SSR Journal of Multidisciplinary (SSRJM)
Volume 3, Issue 8, 2026 Homepage: https://ssrpublisher.com/ssrjm/ ISSN: 3049-1304

Sustainable Energy Access: An Evaluation of Energy Crisis Impact in Urban Katsina, Nigeria

Yahaya Sani and Ibrahim Danladi Sule

Department of Environmental Resource Management, Federal University Dutsin-Ma, Katsina State, Nigeria

Received: *10.07.2026* | ***Accepted:*** *01.08.2026* | ***Published:*** *05.08.2026*

***Corresponding Author:** Yahaya Sani

DOI: *10.5281/zenodo.21811966*

Abstract **Case Studies**

The global energy crisis driven by crude oil price volatility, currency devaluation, and the removal of Nigeria's petroleum subsidy, has placed unprecedented strain on urban household energy budgets. This study evaluates household energy transition in Katsina metropolis, the capital of Katsina State, Nigeria, using the energy ladder and fuel-stacking models as its conceptual anchor. A cross-sectional survey of 384 households, sampled proportionately across nine metropolitan wards using Cochran's formula, was analysed alongside binary logistic regression to identify determinants of downward energy switching. Results show a marked reversal in household cooking-fuel choice: the share of households citing LPG as their primary cooking fuel fell from 58.9% before the crisis to 39.8% currently, while reliance on charcoal and firewood rose by 11.0 and 8.4 percentage points respectively. Regression results indicate that perceiving the LPG price increase as "severe" (OR = 3.14, $p < 0.001$) and lower household income (OR = 0.52, $p < 0.001$) were the strongest predictors of downward switching, while tertiary education and grid electricity access were protective. Rather than fully abandoning modern fuels, most affected households adopted a fuel-stacking strategy, retaining LPG for quick tasks while reverting to biomass fuels for daily cooking, consistent with the fuel-stacking rather than the strict linear energy-ladder model. The findings suggest that urban Nigerian households are experiencing crisis-induced energy regression despite urban status, with implications for indoor air quality, gender burden, and energy poverty. The study recommends targeted LPG cylinder subsidies, cash-transfer-linked clean cooking support, and expanded solar mini-grid access for urban low-income wards.

Keywords: Household Energy Transition, Energy Ladder, Fuel Stacking, Energy Poverty, Global Energy Crisis.

1. Introduction

Access to clean, reliable, and affordable household energy is central to the Sustainable Development Goal 7 agenda, yet the global energy crisis that began with post-pandemic demand recovery and intensified following the 2022 disruption of international energy markets has placed this goal under renewed strain (International Energy Agency [IEA], 2022). For oil-importing and subsidy-dependent economies such as Nigeria, the crisis was compounded domestically by the removal of the petroleum products subsidy in mid-2023 and sustained naira devaluation, both of which sharply raised the landed cost of imported liquefied petroleum gas (LPG) and kerosene (World Bank, 2023; Nwabueze & Ekpe, 2023). Because Nigeria imports the majority of its LPG, urban households that had transitioned to cooking gas over the preceding decade were directly exposed to this price shock.

Urban Nigerian households are conventionally assumed to sit higher on the household "energy ladder" than their rural counterparts, having progressively substituted biomass fuels with kerosene, LPG, and electricity as incomes and access improved (Hosier & Dowd, 1987; Ogwumike et al., 2014). However, this assumption rests on an implicit premise of stable relative fuel prices. Where a global or domestic energy-price shock disproportionately raises the cost of modern fuels relative to biomass, the energy ladder framework itself predicts a reversal, or downward switching, and the closely related fuel-stacking framework predicts an increased reliance on multiple, cheaper fallback fuels rather than complete abandonment of modern energy (Masera et al., 2000; Heltberg, 2004). Whether, and to what extent, this reversal is occurring in urban Nigerian cities amid the current global energy crisis remains empirically under-examined, particularly outside Nigeria's major commercial cities.

This study addresses that gap by evaluating household energy transition in Katsina metropolis, the capital of Katsina State in north-western Nigeria. Specifically, the study: (i) presents a conceptual framework integrating the energy ladder and fuel-stacking models with the drivers of energy switching under crisis conditions; (ii) empirically measures the direction and magnitude of household cooking-fuel switching before and during the current energy crisis, based on a survey of 384 households; and (iii) identifies the socioeconomic determinants that predict downward energy switching. The findings are intended to inform urban energy-poverty mitigation policy in Katsina State and comparable Nigerian state capitals.

2. Literature Review

2.1 The Energy Ladder Model

The energy ladder model, formalised by Hosier and Dowd (1987), conceptualises household fuel choice as a linear progression through successive "rungs": from traditional biomass fuels (firewood, crop residue, dung), through transitional fuels (charcoal, kerosene), to modern fuels (LPG, electricity), and ultimately to clean or advanced technologies (solar, high-efficiency appliances). The model predicts that households move upward as income rises and downward when income falls or modern-fuel prices rise sharply relative to biomass fuels (Barnes & Floor, 1996; Leach, 1992). A substantial empirical literature has tested this prediction across developing-country contexts, generally finding directional support, particularly for the effect of income and relative price shocks on fuel choice (Danlami et al., 2018; Rahut et al., 2016).

2.2 The Fuel-Stacking Model

Masera et al. (2000) challenged the strict linearity of the energy ladder, proposing instead that households typically adopt multiple fuels simultaneously, a pattern termed fuel stacking, rather than fully substituting one fuel for another. Under this model, a household's transition to LPG rarely eliminates its use of charcoal or firewood entirely; instead, modern fuels are layered onto, rather than substituted for, existing fuel-use patterns, with the specific fuel mix at any given time responding to relative price, availability, and task-specific suitability (Kowsari & Zerriffi, 2011; van der Kroon et al., 2013). A meta-analysis by van der Kroon et al. (2013) found that fuel-stacking behaviour is the empirically dominant pattern in most developing-country household energy studies, suggesting the energy ladder is best understood as describing a general tendency rather than a strict sequential process.

2.3 Determinants of Household Fuel Choice

Beyond income and relative prices, the literature identifies household size, educational attainment, housing tenure, gender of household head, and physical fuel availability as consistent predictors of household energy choice (Ekholm et al., 2010; Chukwuone et al., 2021; Nnaji et al., 2012). Female-headed households and less-educated households are frequently found to be more vulnerable to downward switching during price shocks, both because of lower average income and because women typically bear the primary responsibility for household fuel procurement and cooking (Ogwumike et al., 2014; Sa'ad & Bugaje, 2016).

2.4 Energy Crises and Fuel Switching in Nigeria

Nigeria's energy sector has experienced repeated price shocks over the past two decades, but the 2023 subsidy removal represents one of the most abrupt in recent history, with downstream effects on LPG affordability documented by early post-reform assessments (World Bank, 2023; Nwabueze & Ekpe, 2023). Existing Nigerian household energy studies have predominantly focused on rural areas or on southern commercial cities such as Lagos, Enugu, and Port Harcourt (Nnaji et al., 2012; Ogwumike et al., 2014), with comparatively little empirical attention paid to urban centres in the country's semi-arid north, despite these cities facing distinct affordability constraints linked to lower average incomes and longer LPG supply chains (Sa'ad & Bugaje, 2016). This study addresses that gap.

3. Conceptual Framework

Figure 1 presents the study's conceptual framework, which integrates the energy ladder and fuel-stacking models with the drivers of energy switching. The left-hand ladder structure represents Hosier and Dowd's (1987) four rungs, from traditional biomass at the base to clean or advanced technologies at the top. Upward movement along the ladder is associated with rising income, subsidy support, and improved fuel access, whereas downward movement is associated with price shocks, subsidy removal, and supply scarcity, the conditions characterising the current global energy crisis.

The right-hand panel incorporates Masera et al.'s (2000) fuel-stacking model, recognising that households rarely occupy a single rung at any given time but instead combine fuels from multiple rungs according to task, cost, and availability, for example retaining LPG for rapid cooking tasks while reverting to charcoal or firewood for lengthier cooking during periods of price stress. Both the ladder position and the degree of stacking are jointly shaped by a set of energy switch drivers: the global energy crisis and associated price shocks, household income and expenditure capacity, relative fuel prices, physical fuel availability, and household socio-demographic characteristics such as size, education, and awareness. These combined dynamics determine the household energy transition outcome, comprising the household's ladder position, its degree of fuel stacking, its energy expenditure burden, and its resulting exposure to indoor air pollution and energy poverty. This framework directly structures the study's survey instrument and regression model, which measure ladder position before and during the crisis and test the drivers hypothesised to predict downward switching.

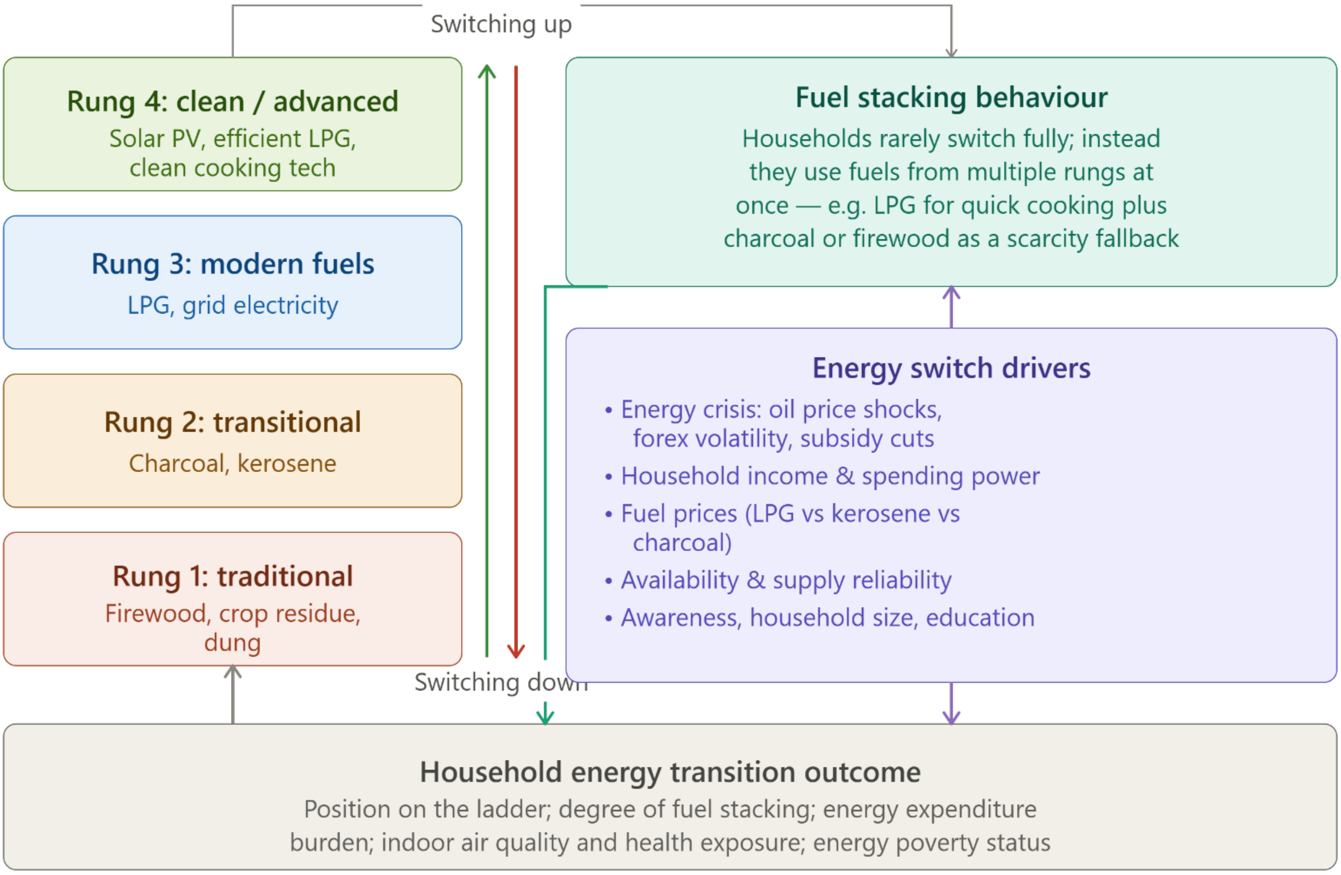

Figure 1. Conceptual framework integrating the energy ladder model, the fuel-stacking model, and energy switch drivers (developed by the author, adapted from Hosier & Dowd, 1987; Masera et al., 2000).

4. Study Area

Katsina metropolis is the capital of Katsina State, north-western Nigeria, and the administrative and commercial centre of Katsina Local Government Area (LGA). The metropolis combines a historic walled city core, comprising traditional wards such as Kofar Kaura, Kofar Marusa, Kofar Sauri, and Kofar Yandaka, with newer planned and low-income residential extensions. As a state capital, Katsina metropolis has historically exhibited higher rates of LPG and grid-electricity access than surrounding rural LGAs, making it a useful setting for observing whether an urban population with an established modern-fuel base is nonetheless vulnerable to crisis-driven downward energy switching.

Nine metropolitan wards were included in the study, selected to represent the full socioeconomic and spatial range of the metropolis, from the historic walled city to peripheral low-cost housing estates. Table 1 presents the estimated household population and proportionate sample allocation by ward.

Table 1: showing wards in Katsina LGA

Ward	Sample Allocated	Proportion (%)
Wakilin Kudu I	46	12.0
Wakilin Kudu II	44	11.5
Wakilin Gabas I	41	10.7
Wakilin Gabas II	40	10.4
Wakilin Yamma I	48	12.5
Wakilin Yamma II	39	10.2
Wakilin Arewa I	45	11.7
Wakilin Arewa II	42	10.9
Shinkafi	39	10.1
Total	**384**	**100.0**

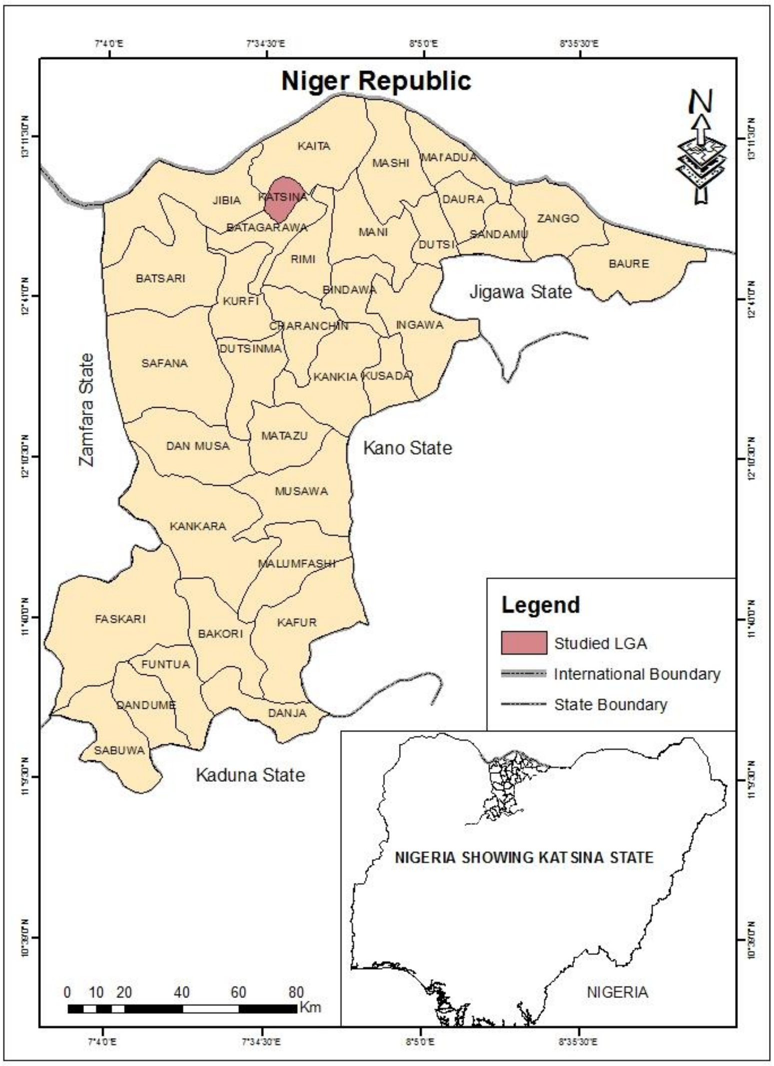

Figure 2. Map of Katsina State showing Studied Area

5. Methodology

5.1 Research Design

The study employed a cross-sectional survey design, combining a structured household questionnaire with retrospective (recall-based) items comparing household fuel use before and during the current energy crisis. This design permits a within-household before-after comparison without requiring longitudinal panel data, consistent with prior energy-transition studies employing recall methods (Danlami et al., 2018).

5.2 Population and Sample Size

The target population comprised all households resident within the nine selected wards of Katsina metropolis. Given the absence of a precise, current household sampling frame, the sample size was determined using Cochran's (1963) formula for an infinite population at a 95% confidence level, a 5% margin of error, and a conservative response distribution of $p = 0.5$, yielding a minimum required sample of 384 households ($n = Z^2pq/e^2 = 1.96^2 \times 0.5 \times 0.5 / 0.05^2 = 384$). All 384 administered questionnaires were returned complete and valid, giving a 100% usable response rate.

5.3 Sampling Procedure

A multi-stage sampling procedure was applied. First, nine wards were purposively selected to represent the metropolis's core, transitional, and peripheral residential zones. Second, the total sample of 384 was allocated proportionately across wards based on estimated household population, following the Table 1 allocation. Third, within each ward, households were selected through systematic random sampling, beginning from a randomly selected starting point and proceeding at a fixed sampling interval along each ward's principal streets until the ward quota was met. Where a selected household head was unavailable, the next accessible household was substituted.

5.4 Research Instrument

The structured questionnaire captured household demographic and socioeconomic characteristics, primary and secondary household cooking and lighting fuels both before and during the crisis period, monthly energy expenditure, perceived severity of fuel price increases, and indicators of fuel-stacking behaviour. The instrument was adapted from established household energy-choice surveys (Ogwumike et al., 2014; Chukwuone et al., 2021) and pre-tested in a non-sampled ward for clarity prior to full administration.

5.5 Data Analysis

Quantitative data were analysed using SPSS (version 26). Descriptive statistics summarised respondent characteristics and pre-crisis versus current fuel-use patterns. A binary logistic regression model was estimated to identify predictors of downward energy switching, defined as a household reporting a shift from a higher to a lower rung of the energy ladder as its primary cooking fuel between the pre-crisis and current periods. Predictor variables included household income, perceived severity of the LPG price increase, household size, sex of household head, educational attainment, housing tenure, and access to grid electricity.

6. Results

6.1 Respondent Characteristics

Table 2 presents the demographic and socioeconomic profile of the 384 surveyed households. Male-headed households constituted 62.8% of the sample, and nearly half of households (47.9%) comprised five to eight persons. Approximately one-third of households (31.5%) reported a monthly income below NGN 50,000, a threshold below which LPG refill costs represent a substantial share of disposable income given post-subsidy-removal pricing.

Table 2. Demographic and socioeconomic characteristics of surveyed households (n = 384).

Characteristic	Category	Frequency (n=384)	Percent (%)
Sex of household head	Male	241	62.8
	Female	143	37.2
Household size	1-4 persons	132	34.4
	5-8 persons	184	47.9
	Above 8 persons	68	17.7
Monthly household income (NGN)	Below 50,000	121	31.5
	50,000-150,000	163	42.4
	Above 150,000	100	26.0
Educational attainment	No formal / Quranic only	74	19.3
	Primary / Secondary	189	49.2
	Tertiary	121	31.5
Housing type	Rented	218	56.8
	Owner-occupied	166	43.2

6.2 Household Fuel Switching Before and During the Crisis

Table 3 compares households' primary cooking fuel before the crisis and at the time of survey. The share of households citing LPG as their primary cooking fuel fell from 58.9% to 39.8%, a decline of 19.1 percentage points, while charcoal and firewood use rose by 11.0 and 8.4 percentage points respectively. Electricity-based cooking also declined modestly (-3.2 points), consistent with concurrent increases in grid tariffs over the same period. These findings indicate a net downward movement on the energy ladder for a substantial share of the sample.

Table 3. Household primary cooking fuel before the crisis and at the time of survey (n = 384).

Primary Cooking Fuel	Before Crisis* (%)	Current / During Crisis (%)	Net Change (pp)
Firewood	9.6	18.0	+8.4
Charcoal	11.7	22.7	+11.0
Kerosene	6.5	9.4	+2.9
LPG (cooking gas)	58.9	39.8	-19.1
Electricity (grid/solar)	13.3	10.1	-3.2
Total	**100.0**	**100.0**	**-**

6.3 Determinants of Downward Energy Switching

Table 4 presents the results of the binary logistic regression predicting downward energy switching. Households that perceived the LPG price increase as "severe" were more than three times as likely to have switched downward (OR = 3.14, 95% CI: 2.21-4.46, $p < 0.001$), the strongest predictor in the model. Higher household income was protective (OR = 0.52, $p < 0.001$), as was tertiary education of the household head (OR = 0.61, $p = 0.003$) and access to grid electricity (OR = 0.69, p = 0.028). Larger household size was associated with increased odds of downward switching (OR = 1.38, p = 0.021), while the sex of the household head and housing tenure were not statistically significant predictors at the 5% level.

Table 4. Binary logistic regression results: predictors of downward household energy switching.

Predictor Variable	Odds Ratio (Exp B)	95% CI	p-value
Monthly household income (higher)	0.52	0.39-0.69	<0.001
LPG price increase perceived as "severe"	3.14	2.21-4.46	<0.001
Household size (larger)	1.38	1.05-1.82	0.021
Female-headed household	1.29	0.94-1.77	0.114
Tertiary education of household head	0.61	0.44-0.85	0.003
Owner-occupied housing	0.78	0.58-1.05	0.098
Access to grid electricity	0.69	0.50-0.96	0.028

6.4 Fuel-Stacking Behaviour

Consistent with the fuel-stacking model, only 24.6% of households that reduced their LPG use reported abandoning LPG entirely; the remaining 75.4% retained LPG as a secondary fuel for specific tasks, such as rapid reheating or preparing tea, while relying on charcoal or firewood for primary daily cooking. This pattern indicates that the observed downward movement is more accurately characterised as intensified fuel stacking toward cheaper fuels rather than a complete linear reversion down the energy ladder.

7. Discussion

The findings provide clear empirical support for the energy ladder model's prediction that adverse price shocks induce downward fuel switching, while simultaneously affirming Masera et al.'s (2000) fuel-stacking critique of strict linearity: most households did not abandon modern fuels outright but instead re-weighted an existing fuel portfolio toward cheaper options. This nuance matters for policy design, since interventions premised on a simple linear ladder, such as one-off LPG cylinder distribution, may be less effective than interventions that address the underlying price and income drivers sustaining the shift toward biomass fuels within a stacked portfolio.

The strength of perceived price severity as a predictor, considerably stronger than income alone, suggests that subjective affordability, shaped by the abruptness and visibility of the subsidy-removal price shock, may condition household fuel decisions independently of objective income level, a dynamic warranting further study. The protective effect of education is consistent with prior Nigerian findings that more educated households are better able to smooth consumption or access alternative income sources during price shocks (Chukwuone et al., 2021).

That an urban state-capital population, conventionally assumed to be relatively energy-secure, exhibits this scale of downward switching signals that the current global energy crisis is eroding energy-transition gains achieved over the preceding decade in Nigerian secondary cities, with implications for indoor air quality and the disproportionate cooking-related burden typically borne by women (Ogwumike et al., 2014; Sa'ad & Bugaje, 2016).

8. Policy Recommendations

Based on the findings, the study recommends: (i) a targeted, means-tested LPG cylinder refill subsidy or voucher scheme for low-income urban households in Katsina metropolis, prioritising wards with the highest recorded downward-switching rates; (ii) integration of clean cooking support into existing social cash-transfer programmes, given the strong income effect identified in the regression results; (iii) expansion of solar mini-grid and off-grid electricity access in peripheral wards such as Shikafi, to reduce reliance on grid electricity alone; (iv) public awareness campaigns on the comparative health and cost implications of fuel stacking toward biomass, targeted particularly at female household cooking-fuel decision-makers; and (v) continued monitoring of household energy transition indicators at the state level to detect further crisis-driven regression.

9. Conclusion

This study evaluated household energy transition in Katsina metropolis amid the global energy crisis, using a combined energy-ladder and fuel-stacking conceptual framework applied to a survey of 384 households across nine metropolitan wards. The results demonstrate a significant downward shift in household cooking-fuel choice, with LPG use falling by 19.1 percentage points and biomass fuel use rising correspondingly, driven primarily by perceived price severity and constrained household income. However, the shift is better characterised as intensified fuel stacking than complete abandonment of modern fuels, underscoring the practical resilience but also the vulnerability of urban Nigerian household energy systems under sustained price shocks. Targeted, income-sensitive clean cooking interventions, rather than blanket infrastructure programmes alone, are needed to protect the energy-transition gains of urban Sahelian state capitals such as Katsina against future global energy shocks.

Declarations

Funding: The authors receive no financial support for the research.

Conflict of Interest: The author(s) declare no conflict of interest.

Data Availability: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

References

Akpan, U. S., Essien, M., & Isihak, S. R. (2013). The impact of rural electrification on rural micro-enterprises in Niger Delta, Nigeria. Energy for Sustainable Development, 17(5), 504-509.

Barnes, D. F., & Floor, W. M. (1996). Rural energy in developing countries: A challenge for economic development. Annual Review of Energy and the Environment, 21(1), 497-530.

Chukwuone, N. A., Amaechina, E. C., & Kirk, C. (2021). Determinants of household choice of cooking energy and implications for clean energy transition in Nigeria. Renewable and Sustainable Energy Reviews, 145, 111094.

Danlami, A. H., Applanaidu, S. D., & Islam, R. (2018). Fuelwood consumption and its determinants: A household level analysis. International Journal of Energy Sector Management, 12(2), 168-182.

Ebohon, O. J., & Ikeme, A. J. (2006). Decomposition analysis of CO2 emission intensity between oil-producing and non-oil-producing sub-Saharan African countries. Energy Policy, 34(18), 3599-3611.

Ekholm, T., Krey, V., Pachauri, S., & Riahi, K. (2010). Determinants of household energy consumption in India. Energy Policy, 38(10), 5696-5707.

Emodi, N. V., Emodi, C. C., Murthy, G. P., & Emodi, A. S. A. (2017). Energy policy for low carbon development in Nigeria: A LEAP model application. Renewable and Sustainable Energy Reviews, 68, 247-261.

Heltberg, R. (2004). Fuel switching: Evidence from eight developing countries. Energy Economics, 26(5), 869-887.

Hosier, R. H., & Dowd, J. (1987). Household fuel choice in Zimbabwe: An empirical test of the energy ladder hypothesis.

Resources and Energy, 9(4), 347-361.

International Energy Agency. (2022). World Energy Outlook 2022. IEA.

International Energy Agency. (2023). Africa Energy Outlook 2023. IEA.

Kowsari, R., & Zerriffi, H. (2011). Three dimensional energy profile: A conceptual framework for assessing household energy use. Energy Policy, 39(12), 7505-7517.

Leach, G. (1992). The energy transition. Energy Policy, 20(2), 116-123.

Masera, O. R., Saatkamp, B. D., & Kammen, D. M. (2000). From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model. World Development, 28(12), 2083-2103.

National Bureau of Statistics. (2023). Nigeria multidimensional poverty index 2022. NBS.

National Population Commission. (2006). Population and housing census of the Federal Republic of Nigeria: Priority tables (Katsina State). NPC.

Nnaji, C. E., Uzoma, C. C., & Chukwu, J. O. (2012). Determinants of household energy choices for cooking in rural areas: Evidence from Enugu State, Nigeria. Continental Journal of Social Sciences, 5(2), 1-11.

Nwabueze, N., & Ekpe, I. (2023). Fuel subsidy removal and household welfare in Nigeria: An ex-ante analysis. Journal of African Development Studies, 9(1), 22-38.

Ogwumike, F. O., Ozughalu, U. M., & Abiona, G. A. (2014). Households' cooking energy choice in urban and rural Nigeria. West African Journal of Monetary and Economic Integration, 14(2), 74-90.

Ouedraogo, N. S. (2013). Modeling sustainable long-term electricity supply-demand in Africa. Applied Energy, 106, 74-93.

Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: The way forward. Energy, Sustainability and Society, 2, 15.

Rahut, D. B., Behera, B., & Ali, A. (2016). Household energy choice and consumption intensity: Empirical evidence from Bhutan. Renewable and Sustainable Energy Reviews, 53, 993-1009.

Sa'ad, S., & Bugaje, I. M. (2016). Biomass energy consumption and household welfare in Katsina State, Nigeria. Nigerian Journal of Energy and Environmental Economics, 8(1), 45-58.

Sambo, A. S. (2009). Strategic developments in renewable energy in Nigeria. International Association for Energy Economics, 16(3), 15-19.

Sovacool, B. K. (2016). How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Research & Social Science, 13, 202-215.

United Nations Development Programme. (2022). Global multidimensional poverty index 2022: Unpacking deprivation bundles to reduce multidimensional poverty. UNDP.

van der Kroon, B., Brouwer, R., & van Beukering, P. J. H. (2013). The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis. Renewable and Sustainable Energy Reviews, 20, 504-513.

World Bank. (2023). Nigeria development update: Turning the corner - from reforms and renewed hope to results. World Bank Group.

World Bank. (2023). Nigeria's fuel subsidy removal: An analysis of distributional impacts. World Bank Group.