricity access. The indirect effect was evaluated using 5,000 bootstrap samples and a 95% confidence interval. Because the design is cross-sectional, the mediation result is interpreted as a statistical indirect pathway rather than definitive causal sequencing.

RESULTS

Descriptive profile of household expenditure pressure

The descriptive results show strong agreement that expenditure conditions constrain electricity access. Across the ten items, the composite mean was 4.3221 with a standard deviation of .40607. The relatively small dispersion indicates that respondents held broadly consistent views about the role of household spending pressure in electricity access.

The highest-rated statement was that higher household expenditure on essential needs limits funds available for electricity access (M = 4.59, SD = .670). Respondents also strongly agreed that increased spending on food, health care and education reduces the ability to afford electricity connections (M = 4.39, SD = .650). These two items capture the core crowd-out mechanism: essential needs receive priority and reduce the financial room available for electricity.

Households also strongly agreed that poverty forces income toward immediate needs, hindering electricity investment (M = 4.35, SD = .578). Items concerning limited financial resources, expenditure management, high essential expenditure and poverty reduction all recorded means above 4.20. The results therefore show that respondents perceive electricity access as a household budgeting issue as well as an infrastructure issue.

Table 2: Descriptive statistics for household expenditure

Item	**N**	**Mean**	**SD**
Essential-needs expenditure limits electricity funds	380	4.59	.670
Survival priorities displace electricity investment	380	4.21	.605
Food, health and education spending reduces connection affordability	380	4.39	.650
High necessities expenditure limits financial resources	380	4.28	.578
Immediate needs hinder electricity investment	380	4.35	.578
Effective expenditure management can improve access	380	4.28	.560
Essential expenditure leaves little room for electricity costs	380	4.26	.619
Poverty reduction enables expenditure reallocation	380	4.29	.608
Basic expenditure prevents reliable-energy upgrades	380	4.29	.606
Addressing poverty improves expenditure management and access	380	4.28	.599
Composite score	380	4.3221	.40607

Source: Field data (2026)

Factorability of the household expenditure construct

The KMO measure for the expenditure items was .905, indicating excellent sampling adequacy. Bartlett's Test of Sphericity was also statistically significant ($\chi^2 = 1261.606$, df = 45, $p < .001$). These results indicate that the items share sufficient correlation and common variance to justify principal component analysis.

Table 3: KMO and Bartlett's Test for household expenditure

Diagnostic	**Value**
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.905
Bartlett's Test - Approx. Chi-Square	1261.606
Degrees of freedom	45
Significance	<.001

Source: Field data (2026)

Communalities and representation of expenditure items

Extraction communalities ranged from .464 to .684. The strongest represented item was increased spending on food, health care and education reducing the ability to afford electricity connections (h^2 = .684). This indicates that essential-needs crowd-out is central to the shared expenditure structure.

Effective expenditure management (h^2 = .604) and poverty reduction enabling expenditure reallocation (h^2 = .603) were also strongly represented. The lowest communality was .464 for the statement that financial constraints caused by high expenditure on basics prevent households from upgrading to reliable energy solutions. Although lower than the other items, it remained sufficiently substantive for the study's expenditure construct.

Table 4: Household expenditure communalities

Expenditure indicator	**Extraction**
Essential-needs expenditure limits electricity funds	.549
Survival priorities displace electricity investment	.482
Food, health and education spending reduces connection affordability	.684
High necessities expenditure limits financial resources	.554
Immediate needs hinder electricity investment	.518
Effective expenditure management can improve access	.604
Essential expenditure leaves little room for electricity costs	.533
Poverty reduction enables expenditure reallocation	.603
Basic expenditure prevents reliable-energy upgrades	.464
Addressing poverty improves expenditure management and access	.585

Source: Field data (2026)

Dimensionality of household expenditure pressure

Principal component analysis retained two components with eigenvalues above one. Component 1 had an eigenvalue of 4.529 and explained 45.286% of the variance. Component 2 had an eigenvalue of 1.047 and explained a further 10.472%. Together, the two components accounted for 55.758% of total variance.

This result is substantively important. Household expenditure pressure is not entirely one-dimensional. The first component reflects a broad affordability and expenditure-pressure dimension, whereas the second appears to differentiate immediate essential-expenditure crowd-out from management- or solution-oriented items. This provides a richer explanation of why household spending matters for electricity access: the problem involves both the overall pressure on household resources and the specific competition between electricity and essential consumption.

The unrotated component matrix nevertheless shows cross-loadings on some items. For a future journal extension, confirmatory factor analysis or an exploratory factor analysis with an appropriate rotation would

provide a stronger test of the proposed sub-dimensions. The present manuscript retains the original project's PCA results and does not introduce new factor estimates.

Table 5: Total variance explained by household expenditure components

Component	Eigenvalue	% Variance	Cumulative %
1	4.529	45.286	45.286
2	1.047	10.472	55.758
3	.751	7.513	63.270
4	.719	7.187	70.458

Source: Field data (2026)

Regression effect of household expenditure on electricity access

The overall regression model was statistically significant, $F(3, 376) = 630.955$, $p < .001$. The model produced $R = .913$ and $R^2 = .834$, indicating that household access to credit, household expenditure and household living conditions jointly accounted for 83.4% of the measured variation in electricity access. The adjusted R^2 was .833.

Household expenditure had a positive and statistically significant coefficient ($B = .041$, $SE = .006$, $\beta = .266$, $t = 6.270$, $p < .001$). The null hypothesis was therefore rejected. Holding household access to credit and living conditions constant, a one-unit increase in the household expenditure construct was associated with a .041-unit increase in the electricity-access score.

The standardized coefficient of .266 indicates that household expenditure was the second strongest predictor in the model after household access to credit ($\beta = .471$) and ahead of household living conditions ($\beta = .226$). The result confirms that expenditure conditions have an independent relationship with electricity access rather than merely reflecting the effects of credit or housing conditions.

Table 6: Regression results for socioeconomic predictors of electricity access

Predictor	B	SE	Beta	t	p
Constant	1.584	.065	-	24.440	<.001
Household access to credit	.070	.007	.471	10.519	<.001
Household expenditure	.041	.006	.266	6.270	<.001
Household living conditions	.035	.007	.226	5.207	<.001

Source: Research Data (2026)

Is the expenditure effect transmitted through poverty?

The supplementary mediation result sharpens the interpretation of the regression finding. Household expenditure significantly predicted poverty in the mediator model ($a = .0465$, $SE = .0061$, $t = 7.6033$, $p < .001$). Poverty also significantly predicted electricity access after controlling for expenditure ($b = -.0931$, $SE = .0345$, $t = -2.6997$, $p = .0073$). The direct effect of household expenditure remained positive and significant ($c' = .1338$, $SE = .0044$, $t = 30.3929$, $p < .001$).

Despite the significance of the a- and b-paths, the bootstrapped indirect effect was not statistically significant. The indirect effect was -.0043 with a bootstrap standard error of .0029 and a 95% confidence interval from -.0106 to .0010. Because this interval includes zero, there is insufficient evidence that poverty mediates the expenditure-electricity access relationship in the study.

This non-significant indirect effect is an informative finding; it is theoretically informative. It suggests that expenditure conditions are associated with electricity access mainly through more immediate pathways such as the prioritization of connection fees, timing of cash availability, ability to meet recurring payments and competition among household needs. Poverty remains relevant to electricity access, but it does not statistically account for the expenditure effect measured here.

Table 7: Supplementary mediation results - HEE → Poverty → Electricity Access

Path/effect	**Estimate**	**SE**	**t**	**p**	**95% CI / Boot CI**
a: HEE → Poverty	.0465	.0061	7.6033	<.001	[.0345, .0585]
b: Poverty → EA	-.0931	.0345	-2.6997	.0073	[-.1609, -.0253]
c': HEE → EA	.1338	.0044	30.3929	<.001	[.1252, .1425]
Indirect a×b	-.0043	BootSE=.0029	-	-	[-.0106, .0010]

Source: Research Data (2025); PROCESS Macro v4.2, Model 4; Bootstrap = 5,000; Confidence Level = 95%.

DISCUSSION

The central finding is that household expenditure conditions significantly predict electricity access in rural Kitui County. The result supports the argument that electrification is partly a household resource-allocation problem. Electricity may be technically available, but access depends on whether households can accommodate connection and recurring electricity costs alongside essential consumption.

The descriptive findings make this mechanism concrete. Respondents most strongly identified essential-needs expenditure as a constraint. Food, health care and education do not merely correlate with electricity spending; they compete for the same limited household resources. When these expenditures become binding, electricity can be delayed even if households recognize its welfare and productive benefits.

The PCA results add an important measurement insight. Two components explain the expenditure scale better than a strictly one-dimensional interpretation. This indicates that the household budget constraint contains at least two related elements: a general affordability-pressure dimension and a more immediate essential-expenditure burden. For journal-oriented energy-access research, this distinction matters because interventions aimed at long-term income or poverty improvement may operate differently from measures that directly ease connection charges or monthly payment pressure.

The regression coefficient is positive, which must be interpreted in light of the scale construction. The project does not measure raw expenditure in Kenyan shillings; it uses a composite of expenditure-related perceptions and management conditions. Consequently, the coefficient should not be read as evidence that simply spending more money causes electricity access to increase. Rather, the result indicates that the measured household expenditure condition is significantly associated with electricity access after controlling for credit access and living conditions.

The mediation result further strengthens this interpretation. If expenditure were simply another expression of poverty, a significant indirect pathway through poverty would be expected. Instead, the bootstrap confidence interval includes zero. This suggests that the expenditure-access relationship contains mechanisms distinct from the general poverty construct. The result is consistent with the broader project interpretation that

expenditure influences access through budgeting, liquidity timing and the capacity to sustain electricity-related payments.

These findings complement the rural electricity literature cited in the project. Poblete-Cazenave and Pachauri (2021) emphasize the importance of household demand and economic capacity in energy poverty, while Zuch (2025) reports that household expenditures significantly influence willingness to pay for electricity access in Kenya. The present evidence adds a county-level household perspective by showing that expenditure conditions remain significant even when other socioeconomic predictors are included.

A further implication concerns the interaction between affordability and reliability. Bajo-Buenestado (2021) shows that unreliable supply can discourage both connection and appliance acquisition, while Dominguez et al. (2021) report similar effects for rural Kenyan energy transitions. Expenditure pressure may therefore be intensified when households perceive uncertain returns from electricity spending. A household that must sacrifice other necessities to pay for connection has a stronger reason to postpone adoption when service interruptions reduce the expected benefits. Affordability interventions should consequently be coordinated with improvements in service reliability rather than treated as an isolated financial issue.

The result also aligns with a broader shift in energy-access research from binary connection measures toward the quality and affordability of the service received. Kenya has made substantial progress in expanding electricity access, but national assessments continue to identify affordability as a barrier to universal and meaningful access (IEA, 2024). This is important for interpreting the Kitui findings: a household may live close to electricity infrastructure yet remain unable to translate that proximity into sustained use when connection, wiring, appliances, and recurrent payments compete with essential consumption.

Household expenditure as an affordability mechanism

The findings indicate that household expenditure should be understood as a mechanism through which the practical affordability of electricity is determined. A household may recognize the benefits of electricity and may even live within reach of an electricity network, but the decision to connect still depends on whether sufficient resources remain after essential needs have been financed. The descriptive results strongly support this interpretation because the highest-rated expenditure item concerned the limitation created by spending on essential needs. This shows that respondents do not treat electricity expenditure in isolation; rather, they evaluate it against other immediate household obligations.

The result also helps explain why physical electricity availability and household electricity access can diverge. Infrastructure reduces the geographic barrier to access, but it does not remove the household budget constraint. Connection charges, internal wiring, appliances and recurring payments create a sequence of costs that must be accommodated within household expenditure. Where food, health care and education absorb most available resources, households can remain economically disconnected despite being geographically close to electricity infrastructure. This distinction is important because infrastructure-based measures of electrification can overstate the extent to which households are actually able to use electricity services.

The significant expenditure coefficient therefore has a practical interpretation beyond statistical significance. Household expenditure conditions retain explanatory value even after household access to credit and living conditions are controlled. This means that the expenditure dimension cannot be treated merely as a duplicate of financing access or housing quality. Credit may provide a means of mobilizing funds and better living conditions may make connection technically easier, but households must still decide how available resources are distributed among competing needs. Expenditure captures this immediate allocation problem.

Interpreting the two-component expenditure structure

The principal component results provide additional insight into the structure of the household expenditure constraint. The first component explains 45.286% of the variance, while the second contributes a further 10.472%. The retention of two components suggests that respondents distinguish between related but not identical aspects of expenditure pressure. One aspect concerns the general limitation created by essential

expenditure and scarce financial resources. The other reflects the household's capacity to manage expenditure, reallocate resources and accommodate electricity-related costs.

This distinction matters for intervention design. A household experiencing a broad shortage of resources may require measures that improve overall economic capacity, whereas a household whose main difficulty is the timing or concentration of electricity-related costs may respond to installment payments or flexible connection arrangements. Treating all expenditure barriers as a single problem risks applying the same policy instrument to households facing different constraints. The factor results therefore support a more differentiated approach to electricity affordability.

At the same time, the factor structure should be interpreted cautiously. The original project used principal component analysis and reported an unrotated component matrix. The two retained components are therefore useful for describing the empirical structure of the items, but they should not yet be treated as fully established latent subscales. Future analysis could test whether the apparent dimensions remain stable under rotated exploratory factor analysis or confirmatory factor analysis. Such validation would help determine whether expenditure pressure and expenditure-management capacity should be modeled separately in subsequent research.

Expenditure, poverty and the direct pathway to electricity access

The mediation analysis is especially useful because it distinguishes household expenditure from poverty. The mediator model shows that expenditure is significantly associated with poverty, and poverty is significantly associated with electricity access after expenditure is controlled. Nevertheless, the bootstrapped indirect effect is not statistically significant because its confidence interval crosses zero. Thus, the data do not support the conclusion that poverty is the mechanism through which household expenditure affects electricity access.

This pattern indicates that expenditure has a more immediate relationship with electricity access. A household can face expenditure pressure because several obligations fall due at the same time, because essential consumption takes priority, or because electricity requires a relatively large upfront payment. These constraints can affect electricity decisions even when a broader poverty index does not fully capture them. The result therefore supports separating chronic socioeconomic deprivation from short-term or allocation-based affordability pressure.

The distinction has methodological importance as well. If expenditure and poverty were treated as interchangeable constructs, the analysis would obscure the different pathways represented by each variable. The project results instead show that poverty remains independently relevant while failing to carry the expenditure effect statistically. This suggests that household-level electrification research can gain explanatory precision by measuring both general deprivation and specific expenditure conditions rather than relying on a single socioeconomic indicator.

Implications for rural electrification programmes

The findings suggest that rural electrification programmes should incorporate affordability assessment into the design of connection strategies. Extending lines and increasing the number of technically connectable households addresses only one part of the access problem. Programme design should also consider whether households can absorb connection costs without sacrificing essential consumption. This is particularly important where respondents already report strong pressure from food, health and education expenditure.

Payment flexibility is one practical implication. Where electricity-related costs are concentrated at the point of connection, spreading those costs over time can reduce the immediate competition between electricity and essential household needs. Similarly, predictable payment arrangements may help households whose resources are sufficient in aggregate but irregular in timing. These approaches address the expenditure mechanism identified in the study more directly than a general assumption that infrastructure availability will automatically generate uptake.

The findings also support more careful targeting. The non-significant poverty mediation effect implies that expenditure-related electricity barriers may exist beyond households classified as poor under a broad poverty measure. A household can experience severe budget pressure because of education, health or other necessary expenditure even when its overall socioeconomic position is comparatively better. Electricity-affordability programmes should therefore consider expenditure burden and payment capacity alongside conventional poverty indicators when identifying households that may require support.

Finally, electrification policy should evaluate whether households can move beyond a nominal connection to useful levels of electricity consumption. The Multi-Tier Framework and recent energy-access research emphasize that affordability, reliability, and capacity jointly determine the quality of access. Monitoring should therefore include expenditure burden, continuity of payment, appliance ownership, consumption levels, and service reliability. Such indicators would help distinguish households that are sustainably electrified from those that remain economically constrained after connection.

Programme design should also recognize that affordability is dynamic. Rural household cash flow can vary across seasons and can be disrupted by school fees, illness, agricultural shocks, and other expenditure peaks. Fixed lump-sum connection requirements may therefore exclude households whose annual resources are adequate but whose liquidity is insufficient at the moment payment is required. Installment-based connection charges, transparent lifeline tariffs, and payment schedules aligned with irregular cash flows can reduce this mismatch without assuming that all financially constrained households experience the same form of poverty.

Contribution of the expenditure

By separating household expenditure from the broader socioeconomic analysis, this manuscript highlights why expenditure deserves attention as an independent determinant of electricity access. Although the wider regression model shows that credit access, household expenditure, and living conditions collectively explain a substantial share of the variation in electricity access, the expenditure-focused analysis provides deeper insight into the household realities behind this relationship. It demonstrates how competing essential needs, expenditure priorities, and the ability to manage limited resources shape households' capacity to connect to and sustain electricity services.

The contribution of this study is therefore both empirical and conceptual. From an empirical perspective, household expenditure emerged as a significant predictor of electricity access, with a standardized coefficient of .266. Conceptually, the findings reveal that expenditure pressure is a multidimensional challenge that cannot be fully explained by poverty alone. Rather, household budgeting decisions represent a critical pathway influencing electricity access, suggesting that electrification efforts should consider affordability and resource allocation alongside infrastructure expansion. This perspective shifts the understanding of rural electricity access from being solely an infrastructure challenge to one that is also deeply rooted in household economic realities.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

This manuscript examined household expenditure as a distinct determinant of electricity access in rural Kitui County. The evidence shows that respondents experience electricity access within a wider household budgeting environment in which food, health care, education and other essential needs compete with connection and usage costs.

The household expenditure construct demonstrated strong factorability, and its two-component structure suggests that expenditure pressure is multidimensional. Most importantly, household expenditure remained a positive and statistically significant predictor of electricity access in the multivariate model ($B = .041$, $\beta = .266$, $p < .001$). The study therefore rejects the null hypothesis that household expenditure has no significant effect on electricity access.

The supplementary mediation result shows that the expenditure relationship should not simply be relabeled as a poverty effect. Poverty did not significantly mediate the relationship because the bootstrapped indirect-effect confidence interval included zero. Household expenditure therefore appears to operate mainly through direct affordability and resource-allocation pathways in this dataset.

Policy implications

First, rural electrification policy should address household affordability alongside infrastructure expansion. Connection programs should recognize that households face competing essential expenditures and may be unable to mobilize lump-sum payments even when electricity infrastructure is nearby.

Second, payment arrangements should reduce the mismatch between electricity costs and rural household cash flow. Flexible connection-fee schedules, installment arrangements and predictable low-value payment options can reduce the immediate budget shock associated with electrification.

Third, targeted support should distinguish between chronic poverty and short-term expenditure pressure. The non-significant mediation result indicates that broad poverty reduction alone may not address all expenditure-related barriers. Households can require electricity-specific affordability measures even where they do not fall into the most severe poverty category.

Fourth, electrification monitoring should move beyond counting connections. Indicators of sustained usage, affordability, payment continuity and household expenditure burden would provide a more complete assessment of whether rural households can maintain meaningful electricity access.

Theoretical implications

The findings refine the energy ladder and sustainable livelihoods perspectives by demonstrating that household transition toward electricity depends on resource allocation as well as overall economic status. Expenditure pressure can interrupt the transition even where electricity is available and poverty does not statistically mediate the relationship. The results therefore support a more differentiated household-capability interpretation of rural electrification.

Limitations and future research

The cross-sectional design limits causal interpretation. The regression identifies statistical association rather than proving that changes in expenditure conditions cause changes in electricity access. Longitudinal household data would allow future research to examine how expenditure shocks, seasonal income and electricity adoption evolve over time.

The expenditure variable is a perception-based composite rather than a direct monetary measure. Future studies should combine the scale with objective household expenditure data, expenditure shares, connection costs, electricity bills and income measures. This would make it possible to estimate energy-burden ratios and test nonlinear affordability thresholds.

The two-component PCA structure also warrants further validation. Because the original project reports an unrotated component matrix, future research should use rotated exploratory factor analysis and confirmatory factor analysis to determine whether budget pressure and expenditure-management capacity form empirically distinct dimensions. These extensions could substantially strengthen the contribution for a high-ranking energy

REFERENCES

1. Ang'u, C., Muthama, N. J., Mutuku, M. A., & M'IKiugu, M. H. (2023). Analysis of energy poverty in Kenya and its implications for human health. Energy Policy, 176, 113506.
2. Blimpo, M. P., & Postepska, A. (2020). Why is household electricity uptake low in Sub-Saharan Africa? World Bank.

3. Goretzko, D., Pham, T. T. H., & Bühner, M. (2021). Exploratory factor analysis: Current use, methodological developments and recommendations for good practice. Current Psychology, 40, 3510-3521.
4. Hayes, A. F. (2022). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach (3rd ed.). Guilford Press.
5. Lee, K., Miguel, E., & Wolfram, C. (2020). Does household electrification supercharge economic development? Journal of Economic Perspectives, 34(1), 122-144.
6. Poblete-Cazenave, M., & Pachauri, S. (2021). A model of energy poverty and access: Estimating household electricity demand and appliance ownership. Energy Economics, 103, 105266. https://doi.org/10.1016/j.eneco.2021.105266
7. Schreiber, J. B. (2021). Issues and recommendations for exploratory factor analysis and principal component analysis. Research in Social and Administrative Pharmacy.
8. Shrestha, N. (2021). Factor analysis as a tool for survey analysis. American Journal of Applied Mathematics and Statistics, 9(1), 4-11.
9. Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediation analysis. Journal of Personality and Social Psychology.
10. Zuch, M. (2025). Rural electrification in sub-Saharan Africa: A willingness to pay analysis of electricity access in Kenya. Energy Policy, 199, 114720. https://doi.org/10.1016/j.enpol.2025.114720
11. Bajo-Buenestado, R. (2021). The effect of blackouts on household electrification status: Evidence from Kenya. Energy Economics, 94, 105067. https://doi.org/10.1016/j.eneco.2020.105067
12. Blimpo, M. P., Postepska, A., & Xu, Y. (2020). Why is household electricity uptake low in Sub-Saharan Africa? World Development, 133, 105002.
13. Dominguez, C., Orehounig, K., & Carmeliet, J. (2021). Understanding the path towards a clean energy transition and post-electrification patterns of rural households. Energy for Sustainable Development, 61, 46–64. https://doi.org/10.1016/j.esd.2021.01.002
14. Egli, F., Agutu, C., Steffen, B., & Schmidt, T. S. (2023). The cost of electrifying all households in 40 Sub-Saharan African countries by 2030. Nature Communications, 14, 5066. https://doi.org/10.1038/s41467-023-40612-3
15. International Energy Agency. (2024). Kenya 2024: Energy policy review. IEA.
16. Moshi, B. G. M. (2024). Affordability of electricity to rural consumers in Tanzania: An elephant in the room? Interdisciplinary Journal of Rural and Community Studies, 6. https://doi.org/10.38140/ijrcs-2024.vol6.02
17. Taneja, J. (2022). Rural electrification subsidy estimation: A spatial model development and case study. Environmental Research: Infrastructure and Sustainability. https://doi.org/10.1088/2634-4505/ac9711
18. World Bank. (2021). Energy access diagnostic report based on the Multi-Tier Framework: Kenya. World Bank.
19. Kou, Y., Hirmer, S., Yang, P., Leonard, A., & Egli, F. (2026). Assessing grid affordability for universal electricity access in Sub-Saharan Africa. Nature Communications, 17, 8455. https://doi.org/10.1038/s41467-026-75104-7
20. International Energy Agency. (2024). Kenya 2024: Energy policy review. International Energy Agency.
21. Moshi, B. G. M. (2024). Affordability of electricity to rural consumers in Tanzania: An elephant in the room? Interdisciplinary Journal of Rural and Community Studies, 6. https://doi.org/10.38140/ijrcs-2024.vol6.02
22. Dato, P., Hekponhoue, S., Lawson, L., Mukhaya, B., & Okyere, M. A. (2025). Implications of alleviating unreliable electricity supply for energy poverty: Evidence from households in Benin. Energy Economics, 146, 108548. https://doi.org/10.1016/j.eneco.2025.108548
23. Do, M. H., et al. (2024). Do indicators of safeguards influence off-grid solar choices? Assessing quality, affordability, and service models in Kenya. Energy Policy, 193, 114296. https://doi.org/10.1016/j.enpol.2024.114296
24. International Energy Agency. (2023). Electricity 2023: Analysis and forecast to 2026. International Energy Agency.
25. International Energy Agency. (2023). World energy outlook 2023. International Energy Agency.

26. International Renewable Energy Agency. (2023). Renewable energy statistics 2023. International Renewable Energy Agency.
27. International Renewable Energy Agency. (2024). Tracking SDG 7: The energy progress report 2024. World Bank.
28. United Nations Development Programme. (2023). Human development report 2023/2024: Breaking the gridlock. UNDP.
29. World Bank. (2023). Access to electricity (% of population): Kenya data indicators. World Bank Development Indicators.
30. World Bank. (2024). State of access to modern energy cooking services. World Bank.
31. Riva, F., Ahlborg, H., Hartvigsson, E., Pachauri, S., & Colombo, E. (2021). Electricity access and rural development: Review of complex socio-economic dynamics. Renewable and Sustainable Energy Reviews, 136, 110443.
32. Lee, K., Miguel, E., & Wolfram, C. (2020). Does household electrification supercharge economic development? Journal of Economic Perspectives, 34(1), 122–144.
33. Monyei, C. G., Adewumi, A. O., Jenkins, K. E. H., & Serestina, V. (2021). Energy affordability and household electricity access in developing economies. Energy Research & Social Science, 73, 101926.
34. Pelz, S., Pachauri, S., & Groh, S. (2022). A critical review of energy poverty measurement approaches and implications for policy. Energy Research & Social Science, 87, 102480.
35. Shahzad, U., Xia, W., & Hassan, S. T. (2022). Energy poverty, economic development and household welfare: Evidence from developing regions. Energy Economics, 112, 106126.
36. Kumar, P., & Managi, S. (2023). Energy access, affordability and sustainable development: Evidence from emerging economies. Energy Policy, 173, 113384.
37. Mutiso, R., & Baker, L. (2021). Energy transitions and electricity access in Sub-Saharan Africa: Challenges and opportunities. Energy Research & Social Science, 79, 102153.
38. Ouedraogo, N. S. (2021). Energy consumption and human development in Sub-Saharan Africa: Evidence from household perspectives. Energy Economics, 94, 105050.