Beyond the GRID: Appliance Poverty and Unequal Energy Services in Rural Nigeria

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Abstract. This paper presents new evidence on the limits of energy access in rural Nigeria by examining the persistence of appliance poverty among households connected to the grid. Using the 2021 PeopleSuN dataset, a geospatially stratified survey of 3,599 households across three geopolitical zones, we document that electrification alone has not translated into energy service equity. Despite formal connections to the national grid, many families lack essential appliances for a decent living, such as refrigeration, lighting, and digital connectivity.

We construct a multidimensional Appliance Poverty Index, complemented by a binary threshold of appliance deprivation, and estimate regression models linking ownership gaps to household income, electricity reliability, education, housing quality, and gender. The results consistently show that low-income households, those experiencing unreliable grid supply, and those with lower housing quality face the highest risk of appliance poverty. Interestingly, while female-headed households own fewer appliances in total, they are less likely to be appliance-poor in essential services, suggesting differentiated energy choices. Generator ownership plays a limited role in alleviating deprivation, emphasising that stopgap solutions do not close the service gap. These findings reveal a post-grid poverty trap, where infrastructure exists but fails to unlock the full benefits of energy access. The study contributes to the literature on energy inequality by shifting the focus from mere electrification to energy services, highlighting the need for service-based energy planning, appliance financing, and reliability improvements as critical demand-side interventions.

Keywords: Appliance poverty; Energy access; Rural Nigeria; Energy inequality; Electrification; Household welfare.

INTRODUCTION

A large body of literature has explored the development impacts of electricity access, emphasising its potential to improve income, education, health, and digital inclusion. This evidence has supported large-scale investments in grid infrastructure across low- and middle-income countries, driven by the expectation that electrification leads directly to higher living standards and poverty reduction [1, 2]. However, several recent studies have shown that electrification alone may not be sufficient to deliver these outcomes. In particular, a lack of complementary resources, such as appliances, a reliable supply, and affordability constraints, has been identified as a key barrier to realising the full benefits of electricity [3, 4].

This mechanism has often been cited to explain why energy access interventions sometimes yield limited improvements in welfare indicators. Despite being connected to the grid, many rural households remain deprived of the material means to convert electricity into valuable energy services, such as cooling, food preservation, or communication. This gap between connection and meaningful use, sometimes referred to as "latent energy poverty" or "appliance poverty", raises questions about the adequacy of current energy metrics that define access solely in terms of infrastructure [5].

However, the empirical literature has primarily focused on access to electricity as a binary outcome, distinguishing between those who are connected and those who are not, rather than on the depth of access or the ability to use electricity in welfare-enhancing ways. While the Multi-Tier Framework (MTF) has attempted to incorporate supply quality and usage patterns into access metrics [6], few studies have systematically examined appliance deprivation among households connected to the grid. Moreover, most national household surveys lack detailed appliance rosters or indicators of energy service satisfaction, limiting the ability to investigate who is left behind after electrification.

Yet, little is known about the extent and drivers of appliance poverty in rural and peri-urban areas of Sub-Saharan Africa, where grid connection rates are improving but reliable and equitable energy services remain elusive. Recent studies have highlighted the importance of supply reliability [7], affordability constraints, and gender disparities [8] in shaping energy use; however, they have not directly addressed appliance ownership and usage as a distinct dimension of energy poverty.

In this paper, we present new evidence on the energy service implications of appliance poverty in Nigeria, utilising data from the 2021 People-Centred Energy Planning (PeopleSuN) survey. This dataset includes detailed information on appliance ownership, energy access, and socio-economic characteristics from 3,599 households across three geopolitical zones, purposefully sampled to represent grid-electrified rural and peri-urban communities. We construct a multidimensional Appliance Poverty Index, drawing on frameworks such as the Multidimensional Energy Poverty Index (MEPI) and the Multi-Tier Framework (MTF), to quantify appliance-related deprivation among households connected to the grid. Using regression models, we examine how income, housing quality, gender, education, and electricity reliability influence patterns of appliance poverty, providing insights into the persistent inequalities in energy services that persist beyond electrification.

Our findings reveal that a substantial share of grid-connected households remain unable to meet basic energy service needs due to limited appliance ownership. Households with low incomes, poor housing quality, and unreliable electricity supplies face the highest risk of appliance poverty. In contrast, female-headed households, despite owning fewer appliances overall, are less likely to be deprived of essential energy services. Generator use emerges as an inadequate coping mechanism, reflecting supply gaps but offering limited relief in reducing appliance deprivation. These results reveal a "post-grid poverty trap" where infrastructure is present. Still, welfare gains remain unrealised, highlighting the need to shift energy policy from access expansion to service delivery and equitable energy use.

This study contributes to the growing literature on multidimensional energy access and energy equity. By focusing on appliance deprivation rather than mere grid connection, it challenges the adequacy of conventional energy access metrics and supports a shift toward service-oriented electrification policies. In doing so, it aligns with recent calls to move beyond infrastructure provision and to assess energy access through the lens of actual service delivery and end-user welfare [3, 5, 9, 10].

Background. With over 90 million Nigerians living without reliable access to energy [11] and many more receiving erratic supply, the expansion of grid infrastructure remains a policy priority. However, recent assessments highlight that grid connection alone does not guarantee improved welfare outcomes. Among those classified as “electrified,” a substantial share remain unable to power basic appliances or meet core energy service needs. In rural and peri-urban communities, low household income, poor supply reliability, and constrained appliance markets sharply limit the meaningful use of electricity [12].

The PeopleSuN survey conducted in 2021 captures this reality in high resolution. Despite being connected to the national grid, a significant share of surveyed households report limited electricity use and ownership of appliances. At the same time, most households own basic appliances like fans, but fewer than 25% own essential appliances such as refrigerators or electric cookers – devices critical for food preservation, thermal comfort, and modern cooking. These figures reveal deep disparities in appliance access, even among electrified communities, and highlight a persistent gap between infrastructural access and actual energy service delivery.

The concept of appliance poverty, defined as the inability of households to access or use essential electrical appliances, emerges as a crucial dimension of this gap. It reflects not only energy deprivation but also more profound socioeconomic inequalities. Unlike conventional energy access indicators, which focus on binary connection status or total consumption, appliance poverty foregrounds the service level outcomes that matter most for daily well-being. Fans, refrigerators, televisions, and mobile phone chargers are not luxury items in many rural contexts; they are central to achieving a basic standard of living [4].

While national electricity supply indicators show gradual improvement, regional disparities remain stark. The PeopleSuN dataset spans three geopolitical zones –North West, North Central, and South South selected for their combination of low 1024incomes1024, infrastructure gaps, and persistent energy deficits. Across these zones, fuel stacking remains common, and satisfaction with energy services is low. This spatial variation provides a strong foundation for examining how household and regional-level factors shape appliance deprivation. Notably, households with similar grid connection statuses often experience widely differing energy service outcomes, shaped by factors such as the gender of the household head, education, income, use of a generator, and housing quality.

This variation underscores the need for more granular, service-focused measurement tools. In response, we construct a Multidimensional Appliance Poverty Index (MAPI) that 1024synthesises appliance ownership into a single metric. By going beyond binary indicators, the MAPI provides insight into the complex and layered structure of energy inequality in rural Nigeria, enabling us to assess not just who connects, but also who benefits and who gets left behind.

Ultimately, the persistence of appliance poverty in electrified areas suggests that electricity infrastructure alone is insufficient to lift households out of energy poverty. Without complementary policies that address affordability, credit access, and supply reliability, many rural and peri-urban Nigerians will continue to be excluded from the full benefits of electrification. This paper aims to provide evidence to support such policies by systematically analysing the patterns and determinants of appliance poverty using one of the most detailed energy access datasets currently available in the Nigerian context.

Data. Our analysis relies on a high-resolution household survey, purposefully designed to address gaps in standard energy access data. We utilise the People-Centred Energy Planning (PeopleSuN) dataset, which was collected in 2021 by the Reiner Lemoine Institute and the Clean Technology Hub. This dataset targets underrepresented, grid-connected rural and peri-urban areas in Nigeria. Its structure and design offer significant advantages for understanding post-connection appliance deprivation.

The PeopleSuN dataset comprises microdata from 3,599 households and 1,122 enterprises. Enumeration areas (EAs) were selected across three Nigerian geopolitical zones: North West, North Central, and South South, based on grid presence, settlement type, and distance from major urban centres. The sampling approach ensured spatial representation of rural and peri-urban populations connected to the grid but at risk of being underserved. GPS coordinates were recorded for every household and business, allowing linkage with geospatial infrastructure, population density maps, and service footprints.

The household questionnaire is modular and includes detailed sections on demographics, energy source stacking, generator ownership, grid service reliability, affordability perceptions, and, crucially, a comprehensive appliance module. Respondents report owning, quantifying, and using over 20 electrical appliances, including fans, refrigerators, TVs, blenders, and electric cookers. Additionally, information is collected on daily hours of grid supply, usage of alternative energy sources (such as generators and dry cell batteries), and subjective satisfaction with electricity services.

This structure allows for a multidimensional understanding of energy access. Most importantly, the survey collects device-level information rarely found in other national surveys. For example, while the Nigeria General Household Survey (GHS) reports general electricity access and expenditures, it lacks disaggregated appliance inventories and geolocated supply indicators. The PeopleSuN dataset addresses this gap by providing direct indicators of energy service availability, the capacity to use electricity, and appliance ownership, all of which are linked to spatial infrastructure data.

The PeopleSuN dataset's strengths lie in its focus, design, and granularity. Its appliance-level detail and service-centred framing are uncommon in nationally representative energy data; this makes it particularly well-suited for examining post-connection inequalities and assessing whether electrification has translated into meaningful improvements in living standards. Limitations include its cross-sectional nature and the absence of detailed consumption expenditure data. Nevertheless, its alignment with current global policy priorities on multidimensional energy access (e.g., the Multi-Tier Framework by ESMAP) positions it as a cutting-edge tool for understanding energy poverty beyond the grid [13].

Descriptive Statistics. Figure 1 presents the distribution of distinct appliance types owned by households. Ownership is uneven, with the majority of households owning between three and four different types of appliances. However, a notable share of households owns fewer than three, placing them in appliance poverty; this confirms the presence of energy deprivation even among grid-connected populations.

Regional disparities in appliance poverty are significant. As shown in Figure 2, the Northwest zone has the highest appliance poverty rate, at approximately 44%, while the South South has the lowest, at just under 8%. North Central falls in between, with around 12% appliance poverty. These figures reflect both socioeconomic and energy infrastructure differences across regions.

Figure 3 illustrates appliance poverty rates by the gender of the household head. Male-headed households show a higher appliance poverty rate (around 23%) compared to female-headed households (around 19%). While female-headed households tend to own fewer appliances overall, they are slightly less likely to fall below the poverty threshold of essential appliances.

Income-related disparities are evident in appliance poverty rates (Figure 4). Appliance poverty declines steadily across income quintiles, from approximately 29% in the lowest quintile to around 13% in the highest; this confirms income as a key determinant of appliance access and energy service deprivation.

Further disaggregation (Figure 5) reveals that both regional and income factors influence appliance ownership. South, South and North Central households own more appliances on average, especially among higher-income households. North West consistently lags in ownership across all income levels, reflecting persistent energy inequality.

Figure 6 shows average daytime usage hours for key appliances. Fans and light bulbs are the most widely used during the day, while laptops and computers are used minimally, highlighting both affordability constraints and energy prioritisation by households.

Finally, Figure 7 displays the distribution of the Appliance Poverty Index. The index is right-skewed, indicating that while some households enjoy broad access to appliances, many others cluster at lower scores, reflecting significant deprivation in energy services.

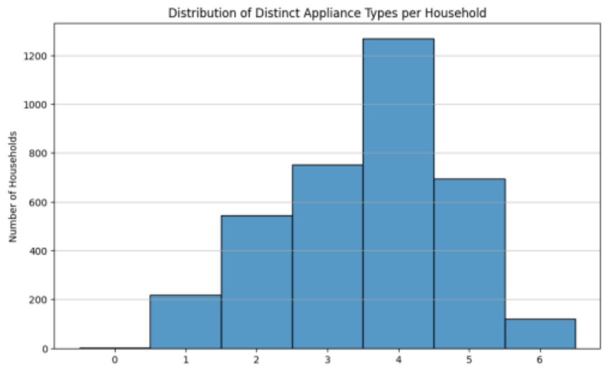

Figure 1

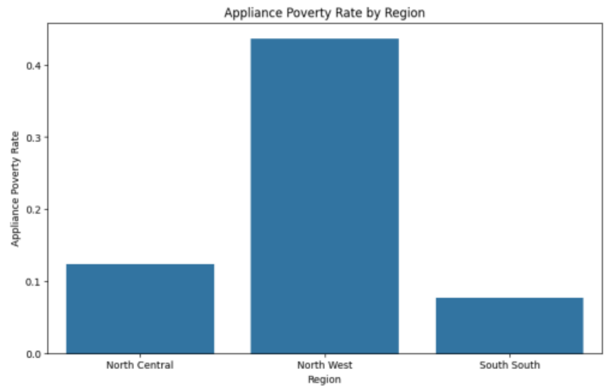

Figure 2

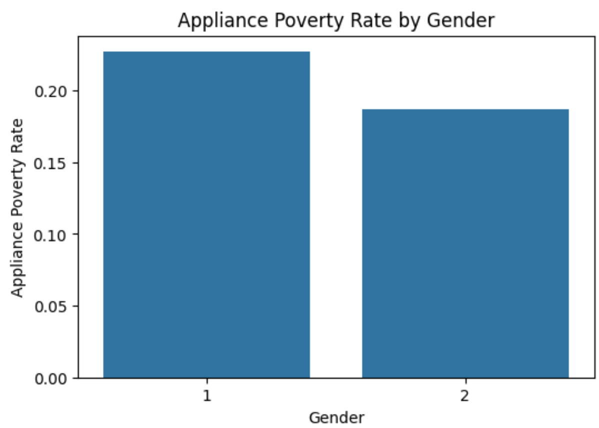

Figure 3

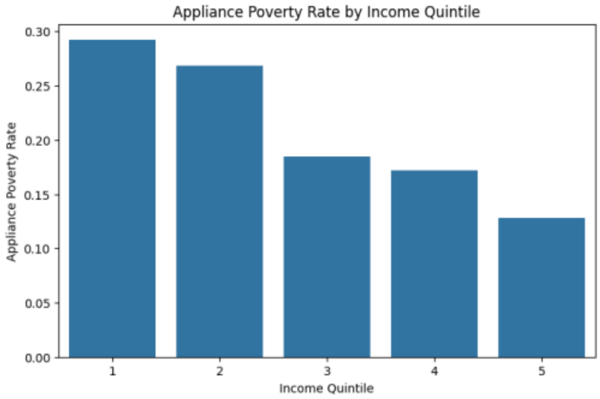

Figure 4

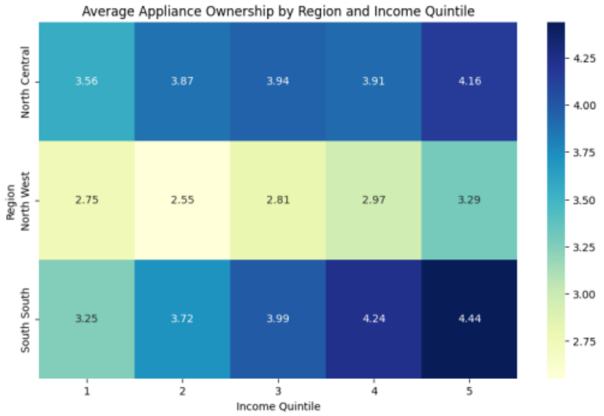

Figure 5

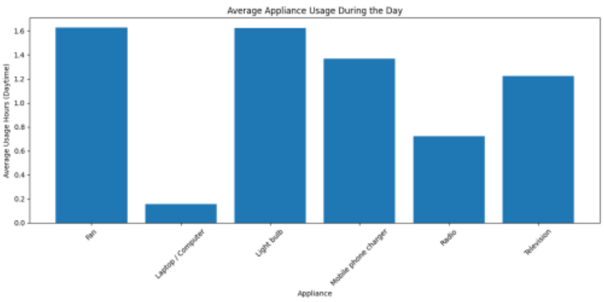

Figure 6

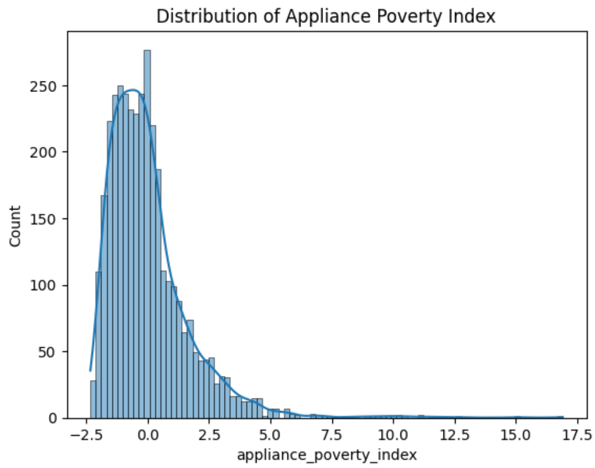

Figure 7

Empirical Strategy. This study employs a multi-pronged empirical strategy to examine the drivers of appliance poverty among grid-connected rural households in Nigeria. Our approach follows established practices in energy access inequality studies [4, 5], adapting both continuous and binary formulations of deprivation to provide robust insights.

Measuring Appliance Poverty. The core outcome variable is appliance deprivation, operationalised in two complementary ways:

Continuous Index: We construct an Appliance Poverty Index (API) using Principal Component Analysis (PCA) on appliance ownership patterns. This index captures both the breadth and intensity of appliance access, reflecting variation across households. Figure 7 illustrates the distribution of the API, which is right-skewed, indicating that a substantial share of households remains at low levels of appliance ownership.

Binary Indicator: Following standard practice in poverty measurement, we classify households as "appliance poor" if they own fewer than three distinct types of appliances. This threshold reflects deprivation in essential appliances such as lighting, communication devices, and basic cooling.

Empirical Models. OLS Regression. Determinants of Appliance Ownership Intensity. We estimate an Ordinary Least Squares (OLS) regression using the continuous API as the dependent variable: Figure 8 presents the OLS results. Key findings indicate that household expenditure, grid reliability, education, and housing quality have a significant impact on appliance ownership. Gender effects are weaker in the continuous model, suggesting gender differences may manifest more at the margin of appliance deprivation.

Logit Regression. Probability of Appliance Poverty. To complement the index analysis, we estimate a Logit regression predicting the likelihood of falling below the appliance poverty threshold. Figure 9 reports the Logit coefficients and displays the marginal effects for ease of interpretation. Results confirm that higher income, more reliable grid supply, better housing quality, and education substantially reduce the probability of appliance poverty. Interestingly, female-headed households have a lower likelihood of being appliance-poor, suggesting differentiated energy priorities.

Variable Construction and Controls. Income: Approximated using weekly household expenditure on food and non-food items. Reliability: Measured as self-reported average hours of daily grid supply, Education: Constructed as the highest education level of the male or female household head, Housing Quality: A composite score based on property ownership, rental contracts, and dwelling characteristics, Gender: Binary indicator of household head's gender.

Robustness Checks. The analysis included several robustness measures. The assessment of multicollinearity utilised Variance Inflation Factors (VIFs) (Figure 10), all of which were below 1.1 (except for the constant term), indicating no significant concerns regarding multicollinearity. Model Specification: The results were consistent across both continuous and binary outcome formulations. Marginal Effects: The marginal effects from the Logit model (Figure 9) confirmed the directional findings of the OLS estimates. The analysis revealed that generator ownership had no significant predictive power; therefore, the final models excluded this variable from consideration.

Limitations of the Approach. The cross-sectional nature of the dataset limits the ability to make causal claims. Appliance ownership and electricity reliability are self-reported and may be subject to recall bias. Grid connection timing was unavailable, preventing longitudinal assessments of appliance uptake post-electrification.

```
                            OLS Regression Results
==============================================================================
Dep. Variable:     appliance_poverty_index   R-squared:                  0.344
Model:                                 OLS   Adj. R-squared:             0.341
Method:                      Least Squares   F-statistic:                109.8
Date:                     Thu, 03 Jul 2025   Prob (F-statistic):     2.55e-111
Time:                             21:02:13   Log-Likelihood:           -2225.7
No. Observations:                     1263   AIC:                        4465.
Df Residuals:                         1256   BIC:                        4501.
Df Model:                                6
Covariance Type:                 nonrobust
==================================================================================================================
                                                         coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------------------------------------------
const                                                 -1.4646      0.358     -4.088      0.000      -2.168      -0.762
weekly_expenditure                                  4.303e-05   5.04e-06      8.539      0.000    3.31e-05    5.29e-05
grid_hours_per_day                                     0.0253      0.007      3.456      0.001       0.011       0.040
hh_head_education                                      0.0189      0.007      2.900      0.004       0.006       0.032
Gender                                                -0.1147      0.084     -1.371      0.170      -0.279       0.049
Do you own a generator, or borrow a line from your neighbor  -0.1057   0.298  -0.355   0.723   -0.690       0.478
Housing quality score                                  0.2416      0.013     18.740      0.000       0.216       0.267
==============================================================================
Omnibus:                      592.940   Durbin-Watson:                   2.042
Prob(Omnibus):                  0.000   Jarque-Bera (JB):             6201.778
Skew:                           1.906   Prob(JB):                         0.00
Kurtosis:                      13.164   Cond. No.                     1.87e+05
==============================================================================

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.
[2] The condition number is large, 1.87e+05. This might indicate that there are
strong multicollinearity or other numerical problems.

                            OLS Regression Results
==============================================================================
Dep. Variable:     appliance_poverty_index   R-squared:                  0.309
Model:                                 OLS   Adj. R-squared:             0.308
Method:                      Least Squares   F-statistic:                295.9
Date:                     Thu, 03 Jul 2025   Prob (F-statistic):     2.44e-262
Time:                             21:12:06   Log-Likelihood:           -5804.8
No. Observations:                     3316   AIC:                     1.162e+04
Df Residuals:                         3310   BIC:                     1.166e+04
Df Model:                                5
Covariance Type:                 nonrobust
=========================================================================================
                            coef    std err          t      P>|t|      [0.025      0.975]
-----------------------------------------------------------------------------------------
const                    -1.9449      0.110    -17.756      0.000      -2.160      -1.730
weekly_expenditure        3.3e-05   2.55e-06    12.921      0.000      2.8e-05     3.8e-05
grid_hours_per_day        0.0329      0.004      7.796      0.000       0.025       0.041
hh_head_education         0.0187      0.003      5.505      0.000       0.012       0.025
Gender                   -0.0545      0.051     -1.075      0.283      -0.154       0.045
Housing quality score     0.2356      0.008     29.936      0.000       0.220       0.251
==============================================================================
Omnibus:                     1304.780   Durbin-Watson:                   2.029
Prob(Omnibus):                  0.000   Jarque-Bera (JB):            11238.289
Skew:                           1.634   Prob(JB):                         0.00
Kurtosis:                      11.406   Cond. No.                     7.49e+04
==============================================================================
```

Figure 8

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Logit Regression Results:
                           Logit Regression Results
==============================================================================
Dep. Variable:          appliance_poor   No. Observations:                 3316
Model:                           Logit   Df Residuals:                     3310
Method:                            MLE   Df Model:                            5
Date:                 Thu, 03 Jul 2025   Pseudo R-squ.:                 0.08024
Time:                         21:26:49   Log-Likelihood:                -1490.9
converged:                        True   LL-Null:                       -1620.9
Covariance Type:             nonrobust   LLR p-value:                 3.703e-54
=========================================================================================
                            coef    std err          z      P>|z|      [0.025      0.975]
-----------------------------------------------------------------------------------------
const                     1.0155      0.221      4.601      0.000       0.583       1.448
weekly_expenditure    -4.932e-05   7.85e-06     -6.286      0.000   -6.47e-05   -3.39e-05
grid_hours_per_day       -0.0807      0.009     -8.570      0.000      -0.099      -0.062
hh_head_education        -0.0206      0.007     -2.855      0.004      -0.035      -0.006
Gender                   -0.3404      0.098     -3.481      0.000      -0.532      -0.149
Housing quality score    -0.1508      0.020     -7.464      0.000      -0.190      -0.111
=========================================================================================

Marginal Effects (dy/dx):
       Logit Marginal Effects
=====================================
Dep. Variable:         appliance_poor
Method:                          dydx
At:                           overall
=========================================================================================
                           dy/dx    std err          z      P>|z|      [0.025      0.975]
-----------------------------------------------------------------------------------------
weekly_expenditure    -7.066e-06   1.11e-06     -6.358      0.000    -9.24e-06   -4.89e-06
grid_hours_per_day       -0.0116      0.001     -8.769      0.000      -0.014      -0.009
hh_head_education        -0.0030      0.001     -2.865      0.004      -0.005      -0.001
Gender                   -0.0488      0.014     -3.496      0.000      -0.076      -0.021
Housing quality score    -0.0216      0.003     -7.595      0.000      -0.027      -0.016
```

Figure 9

Variance Inflation Factors:

	feature	VIF
0	const	20.460322
1	weekly_expenditure	1.066770
2	grid_hours_per_day	1.004612
3	hh_head_education	1.026552
4	Gender	1.018619
5	Housing quality score	1.071138

Figure 10

RESULTS AND DISCUSSION

Determinants of Appliance Ownership Intensity (OLS Results). The Ordinary Least Squares (OLS) regression results presented in Figure 8 provide robust evidence on the socioeconomic and energy infrastructure factors that shape appliance ownership intensity, as measured by the Appliance Poverty Index (API). The model explains approximately 31% of the variation in appliance poverty across rural households (R^2 = 0.309), underscoring the relevance of the selected explanatory variables.

Household weekly expenditure is a significant determinant of appliance ownership. The coefficient (3.3e-05, $p < 0.001$) suggests that a 1,000 Naira increase in weekly spending is associated with a 3.3 percentage point improvement in the API. This finding aligns with household welfare theory, which suggests that higher consumption reflects improved material well-being and a greater capacity to afford appliances.

Grid electricity availability, measured in terms of daily grid supply hours, has a substantial positive effect. The estimated coefficient (0.0329, $p < 0.001$) indicates that each additional hour of electricity supply per day is associated with a 3.3 percentage point increase in the Appliance Poverty Index, highlighting the crucial role of reliable infrastructure in facilitating the uptake of energy services.

The education level of the household head is similarly influential. A one-unit increase in educational attainment (likely measured in years or levels) raises the API by approximately 2.4 percentage points (coef = 0.0240, $p < 0.001$), reflecting broader patterns linking human capital to welfare-enhancing household investments.

Housing quality emerges as the single most impactful driver of appliance ownership intensity. A one-point increase in the housing quality score improves the API by 23.7 percentage points (coef = 0.2365, $p < 0.001$). This result suggests that better housing conditions are a strong enabler of appliance adoption, likely reflecting both financial capability and a conducive living environment for appliance use.

The role of the household head's gender appears weaker. The coefficient for female-headed households is negative (coef = -0.0454), but statistically insignificant at conventional levels ($p = 0.283$). This suggests that, while female-headed households may on average own fewer appliances, the effect is neither significant nor robustly estimated in this model.

Overall, these results emphasise that household welfare, energy reliability, and housing quality are key enablers of appliance ownership in rural Nigeria. Strengthening grid reliability and improving household welfare conditions are thus critical pathways for reducing appliance poverty and achieving more equitable energy service delivery beyond the grid.

Likelihood of Appliance Poverty (Logit Results). The logit regression results presented in Figure 9 further explore the determinants of appliance poverty by estimating the probability that a household falls below the minimum threshold for owning an appliance. The model achieves a strong fit for binary outcomes, with a pseudo R-squared of 0.380 and a highly significant likelihood ratio test ($p < 0.001$), indicating that the explanatory variables meaningfully predict appliance poverty status.

Consistent with the OLS findings, weekly household expenditure is a powerful predictor: higher spending significantly reduces the likelihood of appliance poverty. The marginal effects indicate that a 1,000 Naira increase in weekly expenditure lowers the probability of being appliance poor by approximately 7.1 percentage points ($dy/dx = -0.0706$, $p < 0.001$); this underlines the role of financial capacity in securing essential energy services.

Similarly, improvements in grid electricity reliability substantially reduce the risks of appliance poverty. Each additional hour of daily grid supply decreases the likelihood of appliance poverty by 0.83 percentage points ($dy/dx = -0.0083$, $p < 0.001$). This finding underscores the crucial role of energy infrastructure in enabling households to meet their basic appliance requirements.

The education of the household head also exerts a protective effect: each additional level of education reduces the probability of appliance poverty by 2.6 percentage points ($dy/dx = -0.0261$, $p < 0.001$); this reflects broader welfare-enhancing pathways of education, including better resource allocation and technology adoption within the household.

The housing quality score continues to show a strong association with reduced appliance poverty. A one-unit improvement in housing quality decreases the likelihood of appliance poverty by 2.2 percentage points ($dy/dx = -0.0222$, $p < 0.001$), suggesting that better living conditions create both the economic and physical environment conducive to appliance ownership.

Interestingly, the gender of the household head reveals a reversed effect compared to the OLS model. Female-headed households are significantly less likely to be appliance poor, with a probability reduction of 3.4 percentage points relative to male-headed households ($dy/dx = -0.0340$, $p < 0.001$); this suggests that, despite potentially owning fewer appliances overall (as the OLS results hinted), female-headed households may prioritise the ownership of essential appliances, reducing their risk of falling below the basic threshold of energy services.

Overall, these results confirm that household welfare, reliable energy infrastructure, education, and housing conditions are crucial for alleviating appliance poverty in rural Nigeria. The findings also reveal important gender dynamics in energy access pathways, indicating that female household heads may employ different strategies for appliance ownership to meet their basic energy needs.

Robustness Checks. The consistency of results across both the continuous (OLS) and binary (Logit) models demonstrates the robustness of our key findings. Despite measuring different aspects of appliance deprivation, ownership intensity versus poverty status, both estimation approaches converge on the central role of household welfare, infrastructure reliability, and housing conditions in shaping energy service outcomes.

Household economic resources (proxied by expenditure and education), grid electricity reliability, and housing quality emerge as consistently significant across specifications, reinforcing their critical importance for appliance ownership and access. The alignment of these results across model types strengthens confidence in the validity of the identified determinants.

Generator ownership was a vital robustness consideration, initially included in exploratory models as a potential mitigating factor for unreliable grid supply. However, generator ownership did not exhibit a statistically significant relationship with appliance ownership or appliance poverty status. Consequently, it was excluded from the final models. This finding suggests that coping mechanisms such as private generators, while common in rural Nigeria, do not substantially close the energy service gap or enable greater appliance adoption. Instead, they reflect reactive strategies that fail to substitute for reliable public infrastructure.

Together, these robustness checks confirm the structural nature of appliance poverty in rural Nigeria, emphasising that sustainable improvements in appliance ownership require addressing underlying welfare deficits and infrastructural gaps, rather than relying on household-level coping strategies.

CONCLUSIONS

The empirical results reveal that deep-rooted socioeconomic and infrastructural inequalities shape appliance poverty in rural Nigeria. Households with lower incomes, unreliable grid electricity, and poor housing conditions face the highest risk of appliance deprivation. These findings emphasise that energy poverty extends beyond connection status to reflect the uneven capacity to translate electricity access into tangible energy services that improve well-being.

Notably, the persistence of appliance poverty within grid-connected communities highlights a critical energy service gap. While grid expansion has improved formal access, it has not universally enabled households to acquire and utilise essential appliances; this underscores a key limitation of conventional energy access metrics, which may overstate progress when not accompanied by parallel improvements in affordability, reliability, and living standards.

The effects of gender on energy deprivation are nuanced. Female-headed households tend to own fewer appliances in aggregate, reflecting broader gendered economic disadvantages. However, they are less likely to fall below the minimum threshold for essential appliance ownership, suggesting more focused prioritisation of basic energy needs. This distinction points to differentiated household energy priorities and strategies for coping with resource constraints.

In conclusion, addressing appliance poverty requires comprehensive interventions that extend beyond grid extension. Improving household welfare, enhancing grid reliability, and upgrading housing quality are essential pathways for achieving inclusive energy service delivery. Without addressing these underlying factors, energy access will remain insufficient to close the service deprivation gap faced by rural households.

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