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Customer Attrition and Informal Energy Migration among Electricity Distribution Company Subscribers in Nigeria: Drivers and Policy Implications

Godwin Orakpowenri Orovwiroro, PhD, DBA, FIMC, CGEIT
University of Port Harcourt Business School

ABSTRACT: Nigeria's electricity distribution sector faces a structural crisis driven by the progressive withdrawal of customers from the national grid. This study investigates the drivers of customer attrition and informal energy migration among subscribers of six electricity distribution companies (DisCos), each drawn from one of Nigeria's six geopolitical zones: Abuja Electricity Distribution Company (AEDC, North-Central), Kano Electricity Distribution Company (KEDC, North-West), Yola Electricity Distribution Company (YEDC, North-East), Enugu Electricity Distribution Company (EEDC, South-East), Port Harcourt Electricity Distribution Company (PHEDC, South-South), and Ikeja Electric Distribution Company (IKEDC, South-West). Drawing on longitudinal secondary data spanning 2013–2025 and primary survey data from 1,850 household and commercial customers across the six zones, the study employs a convergent mixed-methods design underpinned by Institutional Theory, Resource-Based View, and Agency Theory. Four independent variables—supply interruption frequency and duration, off-grid energy affordability, customer perception of DisCo service quality, and tariff regime/willingness-to-pay thresholds—are regressed against four dependent variables: subscriber churn rate, billed energy volume per customer segment, DisCo revenue per connected customer, and rate of informal disconnection from the national grid. Findings reveal that average daily grid supply fell from 6.7 hours in 2013 to 4.0 hours in 2025, while informal disconnection rates among sampled DisCos range from 18.3% (IKEDC) to 38.2% (YEDC). Structural equation modelling confirms that supply reliability ($\beta = -0.421$, $p < 0.001$) and service quality perception ($\beta = -0.389$, $p < 0.001$) are the strongest predictors of informal migration. Cumulatively, informal defection erodes sector revenue by an estimated ₦284 billion annually. The study proposes seven evidence-based policy interventions targeting grid reliability, tariff reform, DisCo recapitalisation, and hybrid grid integration.

KEYWORDS: customer attrition, informal energy migration, electricity distribution companies, off-grid energy, DisCo revenue erosion, Nigeria electricity sector, subscriber churn, energy poverty, tariff reform, NERC regulation

INTRODUCTION

Nigeria's electricity sector privatisation, completed under the Power Sector Reform Act (EPSR Act) of 2005 and the subsequent unbundling of the Power Holding Company of Nigeria (PHCN) in 2013, was premised on the expectation that private capital and commercial discipline would catalyse a turnaround in distribution efficiency, service quality, and investment in network infrastructure (Adenikinju, 2005; World Bank, 2014). More than a decade after the transfer of distribution assets to eleven successor DisCos, however, the sector confronts a paradox that threatens the foundational logic of the reform: connected customers are progressively withdrawing from the grid, not through formal disconnection notices, but through the quiet, self-organised migration to solar photovoltaic (PV) systems, battery-inverter combinations, petrol and diesel generators, and licensed or unlicensed mini-grids (Oke, Akinwale, & Abolarin, 2021; NERC, 2023).

This phenomenon, herein termed informal energy migration, is substantively different from load shedding or technical disconnection. It represents a deliberate, capital-committing decision by customers—household and commercial alike—to reduce or eliminate dependence on DisCo-supplied electricity while retaining, in most cases, their formal connection to the distribution network. The customer remains registered, may receive a meter reading, and may even occasionally draw from the grid during periods of reliable supply; yet the bulk of their energy consumption and expenditure has shifted to off-grid or distributed renewable energy (DRE) alternatives. From the DisCo's perspective, such a customer is functionally lost: their billed energy consumption falls, their willingness-to-pay tariff-reflective prices erodes, and their contribution to cost recovery declines precipitously (Okonkwo & Emodi, 2022; Ikechi & Nwosu, 2024).

The macroeconomic context amplifies these dynamics. Nigeria's inflation rate, which exceeded 33% in early 2024 (National Bureau of Statistics [NBS], 2024), has simultaneously made grid electricity tariffs increasingly unaffordable and, paradoxically, reduced the real cost of Chinese-manufactured solar panels and lithium-ion batteries denominated in US dollars—whose naira-equivalent prices, while nominally elevated, offer increasingly favourable levelised cost of energy (LCOE) comparisons with metered or estimated DisCo supply. The naira's depreciation from approximately NGN 197/USD in 2013 to NGN 1,580/USD in 2025 (Central Bank of Nigeria [CBN], 2025) has compressed DisCo operational headroom while simultaneously making off-grid capital equipment more accessible through fintech-enabled pay-as-you-go (PAYG) models (Adewale, Okafor, & Babatunde, 2023).

The revenue consequences for DisCos are severe. Based on data from the Nigerian Electricity Regulatory Commission (NERC) and Electricity Regulatory Commission Annual Reports, collection efficiency across DisCos averages 60.4% against a billed amount that is itself understated due to metering gaps estimated at 47% of connections (NERC, 2024). When the additional erosion of the billable base caused by informal migration is layered on top of existing ATC&C losses, the sector's financial sustainability—already undermined by legacy gas-supply constraints, transmission bottlenecks, and forex-denominated obligations to independent power producers (IPPs)—faces existential pressure (Ekpemiro, 2022; PricewaterhouseCoopers Nigeria, 2023).

This study addresses that gap by undertaking a systematic, cross-zonal investigation of the drivers of customer attrition and informal energy migration, using a mixed-methods design that integrates twelve years of longitudinal secondary data with primary survey evidence from 1,850 respondents across six DisCo licence areas. The six DisCos selected—AEDC, KEDC, YEDC, EEDC, PHEDC, and IKEDC—ensure geographic representation across Nigeria's six geopolitical zones and encompass a spectrum of operational contexts, from the dense commercial environment of Lagos to the sparse peri-urban zones of the North-East.

STATEMENT OF THE PROBLEM

The central problem confronting Nigeria's electricity distribution sub-sector is the progressive erosion of the effective customer base through informal energy migration. While official metrics report total registered connections of approximately 9.6 million customers as of 2024 (NERC, 2024), field evidence and survey data reveal that a substantial and growing proportion of these registered customers have effectively exited the grid as their primary energy source. This silent attrition is not captured in official DisCo churn statistics, which typically record only customers who formally request disconnection—a rarity in the Nigerian context, given that formal disconnection entails surrendering infrastructure investments (meters, service cables) made by the customer.

Four specific dimensions of the problem motivate this study. First, the average number of daily supply hours delivered by the sampled DisCos has declined from 6.7 hours in 2013 to an estimated cc, with the North-East corridor (YEDC) recording figures as low as 1.5 hours per day. These figures fall far below the Nigerian Electricity Regulatory Commission's minimum service standard targets and are incompatible with productive commercial or industrial activity, driving customers toward self-generation as an operational necessity rather than a preference (Akarakiri, Alabi, & Ajisafe, 2020).

Second, the rapid decline in global solar PV module prices—from USD 0.72/Wp in 2015 to an estimated USD 0.18/Wp in 2025 (International Renewable Energy Agency [IRENA], 2024)—combined with the proliferation of PAYG solar finance products targeting Nigerian low- and middle-income households, has lowered the capital barrier to entry for off-grid energy significantly. The result is a structural shift in the competitive dynamics between grid electricity and distributed alternatives, one that DisCos are institutionally ill-equipped to counter (Onochie, Okonkwo, & Chukwu, 2022).

Third, consumer trust in DisCos has deteriorated markedly. Survey data from this study indicate that only 19.3% of respondents rated their DisCo's service quality as 'satisfactory' or better, and 67.4% reported that frustration with supply reliability was the primary motivation for their investment in off-grid alternatives. This trust deficit has compounded the tariff resistance that greets periodic Multi-Year Tariff Order (MYTO) adjustments, undermining DisCos' ability to signal their commitment to service improvement through cost-reflective pricing.

Fourth, informal energy migration creates a self-reinforcing cycle that this study conceptualises as the Utility Revenue Erosion Cycle (UREC): declining revenue reduces DisCo capacity for capital expenditure; inadequate investment perpetuates supply unreliability; persistent unreliability accelerates informal migration; migration further reduces revenue. Without external intervention, this cycle produces a trajectory toward sectoral insolvency, as evidenced by the accumulated DisCo legacy debt of approximately USD 4.2 billion reported by the Federal Ministry of Finance in 2024 (Federal Ministry of Finance [FMF], 2024).

RESEARCH OBJECTIVES

The overarching objective of this study is to determine the extent to which informal energy migration among registered DisCo customers is driven by supply unreliability, off-grid affordability, service quality perceptions, and tariff regime characteristics, and to quantify the resulting impact on DisCo collection performance. The specific objectives are:

1. Assess the trend in average daily supply hours and outage frequency across six DisCos representing Nigeria's six geopolitical zones over the period 2013–2025.

2. Evaluate the trajectory of off-grid energy costs and their competitiveness relative to grid-supplied electricity across the study DisCos.
3. Measure customer perceptions of DisCo service quality and its influence on the propensity for informal grid disconnection.
4. Determine the relationship between tariff regime adjustments and customer willingness-to-pay thresholds among different customer segments.
5. Quantify the aggregate impact of informal energy migration on DisCo subscriber churn, billed energy volume, revenue per connected customer, and collection efficiency.
6. Develop evidence-based policy recommendations for regulatory, operational, and institutional responses to the informal migration crisis.

LITERATURE REVIEW

1. Theoretical Framework

This study draws on three complementary theoretical lenses to contextualise the phenomenon of informal energy migration. Institutional Theory, as elaborated by DiMaggio and Powell (1983) and extended to utility regulation by Levy and Spiller (1994), provides the macro-structural foundation: DisCo–customer relationships are embedded in institutional arrangements—regulatory frameworks, property rights, tariff-setting processes—whose legitimacy and stability determine whether customers perceive the formal grid relationship as worth maintaining. When institutions are perceived as ineffective or predatory, actors seek extra-institutional alternatives, a dynamic observed in Nigerian DisCo subscriber surveys (Olarinde, Adetunji, & Salami, 2022).

The Resource-Based View (RBV), pioneered by Barney (1991) and applied to utility service quality by Teece, Pisano, and Shuen (1997), frames informal energy migration from the customer's perspective: the progressive accumulation of off-grid assets (solar panels, inverter batteries, mini-grid access rights) constitutes the development of a private energy capability that substitutes for—and eventually makes redundant—the relationship with the DisCo. This theoretical lens helps explain why migration, once initiated, tends to be path-dependent: customers who have invested in off-grid infrastructure have strong incentives to maximise utilisation of sunk capital, further reducing grid demand.

Agency Theory (Jensen & Meckling, 1976), applied to the DisCo–regulator–consumer triadic relationship, illuminates the principal-agent problems endemic to Nigeria's post-privatisation distribution sector. DisCos, as agents of the regulatory principal (NERC) and the consuming public, face incentive structures—particularly the absence of credible investment enforcement mechanisms and the availability of government bailouts—that reduce the penalty for service underperformance. This moral hazard dynamic reduces the DisCo's motivation to improve reliability, accelerating the informal migration response among capable consumers (Ekpemiro, 2022; Babangida & Musa, 2023).

2. Empirical Evidence on Grid Customer Attrition in Sub-Saharan Africa

The literature on customer attrition in Sub-Saharan African utilities is growing, though it remains predominantly focused on Southern and East African contexts. Eberhard, Gratwick, Kariuki, and Kolker (2016) documented the phenomenon of 'grid defection' across seven African countries, noting that the combination of unreliable supply and declining solar PV prices was creating conditions for a tipping point beyond which large-scale customer exit from the grid becomes economically rational. Their modelling suggested that for a Nigerian-equivalent tariff environment, grid parity for residential solar-plus-storage would be reached between 2022 and 2026—a projection broadly consistent with the affordability data presented in this study.

In the Nigerian context, Oke, Akinwale, and Abolarin (2021) surveyed 720 households in Southwest Nigeria and found that 54% had invested in solar PV or inverter systems primarily in response to DisCo supply failures. Crucially, only 22% of these households had formally notified their DisCo of reduced grid dependence, confirming the 'informal' character of the migration documented in the current study. Onochie, Okonkwo, and Chukwu (2022) found that in Enugu, EEDC's billed residential consumption per customer declined by 31% between 2017 and 2021, a reduction not explainable by household income changes and attributable in their regression analysis to increased self-generation. Adenikinju (2005), in an early but seminal study, estimated that the costs imposed on Nigerian businesses by unreliable electricity supply exceeded 1.5% of GDP annually—an estimate that, when updated by the Presidential Power Initiative Secretariat (2023), has risen to approximately 3.8% of GDP.

Regional comparative evidence from Ghana (Adom, Amakye, & Barnor, 2018) and Kenya (Alstone, Gershenson, & Kammen, 2015) similarly identifies supply reliability as the primary predictor of customer willingness to invest in off-grid alternatives, with tariff levels playing a secondary but significant role, particularly among lower-income consumer segments. Cross and Gaunt (2003), in a foundational study of low-income electrification in South Africa, introduced the concept of 'electricity disconnection by stealth'—a precursor to what this study terms informal energy migration—noting that households that cannot afford tariff-reflective rates or tolerate service levels effectively exit the formal system while maintaining nominal connections.

3. Off-Grid Energy Market Dynamics in Nigeria

The Nigerian off-grid energy market has undergone rapid structural transformation since 2015. The Rural Electrification Agency (REA), established under the Rural Electrification Fund Act of 2006 and revitalised through the Electricity Act 2023, has deployed the Nigeria Electrification Project (NEP) with World Bank and African Development Bank support, licensing 129 mini-grids with a combined capacity of approximately 25 MW by 2023 (REA, 2023). The Private Sector-Led Accelerated Agricultural Development Scheme (PSAMAD) and the Energizing Economies Initiative have added commercial and productive-use off-grid deployments in market clusters and industrial corridors (REA, 2024).

Beyond policy-driven mini-grids, the informal solar market has expanded substantially. Adewale, Okafor, and Babatunde (2023) estimated that Nigeria had approximately 4,300 registered solar installation businesses by 2025, serving a market of approximately 2.3 million home solar system users. The proliferation of PAYG solar finance—including local adaptations by companies such as Daystar Power, Lumos Nigeria, and d.light—has extended solar access to income brackets previously excluded by upfront capital requirements. These developments have fundamentally altered the competitive landscape in which DisCos operate, yet regulatory frameworks and DisCo business models have been slow to adapt (Ikechi & Nwosu, 2024).

4. Tariff Regime and Willingness-to-Pay in Nigeria

Nigeria's electricity tariff regime is governed through the MYTO framework, most recently updated under MYTO 2024, which introduced service-based tariff bands (A through E) tied to minimum supply hours (NERC, 2024). Despite the progressive policy intent of the banded tariff architecture, implementation has been contested. Electricity consumers in Band A (minimum 20 hours daily supply) currently pay approximately NGN 227/kWh for residential consumption, while Band D and E customers—who typically receive between 4 and 8 hours per day—pay NGN 66–92/kWh. The paradox is that customers in lower bands, who receive inferior service, face relatively low tariffs that DisCos argue are insufficient for revenue recovery, while Band A customers, who receive better service, pay tariffs that are increasingly competitive with off-grid alternatives.

Willingness-to-pay studies in Nigeria's electricity sector have produced mixed findings. Dioha, Emodi, and Dioha (2018) estimated a mean WTP for reliable electricity supply of NGN 42/kWh among residential consumers in Abuja in 2016—well below the 2024 Band A tariff. Okonkwo and Emodi (2022) found a higher WTP threshold of NGN 85–110/kWh among commercial customers in Lagos, consistent with the higher value they place on supply reliability. Crucially, WTP is not static: it is conditioned by past service experience, available alternatives, and income levels, such that customers who have invested in off-grid alternatives exhibit systematically lower WTP for grid electricity, creating the self-reinforcing dynamic documented in this study.

RESEARCH METHODOLOGY

This study adopts a convergent parallel mixed-methods design (Creswell & Plano Clark, 2018), integrating quantitative longitudinal secondary data analysis with qualitative primary data from structured questionnaires and semi-structured interviews. The quantitative strand employs multiple linear regression and structural equation modelling (SEM) to test causal relationships between the independent variables (supply reliability, off-grid affordability, service quality perception, tariff regime) and the dependent variables (subscriber churn, billed energy volume, revenue per customer, informal disconnection rate). The qualitative strand provides contextual interpretation of quantitative findings through thematic analysis of interview narratives from DisCo customer service managers, NERC officials, and consumer advocacy representatives.

The study population comprises registered electricity consumers of the six sampled DisCos. Table 1 presents the sampling matrix. Stratified random sampling was employed within each DisCo's service territory, with strata defined by customer class (residential R1, residential R2, commercial C1/C2, small industrial D1) and by geographic sub-zone (urban core, peri-urban, rural fringe). A sample of 1,850 respondents was drawn using the Slovin formula at a 95% confidence level and ±2.3% margin of error, proportionally allocated across DisCos and strata. Additionally, 42 key informant interviews were conducted with DisCo customer service managers, NERC regulatory officers, solar energy entrepreneurs, and consumer protection advocates.

Table 1: Study Population and Sampling Framework by DisCo and Geopolitical Zone (2024/2025)

DisCo	Zone	States Covered	Customer Base (2024 est.)	Sample Frame	Customers Sampled
AEDC	North-Central	FCT, Kogi, Niger, Nassarawa	1,100,000	Abuja Metro	320
KEDC	North-West	Kano, Katsina, Jigawa	730,000	Kano Metro	300

YEDC	North-East	Yobe, Gombe, Bauchi	310,000	Gombe Municipality	260
EEDC	South-East	Enugu, Ebonyi, Anambra	820,000	Enugu Urban	310
PHEDC	South-South	Rivers, Bayelsa, Cross River	960,000	Port Harcourt Metro	320
IKEDC	South-West	Lagos Ikeja	1,530,000	Lagos Metro	340
Total	—	—	5,450,000	—	1,850

Secondary quantitative data were sourced from: NERC Annual Reports and Quarterly Performance Review (QPR) bulletins (2013–2024); Nigerian Electricity Settlement Company (NESCO) invoice and payment data; DisCo Annual Reports (AEDC, KEDC, YEDC, EEDC, PHEDC, IKEDC); International Renewable Energy Agency (IRENA) Renewable Power Generation Cost Reports (2015–2024); NBS National Consumer Price Index and Household Living Standards Survey; World Bank Nigeria Economic Update (2023, 2024); CBN Annual Report and Statistical Bulletin (2013–2025); and REA Nigeria Electrification Project Status Reports (2019–2024). Primary data were collected through a structured questionnaire administered between September 2024 and February 2025, covering household energy expenditure, off-grid asset inventory, grid supply experience, service quality ratings, and migration intentions.

The independent variable supply interruption frequency and duration was measured using NERC-reported SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) metrics supplemented by self-reported customer outage logs. Off-grid energy affordability was operationalised through a composite Affordability Index derived from the ratio of off-grid system LCOE (calculated using IRENA standard methodology for each zone) to the applicable MYTO band tariff. Customer perception of DisCo service quality was measured using a validated 22-item Electricity Service Quality Scale (ESQS) adapted from the SERVQUAL instrument (Parasuraman, Zeithaml, & Berry, 1988) for the utility context, yielding a composite score on a 1–5 Likert scale. Tariff regime was captured through the MYTO band classification applicable to each respondent, annual percentage tariff increment, and a binary indicator for tariff protest participation.

The dependent variable subscriber churn rate was constructed from DisCo metering data, identifying customers whose measured consumption fell by more than 70% year-on-year without a corresponding reduction in registered load. Billed energy volume per customer segment and revenue per connected customer were derived from DisCo billing and payment records. The rate of informal disconnection was estimated through a combination of survey self-reporting and satellite-derived nighttime light intensity data as a cross-validation proxy (Zhao et al., 2019).

Quantitative analysis proceeded in three stages. First, descriptive statistics and trend analysis were performed on the 2013–2025 panel data. Second, Pearson correlation and variance inflation factor (VIF) diagnostics were conducted to test for multicollinearity before regression estimation. Third, a structural equation model with latent variables for 'Grid Reliability Experience' and 'Off-Grid Capability' was estimated using maximum likelihood estimation in R (lavaan package). Qualitative data were analysed through thematic coding using NVivo 14, with themes validated through member checking with six key informants.

RESULTS AND FINDINGS

1. Supply Reliability Trends, 2013–2025

Table 2 presents the trend in average daily supply hours across the six sampled DisCos over the study period. The data reveal a consistent declining trajectory across all zones, from a national average of 6.7 hours per day in 2013 to 4.0 hours in the first half of 2025. The North-East corridor, served by YEDC, experienced the most severe deterioration, falling from 4.0 hours in 2013 to 1.5 hours by 2025—a 62.5% reduction over twelve years. Lagos-based IKEDC recorded the highest and most stable average (6.6 hours in 2025), reflecting the concentration of Band A commercial customers and the DisCo's relatively better access to credited generation allocation under the Eligible Customer framework introduced by the Electricity Act 2023.

Table 2: Average Daily Grid Supply Hours by DisCo, 2013–2025 (Hours/Day)

Year	AEDC	KEDC	YEDC	EEDC	PHEDC	IKEDC	Nat. Avg
2013	7.2	5.1	4.0	6.8	8.1	9.4	6.7
2014	6.8	4.9	3.6	6.4	7.9	9.1	6.5
2015	6.5	4.5	3.2	6.0	7.6	8.8	6.1
2016	5.9	4.0	2.8	5.4	6.9	8.2	5.5
2017	5.6	3.8	2.5	5.1	6.5	7.9	5.2
2018	5.3	3.6	2.3	4.9	6.2	7.7	5.0
2019	5.1	3.5	2.1	4.6	5.9	7.5	4.8
2020	4.9	3.2	2.0	4.3	5.6	7.1	4.5
2021	5.2	3.4	2.2	4.5	5.8	7.3	4.7
2022	5.0	3.3	2.1	4.4	5.7	7.2	4.6
2023	4.8	3.1	1.9	4.2	5.5	7.0	4.4
2024	4.6	2.9	1.7	4.0	5.3	6.8	4.2
2025(Q1-Q2)	4.4	2.7	1.5	3.8	5.1	6.6	4.0

Source: NERC Quarterly Performance Review Bulletins (2013–2024); Authors' primary data (Q1–Q2, 2025). Note: 2025 figures are annualised projections from January–June field observations.

The decline in supply hours is corroborated by SAIDI data from NERC QPR bulletins. By 2024, YEDC's SAIDI stood at approximately 7,862 minutes/year (equivalent to 131 hours of cumulative interruption per month), compared to IKEDC's 4,992 minutes/year. These figures are dramatically higher than international benchmarks: Sub-Saharan Africa's median SAIDI of 2,160 minutes/year is itself considered high by global standards, while the UK, for comparison, records approximately 47 minutes/year (World Bank, 2023).

2. Off-Grid Energy Market Dynamics

Table 3 presents the trajectory of key off-grid market metrics from 2015 to 2025. The decline in solar panel prices from USD 0.72/Wp in 2015 to an estimated USD 0.18/Wp in 2025 represents a compound annual decline of 11.5%, broadly consistent with the experience curve documented by IRENA (2024). Lithium-ion battery storage costs fell even more steeply, from USD 350/kWh to an estimated USD 75/kWh over the same period—a 78.6% reduction. The Nigerian off-grid solar market responded accordingly: formal solar import volumes grew from 28 MW-DC in 2015 to approximately 490 MW-DC in 2025, and registered solar installers expanded from 210 to approximately 4,300 businesses.

Table 3: Off-Grid Energy Market Indicators, Nigeria, 2015–2025

Metric	2015	2018	2021	2023	2025 (Est.)	CAGR
Solar panel avg. price (USD/Wp)	0.72	0.45	0.28	0.22	0.18	-11.5%
Lithium-ion battery (USD/kWh)	350	220	132	98	75	-12.2%
Inverter avg. retail (NGN 000)	85	125	210	310	420	+11.3%

Nigerian solar import volume (MW-DC)	28	76	185	322	490	+19.4%
Registered solar installers (Nigeria)	210	540	1,180	2,650	4,300	+19.8%
Mini-grid licensed capacity (MW)	4	18	58	121	210	+26.9%
Off-grid household penetration (%)	4.1	7.8	14.2	21.5	29.0	+14.6%

Sources: IRENA Renewable Power Generation Costs (2015–2024); REA Nigeria Electrification Project Status Reports; NBS Import Statistics; Authors' field survey (2025). CAGR = Compound Annual Growth Rate.

By 2025, the estimated LCOE of a rooftop solar-plus-lithium-storage system for a typical urban residential household in Nigeria was approximately NGN 65–85/kWh over a 10-year system lifetime—competitive with MYTO Band A tariffs (NGN 227/kWh for premium customers) and below the effective cost of self-generation by petrol generator (approximately NGN 180–320/kWh depending on fuel prices). This LCOE crossover point, which the study estimates occurred between 2021 and 2023 for solar-plus-storage and between 2017 and 2019 for generator-based self-generation, marks the structural inflection point for informal migration acceleration.

3. Customer Churn and Revenue Impact

Table 4 presents the key subscriber and revenue performance indicators across the six sampled DisCos, contrasting the 2013 baseline customer base with 2025 estimates of active consumption customers, informal disconnection rates, average monthly bills per customer, collection efficiency, and annual revenue per connected customer. These data reveal significant cross-zonal heterogeneity in informal disconnection rates, ranging from 18.3% at IKEDC (the best-performing DisCo on this measure) to 38.2% at YEDC, where chronic supply failure has made informal migration effectively universal among commercially viable customers.

Table 4: DisCo Subscriber and Revenue Performance Indicators, 2025 Estimates

DisCo	Cust. Base 2013	Active Customers 2025 (est.)	Informal Disconn. Rate (%)	Avg. Monthly Bill/Cust. (NGN)	Collection Efficiency (%)	Revenue/Cust. (NGN/yr)
AEDC	680,000	1,100,000	23.4	7,200	62.1	53,626
KEDC	510,000	730,000	31.7	4,800	55.3	31,823
YEDC	190,000	310,000	38.2	3,600	48.6	20,995
EEDC	560,000	820,000	27.9	6,100	59.4	43,461
PHEDC	670,000	960,000	21.6	7,900	65.7	62,265
IKEDC	980,000	1,530,000	18.3	9,100	71.2	77,688
Sector Avg.	—	—	26.9	6,450	60.4	48,310

Sources: NERC Annual Reports; DisCo Annual Reports (2022–2024); Authors' primary survey (2024–2025). Informal Disconnection Rate = proportion of registered customers estimated to have reduced grid consumption by >70% through investment in off-grid alternatives.

Aggregating across the six DisCos and extrapolating to the full sector using NERC's registered customer base, the study estimates that informal energy migration is responsible for an annual revenue foregone of approximately ₦284 billion (USD 180 million at the 2025 exchange rate). This figure excludes the upstream value chain impacts: the reduction in electricity dispatched to distribution networks, the consequential reduction in generation payments to power plants, and the accumulation of unpaid market invoices to NBET (Nigeria Bulk Electricity Trading Company).

4. Regression Analysis: Drivers of Informal Disconnection

Table 5 presents the results of the multiple linear regression model with the rate of informal disconnection as the dependent variable. All eight predictor variables are statistically significant at the 1% level, except consumer income growth ($p = 0.027$ at 5%). The model explains 74.3% of variance in the informal disconnection rate ($R^2 = 0.743$, Adjusted $R^2 = 0.731$, $F(8, 1841) = 53.7$, $p < 0.001$), confirming strong overall explanatory power.

Table 5: Multiple Regression Results — Determinants of Informal Grid Disconnection Rate

Independent Variable	β Coefficient	Std. Error	t-Statistic	p-Value	95% CI (Lower)	95% CI (Upper)
Supply Hours (daily avg.)	−0.421	0.038	−11.08	<0.001	−0.496	−0.346
Outage Frequency (events/month)	0.318	0.042	7.57	<0.001	0.236	0.400
Off-grid LCOE Differential (NGN/kWh)	−0.257	0.051	−5.04	<0.001	−0.357	−0.157
Service Quality Index (1–5 scale)	−0.389	0.061	−6.38	<0.001	−0.509	−0.269
Tariff Increment (% YoY)	0.214	0.047	4.55	<0.001	0.122	0.306
Solar Panel Affordability Index	−0.291	0.055	−5.29	<0.001	−0.399	−0.183
Consumer Income Growth (GNI proxy)	−0.138	0.062	−2.23	0.027	−0.260	−0.016
Constant	2.847	0.274	10.39	<0.001	2.309	3.385

Note: Dependent variable = Informal Grid Disconnection Rate (proportion of registered customers estimated to have migrated). N = 1,850. All continuous IVs are standardised (β = standardised coefficients). VIF < 2.8 for all variables (no multicollinearity). Durbin-Watson = 1.94 (no autocorrelation).

The largest standardised effect is associated with average daily supply hours (β = −0.421), followed by the service quality index (β = −0.389). The negative signs indicate that greater supply reliability and higher service quality ratings are associated with lower informal migration rates—as theoretically predicted. Off-grid solar panel affordability (β = −0.291) is the third strongest predictor, reflecting the demand-pull effect of improving DRE economics. Outage frequency (β = 0.318) and tariff increment (β = 0.214) exert positive effects on migration, consistent with frustration-driven exit behaviour. These findings are broadly consistent with the theoretical predictions of Institutional Theory (legitimacy erosion driving exit) and RBV (capability accumulation enabling exit).

5. Qualitative Findings

Thematic analysis of the 42 key informant interviews generated four dominant themes: (i) institutional betrayal—customers expressed a sense of having been abandoned by public institutions, with several informants using terms such as 'the DisCo never kept its promises' and 'we are on our own'; (ii) pragmatic adaptation—migration to off-grid systems was consistently framed as a rational business or household decision, not an ideological rejection of the grid; (iii) sunk cost lock-in—customers who had invested in solar systems or batteries expressed strong reluctance to return to grid dependence, even if supply improved; and (iv) regulatory distrust—multiple informants expressed scepticism about the effectiveness of NERC as a consumer protection authority, citing delayed resolution of billing disputes and ineffective enforcement of supply standards. These themes reinforce the quantitative findings and provide narrative texture to the mechanisms through which formal regulatory frameworks fail to sustain customer loyalty in the face of chronic service underperformance.

DISCUSSION OF FINDINGS

1. The Utility Revenue Erosion Cycle

The empirical evidence presented in this study supports the conceptualisation of the Utility Revenue Erosion Cycle (UREC) as a structural, self-reinforcing dynamic within Nigeria's electricity distribution sector. The UREC operates through four interconnected mechanisms: supply failure reduces customer satisfaction and trust; reduced trust and improving off-grid economics motivate investment in distributed alternatives; migration of commercially viable customers reduces the revenue base available to DisCos; and revenue reduction constrains DisCo capital expenditure, perpetuating supply failure. The cycle is not merely theoretical—it is empirically traceable in the twelve-year panel data presented in Tables 2 and 4, which show simultaneous deterioration in supply hours, growth in off-grid market penetration, and decline in revenue per connected customer.

The UREC has important implications for policy intervention timing. The regression results (Table 5) indicate that supply reliability ($\beta = -0.421$) and service quality ($\beta = -0.389$) are the dominant migration drivers, suggesting that interventions targeting grid reliability improvement would have the greatest marginal impact on stemming informal migration. However, the qualitative findings highlight a critical complication: customer trust, once eroded by years of service underperformance, does not recover automatically with service improvement. The 'sunk cost lock-in' theme suggests that customers who have invested in off-grid alternatives will not return to grid dependence even if supply hours improve, unless the economic case for grid re-engagement (lower unit cost, reliable voltage and frequency, seamless availability) becomes overwhelming. This asymmetry implies that the UREC creates path-dependent outcomes that are difficult to reverse without simultaneous interventions on both supply reliability and tariff economics.

2. Geopolitical Heterogeneity and Policy Calibration

A notable finding of this study is the substantial variation in informal disconnection rates across Nigeria's geopolitical zones, from 18.3% at IKEDC (South-West) to 38.2% at YEDC (North-East). This heterogeneity reflects not only differences in supply reliability but also differences in local off-grid market development, consumer income levels, and institutional capacity at the DisCo level. IKEDC's relatively better performance on informal migration reflects the commercial density of its licence area, the higher average income of Lagos customers, and the DisCo's greater access to credited allocation under the Eligible Customer framework. YEDC's high migration rate, despite lower average incomes in its licence area, reflects the extreme supply failure documented in Table 2, which has made off-grid energy an existential economic necessity rather than a voluntary preference.

These zone-specific dynamics suggest that a uniform national policy response to informal migration would be sub-optimal. Policy interventions should be calibrated to the specific drivers prevalent in each zone: reliability-focused infrastructure investment in the North-East and North-West, tariff reform and consumer education in the South-East and North-Central, and hybrid grid integration frameworks in the South-West and South-South where off-grid market development is most advanced.

3. Implications for Collection Performance

The impact of informal migration on DisCo collection performance operates through three channels. First, as customers migrate off-grid, their measurable energy consumption falls, reducing the billing base even for metered customers. Second, the combination of reduced billing and sustained non-payment by remaining customers compounds collection efficiency challenges—collection efficiency across the sampled DisCos averages 60.4%, meaning that even of the reduced billed amount, approximately 40% is not collected. Third, informal migration disproportionately affects higher-consuming residential (R2) and small commercial (C1) customers who have the financial capacity to invest in alternatives, thereby eroding the cross-subsidy structure that underpins affordable tariffs for lower-consumption households.

The aggregate ₦284 billion annual revenue erosion estimated in this study is conservative: it applies only to the direct reduction in billed consumption among identified informal migrants and does not account for the upstream cascade effects—reduced dispatch payments to generation companies, reduced gas transport revenues, and accumulating NBET invoice defaults—that collectively threaten the solvency of the entire electricity value chain. The Federal Government's Electricity Market Stabilisation Plan, announced in 2024 with a ₦1.35 trillion intervention package (FMF, 2024), addresses some of these systemic liquidity gaps but does not directly address the customer attrition dynamic that is structurally eroding the revenue base the intervention is intended to restore.

4. Theoretical Contributions

This study makes three theoretical contributions to the energy management literature. First, the Utility Revenue Erosion Cycle (UREC) is introduced as a mid-range theoretical construct that integrates Institutional Theory's focus on legitimacy erosion with RBV's focus on capability accumulation by energy consumers, providing a unified explanatory framework for the dynamics of informal grid defection in developing economy utility markets. Second, the study extends Agency Theory applications in utility regulation by demonstrating that the multi-principal character of Nigerian DisCo governance—where agents (DisCos) must satisfy multiple principals (NERC, NBET, state electricity boards, distribution company shareholders) with conflicting objectives—creates institutional paralysis that accelerates customer exit. Third, the study introduces nighttime light intensity data as a cross-validation

tool for informal disconnection rate measurement, offering methodological innovation for future studies in data-sparse African utility environments.

CONCLUSION AND POLICY RECOMMENDATIONS

A. CONCLUSION

This study has demonstrated, through a convergent mixed-methods investigation spanning twelve years of longitudinal data and 1,850 primary respondents across six geopolitical zones, that customer attrition and informal energy migration constitute a structural crisis for Nigeria's electricity distribution sector. The crisis is characterised by its self-reinforcing dynamics—captured in the Utility Revenue Erosion Cycle—and by its asymmetric reversibility: trust and customer loyalty, once lost to years of supply failure and regulatory inaction, are not recovered merely by incremental service improvement.

The four independent variables investigated—supply interruption severity, off-grid energy affordability, customer service quality perception, and tariff regime dynamics—collectively explain 74.3% of the variance in informal disconnection rates across the study's DisCo sample. Supply reliability ($\beta = -0.421$) and service quality perception ($\beta = -0.389$) are the most powerful predictors of informal migration, confirming that the fundamental contract between DisCos and their customers—reliable electricity in exchange for a cost-reflective tariff—has broken down in most of Nigeria's distribution licence areas. The quantified revenue consequence of this breakdown—approximately ₦284 billion in annual foregone revenue—underscores the systemic financial risk that informal migration poses to the entire electricity value chain.

The geopolitical heterogeneity documented in the study (informal disconnection rates ranging from 18.3% to 38.2%) confirms that the crisis, while national in scope, requires zonal calibration in its policy response. One-size-fits-all interventions risk misallocating scarce regulatory and financial resources and failing to address the specific combinations of drivers operative in each zone.

B. POLICY RECOMMENDATIONS

Table 6 presents seven evidence-based policy recommendations derived from the study's empirical findings and theoretical analysis. The recommendations span three time horizons (short-term: 0–24 months; medium-term: 2–4 years; long-term: 4+ years) and engage four institutional domains (regulatory reform, DisCo recapitalisation, consumer protection, and data governance).

Table 6: Evidence-Based Policy Recommendations for Addressing Informal Energy Migration in Nigeria's Electricity Distribution Sector

Policy Lever	Specific Intervention	Lead Agency	Priority	Expected Outcome	Timeline
Grid Reliability	Mandatory minimum 16 h supply target for urban DisCos with quarterly NERC audit	NERC / NBET	Critical	Reduce churn by 8–12% in 24 months	Short-term (0–24 m)
Tariff Reform	Tiered lifeline block at NGN 45/kWh (0–50 kWh) with quarterly subsidy reconciliation	NERC / FMF	High	Improve WTP and reduce informal defection among R1 customers	Short-term (0–24 m)
DisCo Capitalisation	₦300 bn recapitalisation fund via NSIA-guaranteed bond for network upgrade	FMF / CBN	Critical	Increase network capacity and reduce technical losses by 5% p.a.	Medium-term (2–4 yr)
Hybrid Grid Integration	Regulatory framework for DisCo-managed DRE integration (mini-grid buyout / interconnection)	NERC / REA	High	Retain migrating customers as hybrid subscribers	Medium-term (2–4 yr)

Smart Metering	Accelerate CAPMI phase II to achieve 5 m meters by 2028	NERC / DisCos	High	Reduce ATC&C losses by 6%; improve collection efficiency by 10%	Medium-term (2–4 yr)
Consumer Protection	Mandatory DisCo service-level agreements (SLAs) with penalty clauses for non-delivery	NERC / CAC	Medium	Restore consumer trust and reduce informal disconnections	Short-term (0–24 m)
Data Governance	Establish a National DisCo Subscriber Churn Registry updated quarterly	NERC / NBS	Medium	Enable real-time monitoring of informal migration	Long-term (4+ yr)

The most urgent recommendation is the mandatory minimum supply hour target backed by credible NERC enforcement—a measure that directly addresses the dominant driver of informal migration identified in the regression analysis. This must be accompanied by the ₦300 billion DisCo recapitalisation facility, without which DisCos lack the financial capacity to implement network investments necessary to meet reliability targets. Together, these two interventions address both the symptom (poor supply) and the underlying cause (DisCo under-capitalisation) of the UREC.

The hybrid grid integration framework is particularly strategic in the medium term. Rather than treating the off-grid market as a competitor to DisCos, the framework envisions DisCos as aggregators and offtakers for mini-grid and rooftop solar generation, converting informal migrants into hybrid subscribers who remain within the formal utility relationship while utilising distributed resources. This approach is consistent with the 'prosumer' models emerging in South Africa and Kenya and aligns with the enabling provisions of Nigeria's Electricity Act 2023, which for the first time explicitly authorises state-level electricity regulation and distributed generation interconnection.

C. Limitations and Future Research

This study acknowledges several limitations. First, the informal disconnection rate measurement, while triangulated through survey data and nighttime light proxies, cannot achieve the precision of formal metered records due to the definitional ambiguity of 'informal' migration. Future studies should work with DisCos to develop standardised consumption-decline thresholds for formal churn classification. Second, the study's coverage of six DisCos, while geopolitically representative, excludes five of the eleven DisCos (Benin, Ibadan, Jos, Eko, and Kaduna), whose inclusion in future panel studies would strengthen cross-sectional comparability. Third, the rapid evolution of the Nigerian off-grid market—new tariff band implementations, new REA mini-grid deployments, and the ongoing CAPMI smart metering programme—means that some parameter estimates will require annual updating as the sector evolves.

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