Title

Work, food, rent, television: The role of lifestyles and experiences on household energy behaviour in rural Lagos, Nigeria

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Abstract

Human engagement with modern energy services is foundational to social and economic welfare, as is their disengagement with welfare inhibiting traditional energy services. With modern energy access often leading to the stacked use of modern and traditional energy services, there is a need to understand the drivers and determinants of the energy decision-making of the energy poor. This study draws on 83 semi-structured in-depth interviews with 67 energy poor households in rural Lagos to explore what their lived realities reveal about the nature of their energy decision-making. We observe three important drivers behind household decision to consistently engage with a fuel-technology combination in practice: their organisation of daily life and by extension their vocational activity, the urgency of operating the service, and experience with and exposure to an energy service. Findings

suggest that if traditional energy services are to be displaced, then rather than using modern energy services to develop people's lives, we need to develop people's lives to use modern energy services.

Keywords

energy transition; energy access; Nigeria; energy poverty; energy stacking; rural household behaviour

1 Introduction

There are an estimated 789 million people globally that lack access to electricity, and approximately 3 billion people who rely on solid fuels for their cooking/heating needs [1]. The poverty of this energy situation is exemplified by the fact that household air pollution (HAP), caused by a reliance on traditional forms of cooking, led to 1.6 million deaths in 2017 [2]. There is thus much focus on how to provide the energy poor with modern, clean and safe energy services. With estimated financing requirements for meeting this global need between $65 billion and $86 billion in annual investments by 2030 [3], private finance is expected to play a central role. However, the commercial market approach to serving what are complex and varied energy poor localities across the globe, has made the search for successful, scalable, and replicable solutions challenging.

Evidence suggests that the process by which the energy poor adopt modern energy services and discontinue traditional energy services is not straightforward, with many instances of concurrent use of traditional and modern energy for a given service, in a situation known as 'energy stacking', as well as other unexpected behavioural and transition outcomes that threaten the desired impacts of modern energy provision [4]–[11]. A better understanding of why and how households make the energy decisions they do will inform efforts to facilitate a sustained and complete transition from traditional energy services, to modern energy services.

This paper provides empirical evidence from rural Lagos, Nigeria, on the decision-making of the energy poor and drivers of their engagement with energy services. It gives voice to local residents on their lived experiences to shed light on the interactions that shape their energy decision-making, and the drivers behind the behaviours experienced. This will reveal some of the nuanced interactions that inform household energy behaviour, which can be integrated into strategies and policies needed to address energy poverty. The study also adopts an alternative lens to energy access research that have been framed around *specific* energy resources, systems, or technologies, and thus somewhat siloed (e.g. solar home systems for electricity activities, separate from clean cookstoves for cooking activities), by providing evidence from a more holistic view of the household-energy interaction that makes it possible to capture potential trade-offs, synergies, and interdependencies between services and the fuel-technology combinations used to fulfil them.

The next section briefly reviews current knowledge on the factors driving household energy decision-making in developing countries. Section 3 details the methodology adopted in this study. Following this, a description of the case communities based in Epe, Lagos state, Nigeria is presented, before a detailed discussion of our main findings from the field. The final section concludes the paper and highlights areas for further research.

2 Literature Review: the factors influencing the energy behaviour of the energy poor

In this discussion of the factors influencing the energy behaviour of the energy poor, we consider household adoption and post-adoption interactions with fuels, energy conversion technologies, and the demands being met by energy consumption.

Historically, explanations of household engagement with modern energy over time have been relatively narrow, considering only the fuels being used, and attributing behaviour change largely to the influence of rising household incomes – the 'energy ladder' theory [12], [13]. There is now greater appreciation that although income (and other money-related factors) is a significant factor affecting household instantaneous and long term energy behaviour, it is not the only factor to be considered.

Rather, there is a plethora of social, economic, cultural, technical, and other market factors that have an important bearing on household energy behaviour over time [14], [15]. These factors can be grouped into two categories: internal and external (Figure 1).

Internal factors

The internal factors consist of the economic and social characteristics of a household, the individual capabilities of the household, and the individual predispositions specific to a household [14], [16].

Virtually all studies identify income to be an important factor influencing household energy decision-making. Social factors observed by a number of researchers to be significant descriptors include: the age or gender of the household head having an influence on clean energy adoption [17]–[21], the size of a household influencing energy demand intensity and thus the type(s) of fuel-technology combinations purchased [17], [22]–[24], the migration status of a household shaping energy and welfare access to influence behaviour [25], [26], and household occupation determining reliance on traditional and/or modern energy services [27]–[29], to name a few.

It has been found that the higher the level of educational attainment of the household head, or any member of the household, the more likely households have been observed to make use of modern energy services in India [30], [31], Nepal [32], Bangladesh [24], Ethiopia [33], Kenya [34], Uganda [35], and Nigeria [17].

From the behavioural perspective, a diversity of tasks associated with a particular energy demand (e.g. cooking) – and the difference in techniques, temperature, duration, surface area required for each task – has been observed to be an important determinant of energy behaviour, as households seek to select the fuel-technology combination they perceive to be best suited to each task [4], [6], [11], [20], [23], [36]–[39]. An illustration of the diversity of tasks is the example of traditional fires for cooking also serving as facilitators of social gatherings in Mexico [11].

Households have displayed individual predispositions and attitudes that impact their energy decision-making, by shaping their preferences, concerns, trust, or relative perception of importance towards various energy services [4], [10], [23], [27], [31], [40]–[44]. Such personal determinants can also come in the form of a household's awareness or understanding of modern energy services and its benefits, or the suitability of their dwelling arrangement [20], [40], [42], [45]. Tradition, culture and religion have also been observed to be significant to household behaviour, in countries such as Guatemala [46], Papa New Guinea [47], Nigeria [48], and India [21].

External factors

The external category consists of factors that directly influence household energy behaviour, as well as factors that indirectly influence behaviour. Direct influencers include: the price of a fuel and/or technology having a significant bearing on household adoption and use [31], [33], [37], [42], [49]; and fuel/technology performance characteristics influencing household confidence and thus reliance, or the resulting behaviour during use [6], [27], [28], [30], [37], [41], [42], [44], [45], [50]–[52], including the presence of useful by-products (e.g. coal from fuelwood use) [20]. Fuel, technology or energy service prestige and the resulting social value associated with ownership or operation can also influence decision-making [37], [42].

Household energy behaviour is also indirectly shaped by factors such as a region's natural climate [11], [53], [54], a household's environment [32], [34], [55], and their location [12], [18], [30], [31], [35], [56], as they influence the fuels and technologies that are both relevant for a market, and make it to the market in a given period of time.

The exact manner in which the various internal and external factors influence household energy behaviour is very complex, with influence to varying degrees cutting across different individuals, socio-economic groups, energy-related behaviours (e.g. acquisition, setup, use, disposal) and more. The factors are also not independent of one another; for example, the (internal) trust factor is linked to the (external) supply reliability/quality factor. As a result there is a need to explore what forces are at play, as households make their energy decisions in reality, from day to day, week to week, month to month.

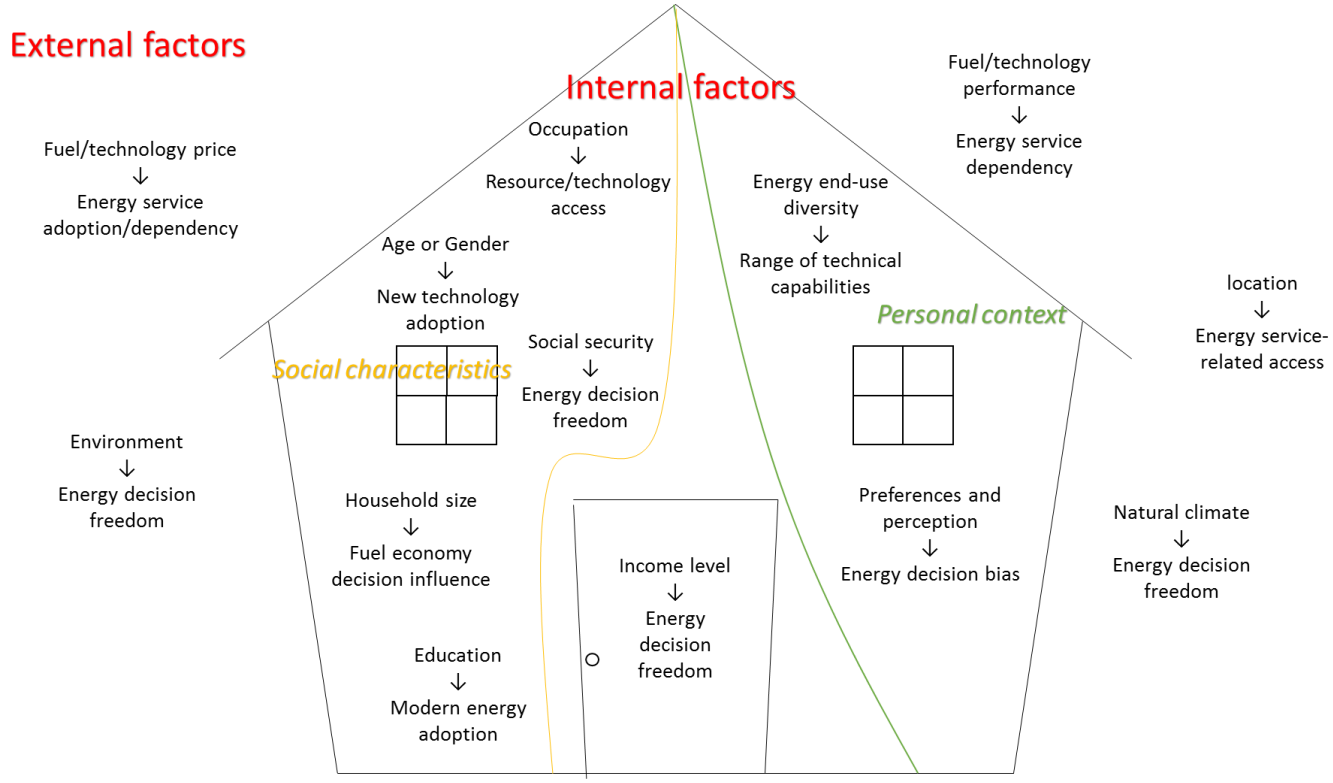


Figure 1: Summary of factors influencing household energy behaviour (Authors' depiction; categories informed by [14]*)*

3 Materials and Methods

The IEA envision 674 million people globally will still be without electricity access by 2030, and 2.3 billion still without access to clean cooking by that year [57]. Of these, 600 million will be in Sub-Saharan Africa (SSA), suggesting that population growth will outstrip any gains in electricity access. A similar situation is expected to exist for clean cooking, with 910 million remaining without access in 2030; the only continent that is forecasted to not achieve net gains in energy access. We therefore give research focus to the continent by selecting a case from Nigeria, whose energy access deficit ranks first globally for electricity, and third for clean cooking [1].

In accordance with the research objective, the case was selected based on:

1. the usefulness of comparing insights across different contexts to aid transferability of insights [58] – differences include availability of energy services/infrastructure, community remoteness, and other socio-economic characteristics;
2. relevance of energy poverty to varying degrees between households and communities;
3. practical accessibility for qualitative field research;
4. access to secondary data;

5. selecting a group of communities that would all be familiar to participants involved, regardless of their residence, to allow participants the opportunity to present their experiences in a wider context, which could then be cross-examined by further field observation and during subsequent interviews to glean new insights and/or verify information;
6. and the ability to obtain rich and diverse insights from the field under limited time, financial, and human resources.

Five rural communities in the Epe local government area (LGA), located in the eastern region of Lagos, Nigeria provided the case setting for this research: Igbodu, Ketu, Elujo-Imowo, Oriba, and Itokin. The communities selected denote a diversity of energy poverty, economic and socio-cultural circumstances, while all capturing contexts where development and household lifestyles are particularly limited compared to urban Lagos. Section 4 provides further details on the case communities.

Primary data collection was undertaken in two stages between May 2013 and November 2014, in which 83 semi-structured interviews with 67 household participants were undertaken. The first stage was spent living and conducting field research in Lagos, Nigeria; facilitating the development of a keen understanding of the issues related to energy services in the state and among rural locals. This was followed by an initial examination of primary data obtained during the first stage. The second stage saw an immersion back into the field in Lagos, to re-engage and clarify emerging insights through elicitation of a second round of primary data collection.

Multiple methods that included interaction with a range of stakeholders across multiple scales and sectors were used to gain an appreciation of the internal and external forces affecting energy decision-making in the case context. A summary of these methods adopted can be found in Table 1. However, the primary method of investigation was the use of semi-structured interviews with household decision-makers.

Table 1: Summary of data collection methods

Method of data collection	**Data type**	**Description**	**Groups method employed with**	**Number undertaken**
Audio-recorded semi-structured interviews	Primary, qualitative	In-depth one-to-one interviews. Flexible structure for conversations with broad areas of inquiry to direct conversations.	Household decision-makers; senior staff of modern (clean) energy technology retailers	91 (83 household interviews; 8 technology retailer interviews)
Focus groups	Primary, qualitative	Unstructured group discussion on community energy services and behaviour with locals in a community.	Group of locals in Igbodu, Elujo-Imowo, and Oriba.	3
Unrecorded semi-structured interviews	Primary, qualitative	Semi-structured interviews with broad areas of inquiry about Lagos and Nigeria's energy market and external decision environment.	Traditional and modern (fossil fuel based) technology retailers; end-user financing institutions; multilateral development institutions (MDI); public institutions; state ministries and parastatals	15

Soft participant observation	Primary, qualitative	Visiting and undertaking interviews in natural environment of participants (e.g. homes, stalls, shops), enabling observations of their surroundings and natural processes.	Households	67 households
Secondary data examination	Secondary, qualitative and quantitative	State and local household/socio-economic surveys to explore case context.	N/A	N/A

Participant selection was based on both the purposive and snowball sampling techniques, where the former technique was used to capture a wide range of perspectives according to differences in cultural and socio-economic characteristics influencing household energy behaviour. These characteristics included household size, occupation, income, expenditure, residency, gender, migrant status, medicinal practices, marital status, mobile phone ownership, and farming practices. A curtailed list of the characteristics of the 67 study participants can be found in Table A. 1 (in the Appendix).

The semi-structured household interviews were all recorded and transcribed, before qualitative analysis using NVivo software. The analytical process was fluid, moving back and forth between the following steps (adapted from Taylor-Powell and Renner [59]: (i) examining the entire spectrum of data including transcripts and notes taken in the field, and making connections to help re-live the fieldwork process and highlighting important themes; (ii) using the literature to create an initial set of coding avenues, but also noting alternative avenues of interest identified in the field and spotted during transcript analysis which also need exploration; (iii) categorising codes according to appropriate themes and patterns based on particular energy behaviour, decisions, ownership, transitions, or histories – all of which can be cross-examined with other codes or themes and with participant characteristics; (iv) running queries to search for patterns and connections across codes, categorised themes, and participant characteristics to examine relations; and (v) using the connections assembled in conjunction with other interview stories, to interpret the findings as they relate to reasons and observations of energy behaviour.

Research Limitations

The research adopted a methodology suited to the objectives of the study and the resources available. Nevertheless, it is useful to acknowledge and treat the limitations of the chosen method [60]. One area of consideration is to do with the case selection. There are other regions in Nigeria, such as the far west and north-east, which exhibit strong characteristics of energy poverty and remoteness and could have been included for greater diversity. However, constraints on resources, community access, and the practicalities of undertaking safe fieldwork made it necessary to limit the scope of the areas being researched.

The use of a representative sample of the case – which are common in questionnaire surveys – would have made it possible to generalise findings to the case population. However, this research was interested in *why* households interact with energy the way they do. This involves eliciting information around a participant's reality, around motivations, around histories, opportunities and future hopes. The process expects to encounter both new doors of inquiry not previously known to us nor found in existing literature, and also reveal nuanced relationships observed for other contexts in the literature

[61]–[63]. Therefore, the close-ended nature of a questionnaire survey, which limits the breadth of consumer responses, is not suitable as the primary method for this research.

The study could have elicit elicited information showing differences in how people perceive their energy issues at different times of the year if the two periods of fieldwork were planned to cover different seasons. However, this would have increased the complexity of data collection and analysis required, but is a useful area of future research. Nevertheless, this potential limitation was treated by capturing seasonality in the nature of questions asked. Participants were encouraged to compare their behaviour across seasons and under different circumstances.

Finally, the paper would be better served providing evidence on data collected more recently than 2014. However, the context of most of the communities included for research have not undergone dramatic change since then. More importantly, there remain many communities in Lagos, Nigeria, and beyond that can be characterised today by the 2013/2014 situation of the case communities, for which the insights obtained are transferable. For this reason, a rich description of the case context at the time of data collection is provided in the next section.

4 Research Context: Household energy and livelihoods in Epe, Nigeria

This section will review the case context at the time of fieldwork (i.e. 2013/2014), and will present data based on that period. Epe has the Lagos lagoon running through it from its west to eastern border, with coastline communities either side of the water body situated around swampy marshlands, which provide naturally fertile soil for agriculture [64] (Figure 2). The segment north of the lagoon, connected to mainland Lagos and other Nigerian states, is bordered by Ogun state in the north and the east, and the Ikorodu LGA of Lagos in the west; while much of the southern segment is surrounded by water, connected in the south to Lagos Island bordering the Ibeju-Lekki LGA.

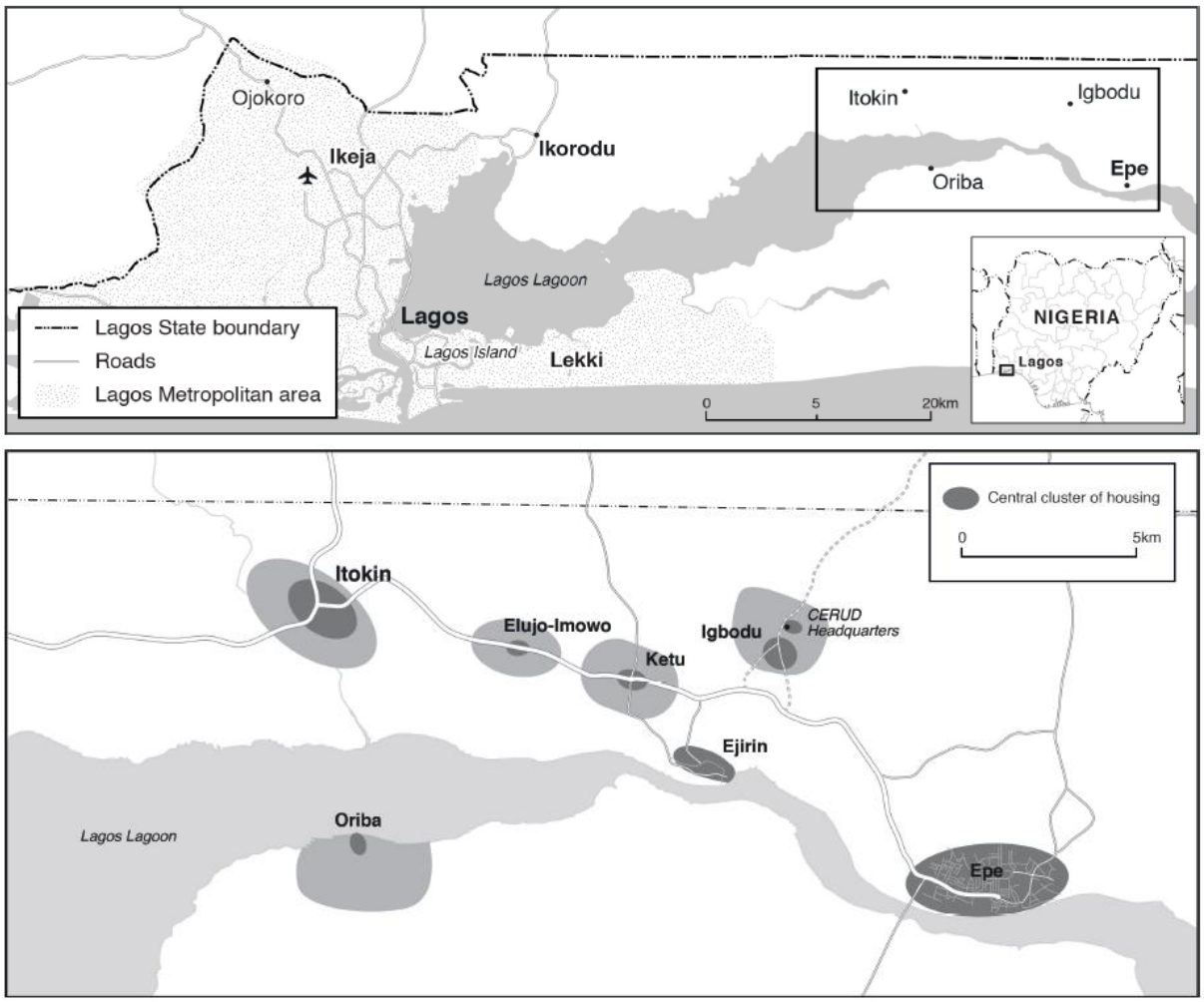


Figure 2: Map of Lagos (above) and map of the study communities (below) (Authors' depiction)

The practices of smallholder farming, fishing and petty trading are the dominant occupations across the working class – the extent of which varies from community to community. Dispersed populations and marshy terrain, amidst vast swathes of forests have increased the cost of critical infrastructure, resulting in a dearth of access to basic services and economic opportunity. Table 2 provides a summary of each community's characteristics.

Table 2: Summary of community characteristics

Community	*Population*	*Community market place*	*Community electricity service*	*Other public services*	*Access to Epe town (or other major trade market)*
Igbodu	1,500	Stall vendors	Tier 0 grid[1]	Unreliable water pumping	16km dilapidated road access

[1] Under the World Bank's Multi-tier framework for measuring energy access, 6 tiers (0 = lowest; 5 = highest) are used to categorise the level of service/access provided by a given energy supply according to characteristics which include, power capacity, available hours, reliability, quality, affordability, and health and safety. A tier 0 level of electricity service denotes the unavailability of access, or (for example) daily service provision that is below the minimum 3W and 4 hours in terms of capacity and availability respectively, that is required for tier 1 classification [69].

Community	*Population*	*Community market place*	*Community electricity service*	*Other public services*	*Access to Epe town (or other major trade market)*
Elujo-Imowo	100	Unavailable	Tier 0 micro-grid	Periodic water pumping	7km dilapidated road access
Itokin	6,000	Multi-service market place	Tier 0 grid	Private water pumping; school	>25km dilapidated road access; in-community weekly trade-market day
Ketu	5,000	Stall vendors	Tier 0 grid	Non-operational clinic; school	15km dilapidated road access
Oriba	50 dispersed villages	Stall vendors	Tier 0 grid	Non-operational clinic; non-operational school; non-operational water pumping	>14km informal road access; unreliable river access

The Epe region has a few market areas – namely 'Epe town' in the east – which make up the major hubs of daily economic activity in the region; where products and services characteristic of a small town centre can be located in accordance with the needs and practices of consumers in the surrounding areas. Some village communities consist of a small number of vendors that source products from market hubs – such as Epe town and beyond – to be sold at the convenience of community residents. Growth in Nigeria's telecommunications sector increased the use of mobile telephony in the region, enhancing productive activities and social relations. Available data at the time of fieldwork showed that approximately 24% of residents in the region lived in relative poverty (national poverty line <$2.5 per day (2010 international prices)) [65]; while remittances or borrowing from family and friends formed the primary mode of financial support [65], [66].

Figure 3: Types of amenities sold by petty traders in the Ketu community (Authors' picture)

A typical day for many of the residents in the communities visited starts at the break of dawn (circa 6am); where children who attend school make their own way to school, and working adults prepare to make their way to the farm, sea or forest. Residents that engage in non-farm work have a more flexible start to the day, where commitments and activities at home can influence proceedings.

Household sizes range between 3 and 10 persons, except for extreme cases.[2] Housing structures in the communities have not been designed to make good use of daylight, and rarely facilitate quality ventilation. As a result, residents spend most of their days outside built structures; whether at the house or at the work place.

Figure 4: Straw-thatch house in Oriba community (left) and typical outdoor petty trader stall (Itokin) (Authors' pictures)

Energy stacking is widespread in the region for lighting, cooking, and food preservation services. Manual harvest of freely collected fuelwood is common practice in the communities visited; an activity that sometimes includes children once the school day is over (circa 4.30pm). When twilight is no longer sufficient for vision (between 7.30pm and 8.30pm), all farming activities cease. Some community traders continue sales activity supported by lighting services, while others close and gather with their family in their homes for evening meals and other activities. A range of energy services are used by local households to facilitate the daily activities described above (see Table 3).

Figure 5: After-school fuelwood collection by children is common in the communities (Authors' picture)

Table 3: Household energy services in communities visited

Energy Service	**Fuel and Technology**		
	Primary Energy Carrier	*Secondary Energy Carrier*	*Conversion Technology*
Cooking	Gasoline; diesel; grid	Fuelwood; kerosene; charcoal; private electricity (diesel-based only; community electricity; grid electricity; LPG	Three-stone stove; welded fuelwood stove; charcoal stove; smoking wood stove; kerosene stove; electric stove; LPG stove

[2] A small number of households cited household sizes in the region of 15 to 19 persons, comprising multiple generations living at the same premises.

Lighting	Gasoline; diesel; sunlight; grid	Kerosene; rechargeable batteries; home private electricity; community electricity; grid electricity; LPG	Kerosene Lantern; torch; rechargeable lantern; mobile phone light; light bulbs; street lamp; solar lantern
Space Cooling	Gasoline; diesel; grid	Batteries; private electricity (diesel-based only; community electricity; grid electricity	Fan; air conditioning
Food Storage	Diesel; grid	Fuelwood; private electricity (diesel-based only; community electricity; grid electricity	Smoking stove; refrigerator; freezer
Television Watching	Gasoline; diesel; grid	Private electricity (diesel-based only; community electricity; commercial electricity; grid electricity	Home television; commercial television
Mobile Phone Charging	Gasoline; diesel; sunlight; grid	Private electricity (diesel-based only; community electricity; grid electricity	Home power socket; commercial power socket; solar lantern socket
Productive Activity	Diesel; sunlight; grid	Fuelwood; kerosene; charcoal; private electricity; grid electricity	Various types

Note: 'Primary Energy Carrier' denotes fuel that is converted to electricity, or electricity transmitted from central grid.

Consistent with other regions of Lagos and Nigeria, kerosene is the most commonly used fuel in the communities visited, since it meets both the lighting and cooking energy services. Kerosene and fuelwood are the only fuel resources sold by community vendors; all other fuels are purchased at petrol stations found in market hubs. Residents who own their own homes as detached structures situate their kitchens outside, in some cases with a roof to assist cooking during the raining season. Some of those who rent their homes have shared communal kitchens only, situated inside the building structure for indoor cooking. It is common practice in this region for fuelwood cooking to be undertaken outdoors only.

Figure 6: Outdoor kitchen (left) and fuelwood mud stove (right) in Igbodu community (Authors' pictures)

To understand the testimonies of the households concerning their energy service behaviours, it is useful to acknowledge the local perception of the relevant energy resources and technologies. These perceptions are influenced by factors such as perception of costs, technical performance, observed social status of owners, prevalence of use within less-developed and more affluent regions of the country, etc., and do not necessarily mirror the attributions of other stakeholder groups, such as in academia and the international practitioner community. Table 4 categorises the household energy services used in the communities according to observed local perception.

Table 4: Energy service definitions used in analysis

Traditional energy services	Kerosene for lighting (*kerosene lantern*); unsustainably harvested biomass (*fuelwood stoves, fish smoking wood-stove*); charcoal (*charcoal stove, charcoal iron*); locally-constructed battery powered lamp
Transitional energy services	Kerosene for cooking (*kerosene stove*); gasoline or diesel for electricity generation (*private gasoline generator*, *community generator* (*diesel-based*)); home appliances powered by fossil fuel-based private generator (e.g. fan, television)
Modern energy services	LPG (*LPG stove*); reticulated electricity (grid and mini/micro-grid); stand-alone renewable electricity; solar lantern; home appliances powered by reticulated or stand-alone renewable electricity

5 Results and Discussion

This section uses the voices of locals to communicate the reality of the forces at play in energy decision-making. Focus is given to the decision to acquire and make use of a fuel and/or technology. Insights do not cover the forces governing the nature of use. To aid discussion, the study categorises

the scope assets of resources (capital) by which an individual or household seeks to sustain or enhance their way of life into five categories: physical, natural, financial, social, and human.[3]

In the quotes that will follow, parentheses () are used to fill responses by providing the context of the question that the answer was in response to, and also to complete sentences spoken in *pidgin* English (a local dialect of the English language), for the sake of understanding. Square-brackets [] are used to provide meanings of colloquial words, and also to indicate the object of any pronoun used.

We observed three important drivers behind household decision to consistently engage with a fuel-technology combination in practice: (1) their organisation of daily life and by extension their vocational activity, (2) the urgency of operating the service, and (3) experience with and exposure to an energy service.

5.1 Organisation of daily life influencing decision to physically acquire fuels

73% (22 of 30) of all farming households interviewed (i.e. having at least one member of the house engaging with crop, livestock or fish farming), made use of fuelwood for cooking to some extent, either exclusively or as part of a stack of cooking energy services. On the other hand, only 30% (11 of 37) of non-farming households made use of fuelwood for their cooking energy service. No other household characteristic showed any connection with the use or non-use of fuelwood. The observed higher dependence on fuelwood by farm households provided the first indication that *vocational activity* was an important determinant of fuel acquisition decisions, and thus energy service use.

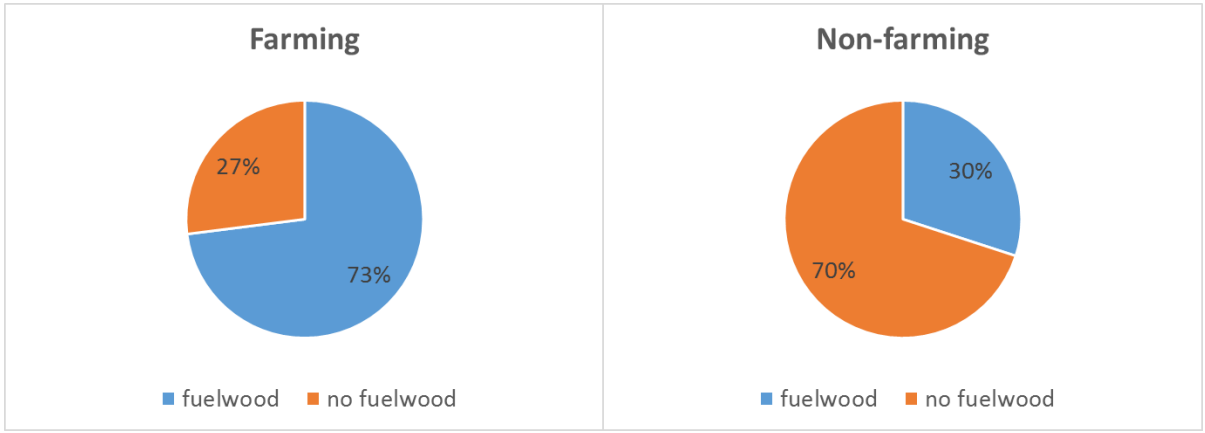


Figure 7: Fuelwood cooking status across farming and non-farming households

Farmers

Fuelwood is harvested and gathered in forests around the vicinity of farm plots where farmers spend a notable amount of their days. This makes the fuel available to them, and since it is free, it is also affordable. Whereas for non-farming households, their days are spent in a manner not conducive for allocating time to collect freely available fuelwood, which gives it a very different availability profile. The process of fuelwood collection can be arduous and draws from the natural (stock of community fuelwood resources) and human (time and energy) resources. Alternatively, acquiring cooking energy carriers such as kerosene largely drew from the economic resources of households, because with the

[3] This categorisation draws on the five livelihood capitals adopted in [75] and [76].

aid of road infrastructure (physical resource) to most communities – although dilapidated – it is available at affordable cost from community vendors.[4]

Insights showed that it is not that farming households – though owning a kerosene stove – desired to trade-off more of their human resource in the form of time and energy to acquire fuelwood than non-farming households, but rather, the drain on the former's human resource was not enough to render fuelwood collection unsustainable for their livelihood. Indeed, for farming households there was enough incentive to collect fuelwood for free to meet their cooking needs – considering widespread positive opinions about its superior performance in meal outcomes, notwithstanding emissions – because they spent much of their day at source already.

Essentially, while both kerosene and fuelwood are, to an extent, affordable for all households, the availability of fuelwood was suitable for farmers because they spent their days at or near the source, while for non-farming households the level of free fuelwood availability was unsuitable. For the latter, the human resource required to acquire fuelwood far outweighed the benefits because their occupations cannot efficiently coincide with long journeys into forests and time spent harvesting fuelwood, regardless of the perception surrounding its use and meal outcomes.[5]

We observed this with insights from farmers on how they integrate fuelwood collection with time spent on the farm, and it is clearly explained by participant H33-IG. She and her husband migrated to the Igbodu community from metropolitan Lagos and live in rented accommodation, which is equipped with an outdoor kitchen, making it possible to cook with fuelwood. Farming on rented land is her primary occupation while her husband works in security. As she discussed her cooking practices and looked back to practices she used in the past while residing in an urban area of Delta state, she explains why her use of fuelwood is now possible by virtue of the ease of its acquisition, whereas this was not the case in the past.

> "*No (I did not use fuelwood back when I lived in Delta state) because my husband was working Oyinbo [non-farm] work at Delta Glass...(I was) using (kerosene) stove at that time...(But I am not using kerosene) because we are in the farm now...No (we were not able to use fuelwood when we were in Delta state)...farm (was) near, but it's [where we stayed] inside the town...it's (an) urban area...No (we could not buy firewood there)...No (we could not collect fuelwood there)...because as we are working for Oyinbo [non-farm] work...(at) that time, me too I am working (non-farm work)...I (was using the) sewing machine...As we are (now) working farm work, I prefer it (fuelwood stove)...during farm work, we prefer it, but if--had it been that we are doing the Oyinbo [non-farm] work (then we can use kerosene)*" (H33-IG November 2014)

For the nine farming households that cited non-use of fuelwood for cooking purposes, we found this to be because of the organisational dynamics of these homes and their farming activities, which do not make fuelwood acquisition as feasible as it was for the farming households that made use of it. Such dynamics included: physical inability (elderly woman) for manual fuelwood harvesting coupled with non-farming daughter-in-laws that undertake all cooking activity, landlord restrictions on fuelwood cooking in rented accommodation that have no outdoor kitchens, and unfamiliarity with fuelwood cooking.

[4] Although kerosene consumption is also related to natural capital, it is unrelated to the communities in discussion because the environmental consequences of kerosene's life cycle up to the point of acquisition largely occur outside the communities.

[5] Note also that farmers, by virtue of farming operations, are already equipped with the tools required for fuelwood collection – the axe (physical capital).

Non-farmers

Insights from non-farmers reveal similar forces associated with vocational activity that render free fuelwood collection incompatible with the sustainability of their livelihood. For example, in contrast to the experience of farmer participant H33-IG presented above, female participant H50-IG, comes from a background of smallholder farming in her younger days, when in the home of her parents in Igbodu. Growing up, she and her siblings practised farming with her parents and their main cooking fuel was – and for her parents she says, still is – fuelwood. She cites that though now living again in Igbodu (she spent some of her schooling years in metropolitan Lagos), in her own home, neither she nor her husband undertake farming activities, and do not engage with fuelwood any longer.

The ten non-farming households that made use of fuelwood – even though their vocational activity was not well aligned with the acquisition requirements of manual fuelwood collection – were found to do so because of circumstantial relative ease of acquisition to the households, which meant that although they were not farmers, the livelihood resources of the households and/or their environment were such that it was either reasonable for them to trade off some of their relevant resources in order to acquire the fuel they desired to use, or that the trade-off required was minimal, or synergy was present.

For example, participant H66-IT is a petty trader who has her stall set up in the Itokin community, while her home is in the Agbowa community; located about 11km west of Itokin. She explains how her cooking energy stack consists of three different fuel-technology combinations; the LPG stove, the kerosene stove, and the traditional fuelwood stove. Her preference is LPG due to its speed of cooking, but the relatively high cost of refill encourages her to ration its use. In particular she avoids using the fuel for meals that take longer to prepare, in her bid to maximise the amount of meals gained per fill. This approach of allocating tasks to certain cookstoves in a bid to maximise fuel economy has also been observed in rural Mexico [5], Nicaragua, Botswana, Thailand, and China [11]. She mostly makes use of kerosene because its demand on her financial resource is not as high as that of the LPG stove. Then she notes that she also uses fuelwood due to its relative speed and its suitability for time-consuming meals, given she does not have to spend money on it. Importantly, fuelwood is accessible to her because of the relationships she has around her home with farmers that make use of fuelwood to process their cassava into a local staple (garri[6]); where they provide her with their excess wood fuel.

> "*I'm not living here, I'm living at Agbowa...My market is here...No I'm not a farmer...I am using three types of cooking...Sometimes--I have a gas stove, that small one, that gas small one [portable 3kg LPG stove with a circa 22.5cm diameter hob]...I have (kerosene) stove. Sometimes if I don't have money to buy kerosene or to fill my gas, I'm using firewood...This morning, I used firewood for the beans that I want to cook...so it will be fast...gas is faster than all those stoves and these things...but sometimes if I use it today, tomorrow I can use (kerosene) stove, next [day after] tomorrow my mind will tell me to use firewood stove. It depends on what I want to cook...Firewood? Ah, we have that one for [in] our area, we have sticks, so many sticks there, I don't buy firewood...pick it and use it...because some people they do [produce] garri for our side [where we live], so I will also use from their side [their fuelwood stock], they have firewood with them*" (H66-IT November 2014)

The daily routine of the lady discussed above was such that she arrived at her stall in Itokin around 9.30am or 10am in the morning, and left for home at 7pm in the evening. There is difficulty integrating this daily routine with free fuelwood collection from the farm. So unless free acquisition was afforded

[6] Garri is a local staple produced for sale. Smallholder farmers produce it through manual processing of cassava; part of which, includes extensive frying with the use of fuelwood, and a bespoke pan and stove.

her by virtue of her immediate environment, the only other way for her to acquire fuelwood would have been to purchase it. Given that she attributed the lack of a need to make monetary payments for fuelwood as an influencing factor in her decision to make use of it for certain meals, it is unknown what her behavioural response might be if she had to purchase it. Nevertheless, in the current case she was able to draw on her social capital to acquire fuelwood, and did not require trade-offs from her financial and/or human resources that would have been costlier to her for acquisition of the fuel; costs that may make its acquisition problematic.

Figure 8: Bespoke garri frying stove (Authors' picture)

The above forces that enabled a non-farming household to engage with fuelwood cooking by drawing on livelihood resources they could afford to trade-off was also observed for other non-farmers with the following resources: financial (H6-IG; H49-IG), social and natural (H41-K), social (H31-IG's wife), financial and natural (H26-IT).

Critically, the means by which these participants were able to draw on their livelihood resources to acquire fuelwood, did not require a trade-off of their time (human resource) in such a way that it affected the undertaking of critical daily activities (i.e. vocational activity).

These observations discussed above are in line with findings in other studies. For example, Wang et al [29] found that a shift from smallholder farming to large-scale commercial farming in rural China, led to greater substitution of fuelwood with alternative fuels, where the presence of more off-farm work led to a higher opportunity cost of fuelwood collection. Using regression analysis, Sehjpal et al. [28, p.1] observed that "as women move towards formal employment, the odds of choosing cleaner fuels increases significantly". Wickramasinghe [27] found both of the above perspectives to be true, highlighting that when women's days are structured around outside wage employment, there is no longer the time to procure and process fuelwood, alongside changes in their cooking habits that cater to alternative fuels as opposed to fuelwood. Huang et al. [67] also found off-farm employment to correlate with the use of solar PV as opposed to traditional fuels in rural China. Makalar et al. [68] found that the use of fuelwood was an obvious practice for farming households in rural India, as long as they continued farming.

This study has used the voices of local residents to explain the reason behind the above observations and any alternative behaviours, to be based on the interaction between a person's willingness to trade off their livelihood resources to engage with a fuel, the fuel options available to them, and their desire

to make use of the fuel. The manner in which households organise their lives is an important determinant of their willingness to trade their various resources.

5.2 Urgency of operating the service: the *perception* of affordability

Although the Itokin, Igbodu, and Ketu communities are all connected to the national grid, and Elujo-Imowo has a community micro-grid, all communities receive the equivalent of a tier-0 level of energy service access from these sources (see Table 2). Therefore, some households make use of private gasoline generators to meet their electricity needs.

Of the 67 participants included in the study, 10 had *no access* to private electricity generation services at home; 6 of them had access to *shared* electricity generation (this includes the 4 participants from Elujo-Imowo that had access to a tier-0 community micro-grid service, because financing generator operations is undertaken by community contributions); 27 participants *rationed* the use of their home private generator (e.g. two nights in a week); 20 made *daily use* of their generators (typically tier-3 usage in terms of hours of operation, 6 to 8 hours every night; but tier-2 in terms of services used – see [69]); and the status and/or nature of use for 4 participants was not revealed during interview proceedings.

We found no connection between household income or expenditure and the frequency of use/ownership of the private electricity generator (Figure 9). Rather, we found that a decision-maker's perception of affordability – or their willingness to allocate financial resources to the purchase of a service/good – is affected by the priority (urgency) it holds relative to other expenditures; and this level of importance attributed can be subject to change.

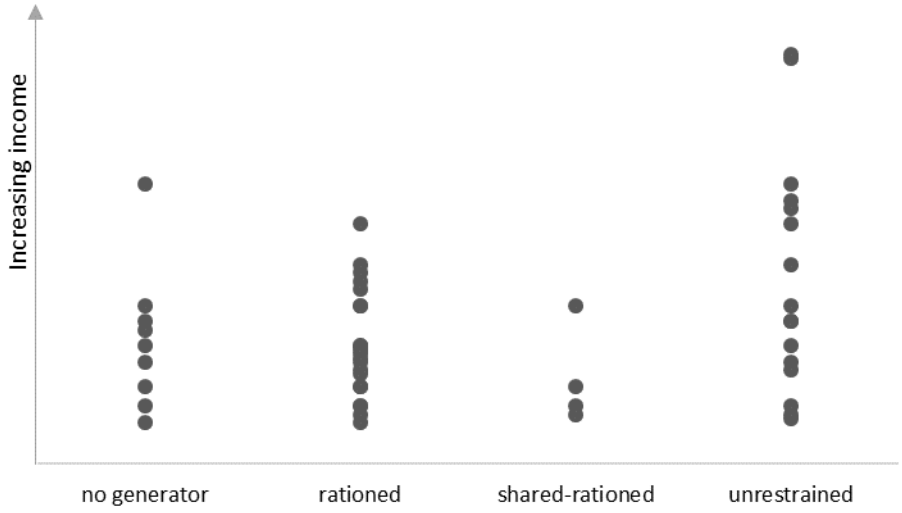


Figure 9: Private electricity generator use versus income

Note: Each dot represents an interview participant with a given income (y-axis) and approach to using privately generated electricity (x-axis).

Consider this example regarding the lifestyle and expenditure practices of a farmer living in Elujo-Imowo (H7-EI). He is the head of a household of 10 persons that include his wife, children and mother. His appreciation of electricity and the energy services it facilitates is clear, as he states: "*it's the (grid) electricity that is the best. You know, because we can't see grid electricity at the moment, we have to use generator. If there was grid electricity from morning till night, then we can charge our phone and it does it faster than the generator. We can't have the generator from morning till night. If there was*

grid electricity, we can use other things like the electric cooker. If grid electricity was around---we would like grid electricity more than all these other things...it will encourage vocational activities to spring up. That's what we need the national grid for" (H7-EI September 2013). Yet, in his home, private electricity generation is rationed.

Though he has access to the community generator that provides 3 hours (7pm till 10pm) of electricity twice a week to households and for water pumping, he supplements this with private generation of his own; operated sparingly from 7pm till 11pm, on the days he decides to make use of it. The main energy services operated within his home when electricity is available are the charging of mobile phones, his wife's freezer – which she uses to cool beverages with the aim of sales – and lighting both inside and outside their home. Outdoor electric lighting is particularly useful to them because their house is small in size; necessitating that many activities, aside from television-watching, are most suitable outside. These include attempted sales of beverages and other food items by his wife and mother respectively, as well as an area for his children to do their homework. His children often go with their mother to collect fuelwood after school; a process he says can take up to three hours of their time in total, and takes place every two or three days. Thus, it is typically after dark when they get home before they get an opportunity for dinner and time to do their homework; and the illumination of their secondary lighting source, used when there is no electricity – the kerosene lantern – is particularly poor for reading and writing, it mainly aids dinner preparation and sales. He highlights that he makes use of two phone batteries because he does not have daily access to electricity. During discussions on how he considers the decision to operate his generator or not vis-a-vis his income, he explains:

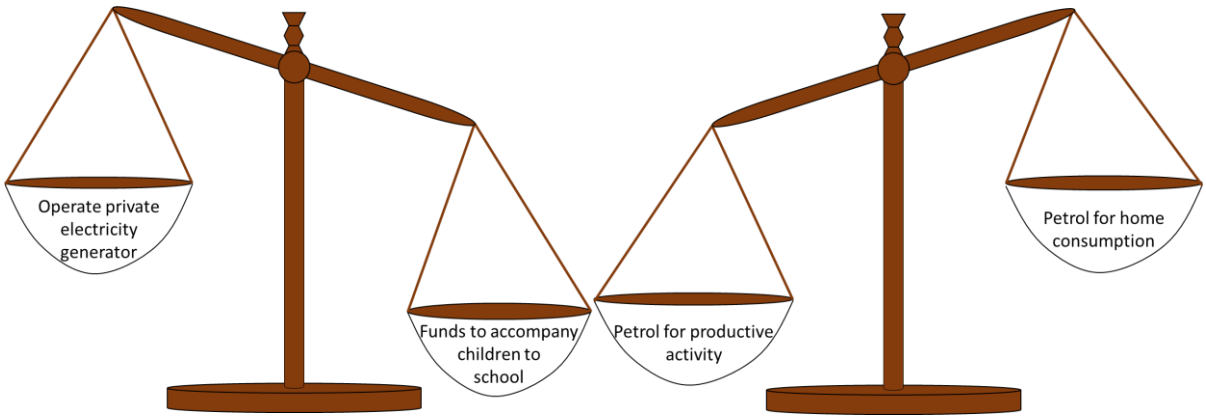
> "*I produce cassava, corn, melon, tomatoes, pepper, okra, and coconut. They all mature at different times in the year so I always have a product that I am selling. When a produce is selling, it can take about one month to complete its selling, but this changes depending on the product and how they mature. On average we will sell every three to five days. Three for tomatoes, corn will be five day selling...If you have 1000 naira [2013 US$6.4] in your pocket, you can afford to say you want to buy 500 naira [2013 US$3.2] petrol and put on the generator, because you still have to give the children 500 naira for school tomorrow. If you only have 500 naira, then you can't then say let's buy petrol.*" (H7-EI November 2013)

In the subtropical climate of the coastal city of Lagos, where annual temperatures rarely fall below 24°C and humidity is high [70], [71], smallholder farmers, lacking access to adequate storage facilities, must aim to take their highly perishable products to market as soon as possible following the harvest. Not only do these circumstances deny them the opportunity for market selection, but they must contend with high levels of loss (product spoilage), and undertake the back and forth process described by the participant of picking and marketing, which limits the productivity of their operations. Following this backdrop that leads to uncertainty in the volume of possible sales, the size of his income from trips to the market is subject to variation. From his simple example shedding light on the nature of his behaviour, it is clear that ensuring his children can access the products and services they need on a school day, is more urgent than fuelling and operating his gasoline generator for electricity services. Between the above two expenditures, on a day when he has N1000 (2013 US$6.4) available to allocate to both, he divides the financial resource between the two. However, on a day when there is only N500 available in consideration of those two expenditures, he allocates it to his children's school day, and foregoes gasoline purchases. An awareness of these priorities and funding limitations forces him to ration the use of his generator, such that it is not used every day; and when used, is operated for only 4 hours. Therefore, his perception of affordability (or willingness to pay) for his children's education is higher than gasoline purchases for home electricity services.

We also observed the perception of affordability for the same energy service differs greatly depending on the purpose being served. For example, participant H15-IG spent only 5% of the weekly gasoline purchases made to operate her chainsaw (used commercially for logging) on fuelling her home-generator for electricity, citing unaffordability in the latter and limiting her home electrical services to mobile phone charging *alone*. The same was observed with attitudes towards fuelwood, where a food vendor – heavily reliant on fuelwood – chooses to purchase it from community vendors and not waste human capital (time) collecting freely available fuelwood. For home consumption, the sense of a fuel being financially accessible is low, because it is consumption-spending, whereas greater funds are willingly committed to purchasing the same fuel applied to the purpose of income generation, because it is investment-spending and leads to the build-up of financial resources – a key livelihood asset.

To buttress the point of urgency is the observation of the poorest participant interviewed at pains to decrease her energy costs, but meeting a threefold increase in the cost of her household's accommodation – because an alternative did not exist. Thus, we see that the perception of affordability is not only defined by the importance of the activity to be undertaken, but the exclusivity of the option on offer to fulfil the service (examples of the behaviours discussed in this section have been depicted diagrammatically in Figure 10). Oftentimes modern energy services are not exclusive due to the market presence of traditional energy services. Even in cases where modern fuels and technologies are exclusive to fulfilling a ubiquitous service, we observed that it did not lead to ubiquitous purchase of the fuel and/or technology. This is because the extent to which options are available to meeting a service can be dependent on the social and cultural dynamics existing in a particular context.

For example, among the communities visited, mobile phone proliferation was high; being used for crucial communication involving client-customer communication, sourcing transportation services, liaising with family over remittances, and for makeshift lighting services. Given the exclusivity of electric mobile phone charging, it can be expected that every mobile phone owner urgently requires electricity access in their homes. However, six of the participants that had no access to private electricity generation talked about charging their mobile phones and recharging lanterns via alternative means. As also observed in other contexts (see [72]), residents drew on relationships (social capital) to charge their mobile phones, and also accessed mobile phone charging from commercial chargers (Itokin only) which is a cheaper expenditure than purchasing gasoline for private electricity generation. Other participants that rationed the use of their private generators also accessed electricity for mobile phone and lantern charging by these means.



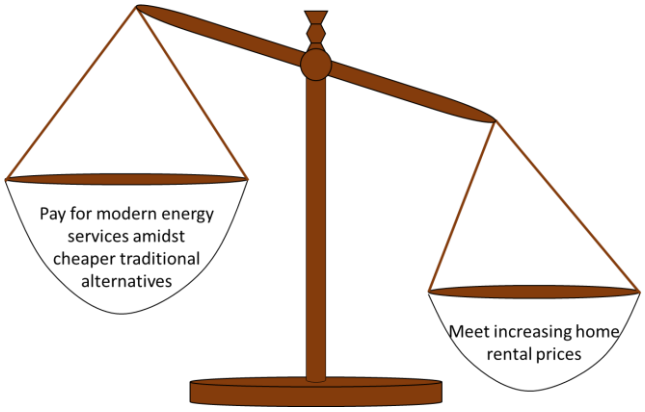


Figure 10: Examples of household urgency of demand (Authors' depiction)

Note: The lower bowl (i.e. heavier weight) in each beam balance illustrated, signifies demands of greater (urgency) relative to the demands in the higher bowl.

5.3 Fuel-technology exposure begets fuel-technology use

Importantly, interviews with the residents revealed that urgency of service use can be developed, as well as the urgency of specific fuel-technology combinations, even in the face of alternatives – a crucial insight for modern energy strategies. This finding corroborates some of the exogenous influences of household energy behaviour highlighted earlier, such as the increased likelihood of Solar Home Systems (SHS) adoption among Kenyan households that resided in districts where SHS was common [34], and other examples in the literature of technology proximity positively impacting adoption and use [73], [74].

We observed *experience* to be an important enabler – or disabler – of consistent reliance on an energy service or fuel-technology combination amidst difficult access and/or in the presence of competing alternatives. One key shaper of the experiences of an individual in Lagos state and the exposure they have to services and products, is the region of the state in which they reside. Urban – and to a lesser extent peri-urban – life is particularly different to the life experienced by members in the rural communities explored. Itokin is the closest of the five communities to having some of the services and lifestyles commonly found in more densely populated and frequented regions, but it still falls short of the environment created in urban areas and the impact they can have on a person's predispositions.

Participants that either commuted from urban or peri-urban Lagos to trade in Itokin, or those that split their time between metropolitan Lagos and rural Lagos spoke of service access at their urban homes very different to the permanent rural dwellers. Amidst greater marketing of a wider array of goods and services, the former areas have greater access to modern and transitional fuels and technologies, and thus greater household use; and provide more difficult (or expensive, in terms of livelihood resources) access to traditional fuels such as fuelwood. Exposed to a wider range of energy services, households in urban regions become more accustomed to their provision. This familiarization remains, even when they relocate to a rural area.

The testimonies of participants that have resided in their respective communities throughout their lives suggested that electricity in the home, and some of the exclusive services it provides besides mobile phone charging (e.g. television and space cooling services), were not urgent demands:

> *"No (we do not use our generator for television services)...Don't use a fan...you know the children in the local area here, immediately you turn on the gen [generator], you turn on the*

TV, for them to go and carry their book [homework] will be their problem...So let them face their book" (H15-IG September 2013)

"*At night time, when we have finished eating, we will pray, everyone just before we sleep. That God should watch over us as we sleep. Sometimes if there is light [electricity], we will watch television. If there is no light, we and the children will sit down and play and chat. And in the morning we all come together and pray as well*" (H14-IG September 2013)

"(when there is no grid electricity) there is nothing I will do. I accept that. I don't use fan. And there is no alternative. When there is no light [grid electricity]. I don't use anything" (H17-IT October 2014)

"*we have (electrical appliances, such as a fan, in our house) but, no light [electricity] to use it*" (H33-IG November 2014)

"*I have (a petrol generator) before but it is not functioning any longer. Since last year, I have not been using generator...(I have a) television, radio, fan, bulb, and charging of phone...They are intact (but) because there is no light [grid electricity] and I don't use gen [generator], I just abandon them there*" (H19-IT October 2014)

All these were passive in their consumption of privately generated electricity or did not consume it at all. On the contrary, the testimony of participants that have spent notable periods of their lives in metropolitan Lagos or other urban regions of Nigeria before migrating (or returning) to rural Lagos, presented very different viewpoints on the urgency of television and/or space cooling services:

"*Yes (we turn on the generator from night till morning)...Yes (every day)...No we are not turning it on (in the daytime) unless if we have a certain match that we want to watch...Like Nigerian match...We will on it...Yes (I like watching football)*" (H41-K November 2014)

"*My fan (is very crucial to me, it is very important)...I am always after my fan...I don't like watching television, but my fan and the fridge...they are very important to me*" (H32-IT October 2014)

"*I put it [generator] on when my children are at home. Often when they are at home, because of heat...when the heat is too much (I leave the generator and fan on till day break)...at times when rain falls, there is no---the heat will not be (that much, so I can turn it off)...Yes (the main reason I leave my generator on for any amount of time is based on how long I want to use my fan)*" (H30-IT October 2014)

"(I turn on my generator at 9pm) Because of the heat. Then I would listen to the news and do some other things...Exactly (when my generator comes on at nine, my fan goes on, my TV goes on)" (H65-K November 2014)

"*There has been no NEPA light [grid electricity], so I use generator a lot...petrol (generator) I use it mainly to power fan...I use it for lighting bulbs and power the fan...and television...and to charge my phone...I do (use the generator during the daytime) sometimes, if I'm at home...for fan...because I am somebody that used to [often] sweats a lot. I use them to cool myself*" (H63-IT October 2014)

"(I have a) TV and radio and fan...Two fans...ceiling fan and standing fan...Yes (I use them at the same time)...(when my generator has a problem I fix it) Immediately...The reason why (I sometimes go and bathe in the river) is when I'm feeling heat, I will now go and bathe in the

river...when I'm outside here [in the community centre, away from home]...and when I'm feeling heat...Yes (I will just decide to go and bathe in the river)" (H64-IT October 2014)

In contrast to the first group, who presented apathetic behaviours towards the television and space cooling services electricity provides, the second group presented these services to be very urgent to their livelihoods. As observed earlier with gasoline acquisition patterns, these differences in behaviour were not explained by stated incomes. The difference in urgency can be explained thus: for the former group, a lifetime absent regular television and space cooling services means those residents are not dependent on them for the sustainability of their lives. Though they may consider the services valuable and desirable, they are an added benefit, almost luxury items that do not form the basis of their daily sustenance. Whereas for the latter group – who have spent notable time in regions where these services and their support systems have greater accessibility, and therefore more consistency of use, leading to a dependence on the capabilities these services provide – there is a need to operate these services as a means of sustaining livelihoods.

These forces of history influencing household present behaviour was repeatedly found in cases of non-use of fuelwood (kerosene only), and amongst the four participants that engage with LPG cooking, and solar lantern use (exposure to technology due to existing relationship with microfinance provider). We also found negative experiences deterring some participants from LPG adoption, with the perception that it posed danger to life from fire.

Now the focus should not be on the two regions (i.e. metropolitan Lagos vis-a-vis in rural Lagos), because this division only represents relative difference in the presence of factors that lead to households being accustomed to modern energy services. A person or family can spend a notable period of time in metropolitan Lagos, but the context behind their time spent there may not lead to urgency in the use of services provided by electrical appliances. Similarly, a lifelong rural dweller can have specific circumstances that lead to the urgency of television and/or space cooling services. This was indeed true for a number of participants, including younger Itokin residents, and Itokin residents that grew up in relative affluence, both of which were accustomed to and appreciate television services.

For some other participants that had previously lived in more developed regions, and were likely accustomed to the use of electrical appliances, the cost barrier to regular engagement with a service they want was cited (H48-IG, H40-IT, H56-K, H43-EI, H11-EI); suggesting that regardless of an energy service being urgent, there may be other services of greater urgency competing for the household's livelihood resources. If the relevant livelihood resource (financial) is limited, the household will be forced to make some sacrifices on services that are urgent. Thus, the urgency of an activity is an important determinant of energy service decision-making, but more important is the availability and affordability of the energy service' components respective of the household's livelihood.

6 Conclusion

Using the voices of the energy poor we have presented the realities of household energy behaviour to illustrate why local residents in rural Lagos interact with energy the way they do. Understanding these dynamics is critical to shaping energy access strategies that will bring about more complete transitions to modern energy services, which are needed to produce the human welfare and sustainable development desired, as opposed to a stacking of the harmful old with the new.

In the case region we found the use of modern fuels and technologies to be of less concern to households as they seek to sustain and develop their livelihoods, when compared with needs such as

food, accommodation, and education. If the cost of living can be made more affordable to local residents modern energy engagement can receive greater attention.

Insights also showed that modern energy exposure begets modern energy use, which over time can serve to reinforce the new socio-technical context to be an important component of local lives. Therefore, community connectivity is of critical importance. Infrastructure provision is at the centre of such efforts. Globally, the provision of telecommunications infrastructure has showcased the usefulness of infrastructure in increasing modern energy access.

However, traditional energy exposure also begets traditional energy use, especially under limited livelihood resources. We found that traditional energy service discontinuation can be subjective, with varying risk-reward profiles even among households with similar socio-economic characteristics. A more objective reason for fuel-technology discontinuation can be inaccessibility for acquisition or use, as was experienced by those in rented accommodation without an outdoor kitchen by which they could engage with fuelwood cooking.

A transformation that leads households to make the personal decision to restrict their access to traditional energy services, while at the same time modern energy services are increasingly being made accessible, can bring forth sustainable complete transitions. Insights suggest that an effective way of achieving this is through a transformation of the organisation of daily life for the average energy-poor household. Given the centrality of a person's vocational activity on how they organise their daily lives and the livelihood resources available to them (including, and beyond their financial resources), it serves to be a major driver of energy service availability and affordability, in practice – that is, beyond the classified social and economic characteristics of a household.

The possible connection between other individual/household descriptors not explored in this work (such as social prestige) and a household's lifestyle, experiences, and livelihood assets to explain energy behaviour, is a useful area of future work to build on the findings in this study. Research that also links the insights of this study to evolving debates in Nigeria on – for example – fuel subsidy reform, the provision of energy access through centralised or decentralised systems, and broader national development strategies and plans will be important to shape effective decision-making in the country.

The strategies needed to affect some of the findings of this study go beyond the realm of the energy sector. While this can make the process of change harder and longer, they are likely to be more pervasive, effective and sustainable. Insights from the field suggest that if traditional energy services are to be displaced, then rather than using modern energy services to develop people's lives, we need to develop people's lives to use modern energy services.

References

[1] IEA, IRENA, UNSD, World Bank, and WHO, "Tracking SDG 7: The Energy Progress Report." World Bank. License: Creative Commons Attribution—NonCommercial 3.0 IGO (CC BY-NC 3.0 IGO), Washington D.C., 2020.

[2] Health Effects Institute, "State of Global Air 2019." Health Effects Institute, Boston, MA, 2019.

[3] World Bank, "Global Tracking Framework 2017: Progress Towards Sustainable Energy." World Bank Group, Washington D.C., 2017.

[4] IEA, "World Energy Outlook 2006." International Energy Agency, IEA Publications, Paris, France, 2006.

[5] V. M. Berrueta, R. D. Edwards, and O. R. Masera, "Energy performance of wood-burning cookstoves in Michoacan, Mexico," *Renew. Energy*, vol. 33, no. 5, pp. 859–870, 2008.

[6] C. Bielecki and G. Wingenbach, "Rethinking improved cookstove diffusion programs: A case study of social perceptions and cooking choices in rural Guatemala," *Energy Policy*, vol. 66, pp. 350–358, 2014.

[7] World Bank, "Rural Energy and Development: Improving Energy Supplies for 2 Billion People," no. July. World Bank Group, Washington D.C., 1996.

[8] M. Banerjee, R. Prasad, I. H. Rehman, and B. Gill, "Induction stoves as an option for clean cooking in rural India," *Energy Policy*, vol. 88, pp. 159–167, 2016.

[9] R. K. Andadari, P. Mulder, and P. Rietveld, "Energy poverty reduction by fuel switching. Impact evaluation of the LPG conversion program in Indonesia," *Energy Policy*, vol. 66, pp. 436–449, 2014.

[10] N. G. Johnson and K. M. Bryden, "Field-based safety guidelines for solid fuel household cookstoves in developing countries," *Energy Sustain. Dev.*, vol. 25, pp. 56–66, 2015.

[11] I. Ruiz-Mercado and O. Masera, "Patterns of Stove Use in the Context of Fuel–Device Stacking: Rationale and Implications," *Ecohealth*, vol. 12, pp. 42–56, 2015.

[12] G. Leach, "The energy transition," *Energy Policy*, vol. 20, no. 2, pp. 116–123, 1992.

[13] A. K. N. Reddy and B. S. Reddy, "Substitution of energy carriers for cooking in Bangalore," *Energy*, vol. 19, no. 5, pp. 561–571, May 1994.

[14] R. Kowsari and H. Zerriffi, "Three dimensional energy profile:," *Energy Policy*, vol. 39, no. 12, pp. 7505–7517, Jul. 2011.

[15] B. Van Der Kroon, R. Brouwer, and P. J. H. Van Beukering, "The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis," *Renew. Sustain. Energy Rev.*, vol. 20, pp. 504–513, 2013.

[16] P. C. Stern, "Toward a Coherent Theory of Environmentally Significant Behavior," *J. Soc. Issues*, vol. 56, no. 3, pp. 407–424, 2000.

[17] L. J. S. Baiyegunhi and M. B. Hassan, "Rural household fuel energy transition: Evidence from Giwa LGA Kaduna State, Nigeria," *Energy Sustain. Dev.*, vol. 20, no. 1, pp. 30–35, 2014.

[18] D. B. Rahut, B. Behera, and A. Ali, "Patterns and determinants of household use of fuels for cooking: Empirical evidence from sub-Saharan Africa," *Energy*, vol. 117, pp. 93–104, Dec. 2016.

[19] D. B. Rahut, B. Behera, and A. Ali, "Household energy choice and consumption intensity:

Empirical evidence from Bhutan," *Renewable and Sustainable Energy Reviews*, vol. 53. Pergamon, pp. 993–1009, 01-Jan-2016.

[20] G. Bauer, "Evaluation of usage and fuel savings of solar ovens in Nicaragua," *Energy Policy*, vol. 97, pp. 250–257, 2016.

[21] A. Shankar *et al.*, "Maximizing the benefits of improved cookstoves: moving from acquisition to correct and consistent use," *Glob. Heal. Sci. Pract.*, vol. 2, no. 3, pp. 268–274, Aug. 2014.

[22] R. Heltberg, "Fuel switching: Evidence from eight developing countries," *Energy Econ.*, vol. 26, no. 5, pp. 869–887, 2004.

[23] S. Komatsu, S. Kaneko, R. M. Shrestha, and P. P. Ghosh, "Nonincome factors behind the purchase decisions of solar home systems in rural Bangladesh," *Energy Sustain. Dev.*, vol. 15, no. 3, pp. 284–292, 2011.

[24] S. A. Hasan and P. Mozumder, "Income and energy use in Bangladesh: A household level analysis," *Energy Econ.*, vol. 65, pp. 115–126, Jun. 2017.

[25] C. F. Mertens, T. B. Bruun, D. Schmidt-Vogt, J. He, and A. de Neergaard, "Rural wood consumption patterns of local and immigrant households with differentiated access to resources in Xishuangbanna, Yunnan, China," *Energy Policy*, vol. 80, pp. 112–121, 2015.

[26] B. P. Nayak, C. Werthmann, and V. Aggarwal, "Trust and cooperation among urban poor for transition to cleaner and modern cooking fuel," *Environ. Innov. Soc. Transitions*, vol. 14, pp. 116–127, 2015.

[27] A. Wickramasinghe, "Energy access and transition to cleaner cooking fuels and technologies in Sri Lanka: Issues and policy limitations," *Energy Policy*, vol. 39, no. 12, pp. 7567–7574, 2011.

[28] R. Sehjpal, A. Ramji, A. Soni, and A. Kumar, "Going beyond incomes: Dimensions of cooking energy transitions in rural India," *Energy*, vol. 68, pp. 470–477, 2014.

[29] C. Wang, Y. Yang, and Y. Zhang, "Rural household livelihood change, fuelwood substitution, and hilly ecosystem restoration: Evidence from China," *Renew. Sustain. Energy Rev.*, vol. 16, no. 5, pp. 2475–2482, 2012.

[30] A. Karimu, "Cooking fuel preferences among Ghanaian Households: An empirical analysis," *Energy Sustain. Dev.*, vol. 27, pp. 10–17, 2015.

[31] M. A. Jeuland *et al.*, "Preferences for improved cook stoves: Evidence from rural villages in north India," *Energy Econ.*, vol. 52, pp. 287–298, 2015.

[32] J. Joshi and A. K. Bohara, "Household preferences for cooking fuels and inter-fuel substitutions: Unlocking the modern fuels in the Nepalese household," *Energy Policy*, vol. 107, no. March, pp. 507–523, 2017.

[33] Y. Alem, A. D. Beyene, G. Köhlin, and A. Mekonnen, "Modeling household cooking fuel choice: A panel multinomial logit approach," *Energy Econ.*, vol. 59, pp. 129–137, Sep. 2016.

[34] J. Lay, J. Ondraczek, and J. Stoever, "Renewables in the energy transition: Evidence on solar home systems and lighting fuel choice in kenya," *Energy Econ.*, vol. 40, pp. 350–359, 2013.

[35] L. Y. T. Lee, "Household energy mix in Uganda," *Energy Econ.*, vol. 39, pp. 252–261, Sep. 2013.

[36] M. U. Treiber, L. K. Grimsby, and J. B. Aune, "Reducing energy poverty through increasing choice of fuels and stoves in Kenya: Complementing the multiple fuel model," *Energy Sustain. Dev.*, vol. 27, pp. 54–62, 2015.

[37] O. R. Masera, B. D. Saatkamp, and D. M. Kammen, “From linear fuel switching to multiple cooking strategies: A critique and alternative to the energy ladder model,” *World Dev.*, vol. 28, no. 12, pp. 2083–2103, 2000.

[38] S. M. Lee, Y. S. Kim, W. Jaung, S. Latifah, M. Afifi, and L. A. Fisher, “Forests, fuelwood and livelihoods-energy transition patterns in eastern Indonesia,” *Energy Policy*, vol. 85, pp. 61–70, 2015.

[39] L. Iessa, Y. A. De Vries, C. E. Swinkels, M. Smits, and C. A. A. Butijn, “What’s cooking? Unverified assumptions, overlooking of local needs and pro-solution biases in the solar cooking literature,” *Energy Research and Social Science*, vol. 28. Elsevier, pp. 98–108, 01-Jun-2017.

[40] T. A. Olang, M. Esteban, and A. Gasparatos, “Lighting and cooking fuel choices of households in Kisumu City, Kenya: A multidimensional energy poverty perspective,” *Energy Sustain. Dev.*, vol. 42, pp. 1–13, Feb. 2018.

[41] J. D. Loo *et al.*, “User perspectives of characteristics of improved cookstoves from a field evaluation in Western Kenya,” *Int. J. Environ. Res. Public Health*, vol. 13, no. 2, 2016.

[42] M. C. Thurber, H. Phadke, S. Nagavarapu, G. Shrimali, and H. Zerriffi, “‘Oorja’ in India: Assessing a large-scale commercial distribution of advanced biomass stoves to households,” *Energy Sustain. Dev.*, vol. 19, no. 1, pp. 138–150, 2014.

[43] W. Akpalu, I. Dasmani, and P. B. Aglobitse, “Demand for cooking fuels in a developing country: To what extent do taste and preferences matter?,” *Energy Policy*, vol. 39, no. 10, pp. 6525–6531, Oct. 2011.

[44] E. Karakaya and P. Sriwannawit, “Barriers to the adoption of photovoltaic systems: The state of the art,” *Renewable and Sustainable Energy Reviews*, vol. 49. Pergamon, pp. 60–66, 01-Sep-2015.

[45] J. M. Eder, C. F. Mutsaerts, and P. Sriwannawit, “Mini-grids and renewable energy in rural Africa: How diffusion theory explains adoption of electricity in Uganda,” *Energy Res. Soc. Sci.*, vol. 5, pp. 45–54, 2015.

[46] N. Lam, M. Nicas, I. Ruiz-Mercado, L. M. Thompson, C. Romero, and K. R. Smith, “Non-invasive measurement of carbon monoxide burden in Guatemalan children and adults following wood-fired temazcal (sauna-bath) use,” *J. Environ. Monit.*, vol. 13, no. 8, pp. 2172–2181, Aug. 2011.

[47] B. K. Sovacool, A. L. D’Agostino, and M. Jain Bambawale, “The socio-technical barriers to Solar Home Systems (SHS) in Papua New Guinea: ‘Choosing pigs, prostitutes, and poker chips over panels,’” *Energy Policy*, vol. 39, no. 3, pp. 1532–1542, 2011.

[48] O. Akintan, S. Jewitt, and M. Clifford, “Culture, tradition, and taboo: Understanding the social shaping of fuel choices and cooking practices in Nigeria,” *Energy Res. Soc. Sci.*, vol. 40, pp. 14–22, Jun. 2018.

[49] J. K. Musango, “Household electricity access and consumption behaviour in an urban environment: The case of Gauteng in South Africa,” *Energy Sustain. Dev.*, vol. 23, pp. 305–316, 2014.

[50] M. Aklin, C. Y. Cheng, J. Urpelainen, K. Ganesan, and A. Jain, “Factors affecting household satisfaction with electricity supply in rural India,” *Nat. Energy*, vol. 1, no. 11, p. 16170, Nov. 2016.

[51] S. Jewitt, P. Atagher, and M. Clifford, “‘We cannot stop cooking’: Stove stacking, seasonality and the risky practices of household cookstove transitions in Nigeria,” *Energy Res. Soc. Sci.*, vol.

61, Mar. 2020.

[52] R. Heltberg, “Factors determining household fuel choice in Guatemala,” *Environ. Dev. Econ.*, vol. 10, no. 3, pp. 337–361, Jun. 2005.

[53] R. J. Elias and D. G. Victor, “Energy Transitions in Developing Countries: a Review of Concepts and Literature,” Standford, California, 40, 2005.

[54] A. Jagadish and P. Dwivedi, “In the hearth, on the mind: Cultural consensus on fuelwood and cookstoves in the middle Himalayas of India,” *Energy Res. Soc. Sci.*, vol. 37, pp. 44–51, Mar. 2018.

[55] C. F. Link, W. G. Axinn, and D. J. Ghimire, “Household energy consumption: Community context and the fuelwood transition,” *Soc. Sci. Res.*, vol. 41, no. 3, pp. 598–611, 2012.

[56] R. H. Hosier and J. Dowd, “Household fuel choice in Zimbabwe. An empirical test of the energy ladder hypothesis,” *Resour. Energy*, vol. 9, no. 4, pp. 347–361, 1987.

[57] IEA, “Energy Access Outlook 2017: From Poverty to Prosperity,” 2017.

[58] J. W. Schofield, “Increasing the Generalizability of Qualitative Research,” in *The qualitative researcher’s companion*, M. Huberman and M. Miles, Eds. Thousand Oaks, London, New Delhi: Sage Publications, Inc., 2002, pp. 171–204.

[59] E. Taylor-Powell and M. Renner, “Analyzing qualitative data,” Madison, Wisconsin, G3658-12, 2003.

[60] S. M. Carter and M. Little, “Justifying knowledge, justifying method, taking action: Epistemologies, methodologies, and methods in qualitative research,” *Qual. Health Res.*, vol. 17, no. 10, pp. 1316–1328, Dec. 2007.

[61] A. Holliday, *Doing & Writing Qualitative Research*, Second. London, UK: Sage Publications, Inc., 2007.

[62] A. Bryman, *Social Research Methods*, 5th ed. Oxford, UK: Oxford University Press, 2016.

[63] C. Grbich, *Qualitative Data Analysis: An Introduction*, Second. Los Angeles, London, New Delhi, Singapore, Washington DC: Sage Publications, Inc., 2013.

[64] CERUD, “Rural resources in Lagos state.” Centre for Rural Development (CERUD), Lagos State Government, Lagos, Nigeria, 2009.

[65] LBS, “Household Survey 2010 Edition.” Lagos Bureau of Statistics (LBS), Lagos State Government, Lagos, Nigeria, 2010.

[66] LBS, “Household Survey Report 2012.” Lagos Bureau of Statistics (LBS), Lagos State Government, Lagos, Nigeria, 2012.

[67] F. Huang, J. Liu, Z. Wang, C. Shuai, and W. Li, “Of job, skills, and values: Exploring rural household energy use and solar photovoltaics in poverty alleviation areas in China,” *Energy Res. Soc. Sci.*, vol. 67, p. 101517, Sep. 2020.

[68] Y. Malakar, C. Greig, and E. van de Fliert, “Resistance in rejecting solid fuels: Beyond availability and adoption in the structural dominations of cooking practices in rural India,” *Energy Res. Soc. Sci.*, vol. 46, pp. 225–235, Dec. 2018.

[69] M. Bhatia and N. Angelou, “Beyond Connections: Energy Access Redefined.” World Bank Group, Energy Sector Management Assistance Programme (ESMAP), Washington D.C., pp. 1–24, 2015.

[70] NBS, “Annual Abstract of Statistics, 2012.” National Bureau of Statistics (NBS), Federal Republic of Nigeria, FCT Abuja, Nigeria, pp. 1–619, 2012.

[71] World Bank, “Average Monthly Temperature for Nigeria at location (6.53,3.37) from 1991-2015.” Climate Change Knowledge Portal, 2018.

[72] P. G. Munro and A. Bartlett, “Energy bricolage in Northern Uganda: Rethinking energy geographies in Sub-Saharan Africa,” *Energy Res. Soc. Sci.*, vol. 55, pp. 71–81, Sep. 2019.

[73] S. Komatsu, S. Kaneko, P. P. Ghosh, and A. Morinaga, “Determinants of user satisfaction with solar home systems in rural Bangladesh,” *Energy*, vol. 61, pp. 52–58, 2013.

[74] X. Lemaire, “Solar home systems and solar lanterns in rural areas of the Global South: What impact?,” *Wiley Interdisciplinary Reviews: Energy and Environment*, vol. 7, no. 5. John Wiley and Sons Ltd, 01-Sep-2018.

[75] DfID, “Sustainable livelihoods guidance sheets.” Department for International Development (DfID), London, UK, 2001.

[76] J. a. Cherni and Y. Hill, “Energy and policy providing for sustainable rural livelihoods in remote locations – The case of Cuba,” *Geoforum*, vol. 40, no. 4, pp. 645–654, Jul. 2009.