R.H. Crawford and A. Stephan (eds.), *Living and Learning: Research for a Better Built Environment: 49th International Conference of the Architectural Science Association 2015,* pp.352–361.

Household energy use in Uganda: existing sources, consumption, and future challenges

Candia Drazu[1], Mark Olweny[2] and Goodman Kazoora[3]
[1,2]Uganda Martyrs University, Kampala, Uganda
h.drazu@umu.ac.ug, molweny@umu.ac.ug
[3]UN-Habitat, Nairobi, Kenya
Goodman.Kazoora@unhabitat.org

Abstract: This paper details patterns of energy consumption for domestic buildings in urban areas of Uganda. The paper shows the range of energy sources employed by households, the level of consumption of energy, as well as common appliances and equipment in use. The findings suggest strong demand for energy, but largely from solid fuel sources, with most households making use of firewood or charcoal for cooking. While currently low by world standards, electrical energy use was largely for lighting and entertainment. Efforts at increasing access to electricity to reduce pressures on dwindling forest resources, although a noble goal, has significant challenges, linked to limited and erratic availability of electricity, approaches to building design, as well as lifestyle transformations that contribute to a growth in energy demand. The study itself contributes to discourse on energy use and energy efficiency in buildings, filling the gap in the availability of information and geared to informing future policy and interventions.

Keywords: Household energy use; household energy consumption; electricity; Uganda.

1. Introduction

Over the past decade Improving access to 'modern' sources of energy has been a key goal of governments across sub-Saharan Africa. This was largely a result of growing concerns for the heavy reliance on wood fuel, accounting for over 80% of domestic energy consumption, but regarded as an inefficient and unsustainable means of meeting energy needs. Across eastern Africa, countries have thus embarked on ambitious rural electrification programmes, with Tanzania, seeking to achieve 30% connectivity by 2015, up from 9% in 2012 (Bloomfield, 2014). Regardless, a move towards increased electricity use in domestic buildings has raised concerns related to its impact on somewhat limited and often erratic electricity supplies, as presented by Pérez-Lombard, et al. (2008). Constant electricity blackouts and brownouts across East Africa, highlight deficiencies in generation capacity, vis-à-vis the fast growing demand for electrical energy. Growth in demand for energy has been from rapid economic growth, as well as electrification drives that have seen a large increase in the number of households connected to mains electricity over the last two decades. This has not been matched by any 'real' increase in generation capacity, and while Uganda has seen an increase in its electrical generation capacity, from 0.766 Billion kWh in 1990 to 2.406 billion kWh in 2010 and largely from hydro, this has barely kept up with the exponential growth in demand, which increased from 0.602 Billion kWh to 2.192 Billion kWh over the same period (not accounting for transmission loses of about 25%). On a per capita basis, generation capacity of 70.8kWh for 2007, was significantly lower than the average for sub-Saharan Africa at 451kWh, and far below the G7 average of 9,837kWh for same year (NationMaster, 2003-2015). This does indicate significant disparity between the available electrical energy supply, and growing demand.

While growth in electricity connectivity is welcome, serving to meet the aspirational desires of the population, and reducing the negative effect of the current heavy reliance on wood fuel, this comes with significant challenges related to the nature of electrical energy generation and distribution. The inevitability of increased demand from domestic connections (currently 26%), thus presents a hurdle for both current, and future energy transitions, particularly given current consumption patterns are largely unknown. Knowledge of current household energy consumption patterns is generally anecdotal, but does suggest growth patterns akin to those seen across the globe, increasing steadily as economies grow. Nevertheless, lack of fine grain data on which to base future energy efficiency measures, emerges as a hindrance to future planning. With blackouts and brownouts showing no sign of abating, increased connectivity without an appreciation of current household electricity consumption patterns may serve to exacerbate the already precarious energy problem. Further, with the exponential increase in residential developments, with more than 60% of planning applications for residential developments in 2013 (Uganda Bureau of Statistics, 2014), understanding the nature of energy consumption in domestic buildings becomes critical, given a general absence of energy related building standards in East Africa, and indeed across much of sub-Saharan Africa (Iwaro and Mwasha; 2010).

According to UMEME (2014), Uganda's energy distributor, the total number of formal grid connections in 2014 stood at 650,573, of which 91% were domestic, accounting for the largest proportion of grid connections (Adeyemi and Asere, 2014). Households are also the fastest growth market for electrical connections, growing at 13% per annum, significant given only 20% of urban households and 1% of rural households were officially connected to the electrical grid in 2001 (Sebbit et al., 2001; 237). Household energy demand thus presents as an important area for investigation, given the total number of households in 2014 stood at 7,353,427 (Uganda Bureau of Statistics, 2014), suggesting a tremendous potential for growth in energy demand. Indeed, it is often cited that for most African countries south of the Sahara, building construction over the next few decades will surpass the number of buildings in existence today, a consequence of a large housing backlog, and a rapidly increasing population (Tipple, 1994).

Understanding demand and consumption of energy, presents an opportunity to better address the needs of users, but requires information about current energy use patterns. This paper investigates the state of domestic energy consumption across Uganda, seeking to gain an appreciation of current energy use. Previous household energy studies, by Sebbit et al. (2001), and Lee (2013), were directed at ascertaining the energy mix in households, but did not investigate the breakdown of energy consumption. The studies did confirm that households were heavily reliant on fuel-wood as the primary source of energy, prompting activities directed at introducing appliances to reduce consumption of wood fuel. Such activities did not address electrical energy use, generally considered to be negligible in relation to total household energy demand. Nevertheless, the disparity between electricity generation capacity (and growth) and growth in consumption of electricity, does call for greater attention to this area, more so in light of recent discoveries of viable oil reserves in Uganda, which have scuttled discourse on energy conservation, skewing it back towards a 'business-as-usual' approach.

2. Methodology

Although the wider project from which this study relates took in over 300 buildings and a variety of building types, as reported by Kazoora, et al. (2015), the focus of this paper is specific for residential buildings. The paper only reports on residential buildings in urban centres, with data from 79 households presented. Data was collected through a walkthrough energy audit, making use of a questionnaire based on the Energy Audit Manual for use in the Operation of Buildings developed by UNHABITAT (1988). The study had two components: the first looking at general elements of the siting and operation of the buildings, and included; site description, nature of the building envelope, nature of lighting, ventilation and use of shading devices. With regard to energy, the second component reviewed electrical bills, documented electrical equipment used within dwellings, as well as the time and duration of use. Buildings studied were sampled from across the three sub-climate zones of Uganda: Hot and Wet – Savannah; the Cool Wet Highland Climate Zone; and, the Hot-Humid Climate Zone – Lakeside. Consideration was made to sample dwellings from different income groups, dwelling sizes, and typologies, although it was acknowledged that access to buildings was a key-determining factor in the selection of buildings surveyed, given overt security concerns across the country. In all, each walk through audit took approximately 60 minutes to complete. Data was analysed using IBM SPSS, Apple Numbers and Microsoft Excel, with two key areas of focus for this paper: the sources of energy used by households; and, energy consumption within the dwellings.

3. Findings

Buildings included in the study showcased a diverse array of housing types built over the past 70-years. A substantial proportion of buildings (over 60%) were constructed after 1990, highlighting the rapid growth in construction after the protracted civil war in Uganda during the 1980s. Dwellings ranged in size, from a tiny 9sq.m., for a single room tenement dwelling (known locally as a *Mizigo*), to over 600sq.m for some large detached dwellings (See Figure 1), giving an average area of 137sq.m. Buildings sat on lot sizes ranging from 120sq.m., to over 16,000sq.m. for some old style company estates that housed junior employees. This gave an average plot ratio of about 0.28, suggesting that most buildings did have access to significant open space around them. Single storey detached housing were predominant in the study, with only a few apartments recorded. The dominance of detached dwellings in urban areas could be linked to the perception of what these represented: upward mobility, wealth and status, somewhat cultivated by the legacy of colonial style bungalows found in wealthy urban neighbourhoods, but also linked to a strong traditional attachment to the land, significant as many living in urban centres are first generation urban residents. The small single or double room *Mizigo* dwellings, predominant for low-income urban housing, emerged as a consequence of pre-independence housing policies. *Mizigo* were originally intended to house temporary workers (generally male), who were expected to return to their main (rural) place of residences on weekends, holidays, and on completion of their employment. These dwellings generally had shared washrooms, and no cooking facilities, and continue to be built to this day, as a cheap means of accommodating the burgeoning number of urban dwellers.

Figure 1: Selection of housing types included in study (Authors).

3.1. Sources of energy

Energy used in households included in the study was largely from two fuels: charcoal (89% of households) and electricity (85% of households). Most households used charcoal for cooking, burning through an average of 71kg of charcoal each month. Less prominent, was the use of kerosene (24% of households), and LPG (22% of households), with an average of 6.7litres, and 14kg per month for each fuel type (See Table 1).

Table 1: Household energy use per month (Authors).

Source (Per cent of Households)	High	Low	Median
Firewood (7.6%)	450.0kg	25.0kg	285.0kg
Charcoal (88.6%)	240.0kg	10.0kg	60.0kg
LPG (21.5%)	50.0kg	3.0kg	7.5kg
Kerosene (24.1%)	50.0litres	0.5litres	2.5litres
Electricity (86.1%)	472.0kWh	7.0kWh	78.3kWh

While black-outs (locally referred to as load shedding) were a regular occurrence across the country, the low penetration of generators, and solar PV systems was surprising, with only two households having generators, one having a small PV collector, and none with solar hot-water systems. Lack of solar PV and solar hot water systems could in part be attributed to the high upfront investment associated with these systems, as well as an enduring belief that solar systems were expensive and unreliable

(Karekezi, and Kithyoma, 2003; Kulabako, 2013). This view persists in spite of a marked fall internationally in the cost of PV systems, and significant improvements in solar technologies in recent years, not to mention the tax-free status for imported solar PV and solar hot-water systems in Uganda, making these considerably cheaper than ever before. Most households made use of a mixed energy regime as a means of mitigating against energy shortages and cost increases, and as a means of ensuring household activities were not affected by the unavailability of one fuel source. The energy mix indicated that households steered clear of formal energy sources (gas and electricity) for cooking.

While a large percentage of urban households were connected to mains electricity, use of charcoal as the predominant fuel for cooking was a significant revelation. This could be linked to three key factors: first, a perception that electricity tariffs are high (relative to income); second, the unreliable electricity supply, compelling households to seek out alternatives due in order to maintain regular meal times; and third, a large percentage of rural-urban migrants comfortable with 'traditional' fuels as a source of energy. This heavy reliance on charcoal, may suggest that moves to change how people consume energy may be far more difficult than imagined, and linked not only to ideas of energy cost and reliability, but to socio-cultural factors, as expressed in through claims that 'food cooked on charcoal stoves tasted better than food cooked on electricity or gas'. Anecdotal evidence also suggested that for many households, fuel for day to day activities was purchased on a 'need-to' basis, a key factor in the introduction of pre-paid metering, giving householders access to electricity, when they needed it, and could afford to pay for it. The low penetration of solar PV and solar hot water systems, despite more than two decades of irregular electricity supplies, suggests deeper factors influencing the choice of fuel for household use beyond merely cost and availability, more so as charcoal is used across all households and not linked to household status. Indeed, the findings of a similar study conducted in Nigeria by Chidebell-Emordi (2015), found the penetration of generators at 72% of households, a consequence of a highly irregular electricity supply. That study however did not report on the uptake of solar PV or solar hot water systems, although it could be speculated that this was negligible. Tillmans and Schweizer-Ries (2011) suggest that the low uptake of these new technologies, despite their relevance, could be linked to a lack of familiarity or limited exposure, restricting their uptake.

3.2. Energy consumption

Reviewing energy consumption within households, overall consumption considering all sources, and based on conversion rates derived from Myles et al. (2007), was calculated to be about 698kWh per month per household or average; seven times the average monthly household consumption rate for electricity at 96.3kWh per month (1,155kWh per annum). This is a clear indication of the large proportion of energy used for cooking. Looking specifically at electrical energy, 1,155kWh per annum is far below average annual electricity use in different parts of the world: Australia – 7,227kWh; South Africa 4,389kWh, and the global average of 3,471kWh (Wilson, 2012). This imbalance is often cited as justification for a business-as-usual approach to energy use, with developing countries playing 'catch-up'.

Household energy use in itself is misleading, not accounting for dwelling sizes that vary considerably. Taking dwelling size into account was necessary to correlate energy use with building area to give an idea of comparative energy use across different dwellings and dwelling types. On average, households used 86kWh of energy per square metre per annum, however, with charcoal, LPG, and firewood used almost exclusively for cooking, in terms of square metre consumption, they were excluded in subsequent comparisons. Considering only electricity consumption relative to dwelling size, this was found to be 9.4kWh per square metre per annum on average, with higher per square meter consumption in smaller dwellings, as presented in Figure 2. Seeking to contextualise this figure was through comparison with studies undertaken in other parts of the world. Chaiwiwatworakul et al. (2015) found electricity consumption to be 23.6kWh per square metre per annum in northern Thailand. In the UK, Yohanis et al. (2007) determined electricity consumption to be between 30 and 60kWh per square metre per annum (depending on the dwelling type), but acknowledging that most households made use of gas or oil for cooking and space heating respectively. For a hot arid climate, Aldossary et al. (2014), found electricity consumption to be 163 kWh per square metre per annum for houses, and 203 kWh per square metre per annum for flats in Riyadh, Saudi Arabia, most \used for space cooling.

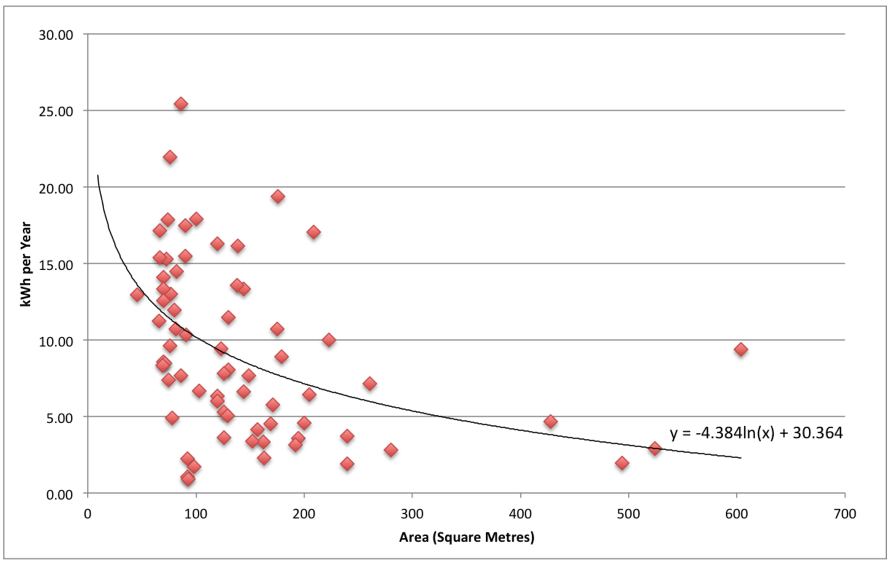

Figure 1: Household electrical energy consumption per square metre (Authors).

The inverse relationship between consumption of electrical energy and building area is indicative of the households not using electricity for space heating or cooling. This however did raise questions about what household appliances were installed in the various households. Major appliances in use in the different households are presented in Table 2. Dwellings has at least one light fitting in each habitable room, most being compact fluorescent bulbs or fluorescent tubes. A few households did make use of incandescent light bulbs, as these considerably cheaper to buy that fluorescents. Of households reporting appliances used, all indicated having at least one mobile phone within the dwelling, with more than 82% of households reporting more than three devices, and some reporting more than eight. While ubiquitous, lighting and mobile phones are generally not large consumers of energy, however use patterns and efficiency are raised as being of particular interest. Besides mobile phones, the most predominant appliances were those related to entertainment: televisions, DVD players and radios/hifi systems, found in about 80% of households. Electric irons were the most common high-energy appliance and found in 82% of dwellings, followed by electric kettles at 57%. Modern kitchen appliances were less common, reflecting the predominance of traditional ways of food preparation, but also a consequence of the poor electricity supply, which affected performance of such equipment. These findings are in line with a similar study conducted in Nigeria by Chidebell-Emordi (2015), who found a high percentage of entertainment equipment in dwellings (100%). A key difference in Nigeria was the use of fans (89%); and the use of AC units (18%), an indicator of the markedly different climate of southern Nigeria relative to Uganda.

Table 2: Household electrical appliances (Authors).

Item	Per cent of Households
Mobile Phone/PDA	100.0%
Computer (Desktop)	17.6%
Computer (Laptop)	60.8%
DVD Player/Games Console	56.9%
Iron	**82.4%**
Kettle (Electric)	**56.9%**
Microwave Oven	**23.5%**
Radio / Hifi	78.4%
Refrigerator/Freezer	54.9%
Television	82.4%
Washing Machine	11.8%

Kwong et al. (2014) suggested that provision of comfort for building occupants is increasingly a key consumer of energy across the tropics. However, the current study did not find many households seeking to achieve comfort through the use of mechanical means, with only two households making use of portable fans. This low penetration of climate modification equipment may be linked to the moderate upland tropical climate of Uganda, with a large diurnal range of 9.0 Deg.C. (Griffiths, 1972), aiding in reducing the impact of high daytime temperatures. While climate related behavioural adaptations were not explicitly investigated in the current study, they nevertheless emerge as an important consideration in the evaluation of current and future trends in energy consumption. In this case, although achieving thermal comfort through mechanical means was not a major contributor to energy consumption, it was nevertheless evident that building performance was a factor in energy use, with building design, siting and layout already influencing use of artificial lighting. The convenience of flicking a switch, making it more likely that lights would be used during the day, influenced by window sizes, which were generally small, and in a number of cases below the minimum required by planning regulations of 10% of the floor area for habitable rooms, with some living rooms having window to wall rations as low as 4%. A further aspect of the contextual zeitgeist is a preoccupation with security, with many builders and householders alike, going to great lengths to install burglar proofing in the already limited window area, further affecting indoor light levels. In addition, with only a small proportion of buildings having their main façades facing North (5%) or South (14%) which are relatively easy to shade, but over 21% facing East, and 14% West, it is evident that building design may play a significant role in climate change related energy demand.

4. Discussion

A high proportion of energy used in the surveyed buildings was found to come from solid fuel sources, a dependency linked to, and perpetuated by an erratic electricity supply, as well as poor availability of modern fuel sources such as LPG. A key challenge linked to the household energy mix, relates to how any transformation or change can be effected, given entrenched attitudes associating formal energy sources with high cost. The view of modern fuel sources as expensive is in the context of the immediate cost, and not the wider social and environmental impacts associated with these fuels. It is here that the somewhat convoluted nature of energy related discourse in the context of Uganda, and for many countries in sub-Saharan Africa. While energy use is low by world standards, the potential for growth is immense, linked not only to an increase in the number of households, but also to increased consumer related practices and modern appliances. While inroads have been made in some areas: seen in the introduction of energy efficient light fittings and the promotion of energy efficient charcoal stoves, these are only a small contributors to energy savings, relative to the exponential growth in overall energy demand. More significantly, this does not address the socio-cultural factors that drive this demand, neither does it link to current and future global CO_2 emission targets, a key challenge for energy transitions in sub-Saharan Africa (Sokona, et al.; 2012).

In relation to future CO_2 emissions link back to architectural design, and the contribution this has to a building's lifetime energy use, with siting and layout potentially contributing to increased demand for energy to cool (or heat) buildings. It is acknowledged that it was not possible to ascertain the extent to which this could contribute to future energy demand without an appreciation of thermal comfort requirements, and the extent to which buildings meet these requirements. What is evident however, are buildings that seemingly ignored some basic tenets of climatic design, with many buildings having their predominant facades facing East and West, and inadequate provision for natural lighting and cross ventilation. While significant for climatic design, a key part of achieving energy efficiency and sustainability goals is evidently linked to the users and their ideals and preferences. This is evident in the use of artificial lighting during the day, a consequence of buildings not being designed for daytime use. Further, facing a building toward the East evokes spiritual beliefs, related to the breaking of a new day, while a tradition of facing the main road, relates to a basic human need for communication, as encompassed in the following passage by Kingsolver (1998; 35):

> In a long row the dirt huts all kneel facing east … east towards the village's one road and the river and behind all that, the pink sunrise surprise. .... But no one here stays under a roof. It is in the front-yards - all the world's a stage of hard red dirt under bare foot ...

Any move to influence future energy demand therefore needs to acknowledge occupancy patterns, as well as attitudes and behaviour nuances as a key factor in current energy use, and its potential impact on future trends. In the context of future demand for energy, these factors take on added impetus, particular given the different motivational factors that drive people to make decisions related to their consumption patterns, as was noted by Fischer (2008). In the context of lighting, the drive to use energy efficient luminaires for instance, was never fully elaborated, and while these may have provided energy saving to householders, this was not immediately evident, and the cost of the new luminaires, is a challenge many failed to account for. Relating this to whole buildings, the disassociation of building design from building performance has also failed to acknowledge the realities of power blackouts and brownouts as a factor to be considered. This does suggest that diffusion of ideas is currently not as evident, ironic given the proliferation of the Mizigo as an appropriate answer to housing demand despite its apparent limitations and inadequacies. Inadequate supplies of mains electricity has in itself been insufficient to prompt social or political change in Uganda, while in Zimbabwe, the country is set to make solar hot water systems compulsory for new houses as a consequence of power generation being less that 50% of peak demand (Zimbabwe to ban electric water heaters to save power, 2015).

5. Conclusions

The energy mix found in different households was a consequence of what could best be described as 'hedging', with households seeking to ensure access to energy resources regardless of changes in availability and cost. These use patterns while key in appreciating the challenges, and opportunities presented for energy saving, the concentration on 'low-hanging fruit' in changes in the use of energy efficient charcoal stoves, or more challenging, the lack of discourse related to energy conservation due to prospects of an oil boom, may serve to present a blind side in regard to a growing but potentially larger challenge. While current energy consumption in Uganda is low by global standards, the potential for it to grown is immense; from new grid connections, as well as from households making use of more electrical equipment and appliances, and not forgetting potential demand driven by climate change. Consequently, understanding the current demand for energy, providing a benchmark from which to plot future patterns and trends is crucial: the 9.4kWh per square metre per annum, giving a point of reference for future changes to energy consumption patterns.

The challenge of transforming attitudes and belief systems is a key hurdle, and linked to broader global systems, whereby societal aspirations are intrinsically tied to 'the other', which for energy could result in a massive growth in consumption from the business-as-usual paradigm. The low penetration of alternative energy sources, and the high percentage of households making use of solid fuel sources, presents a challenge given an inherent slow growth in electricity generation capacity, the difficulty in building traditional distribution networks, and the need to balance economic growth with environmental consciousness. Nevertheless, this scenario could present an opportunity to propose alternative design paradigms that could propagate good practices by example, through what Rogers termed *diffusion of innovation,* described as "the process in which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 1995: 5). Such an approach is however difficult to imagine in the current milieu, more out of circumstance, than necessity. Nevertheless, the challenge in terms of energy transitions in overtly evident, and expressed through a pertinent question for architects in the region and asks: 'can we design and build better *Mizigo* from which this diffusion can spring?'

Acknowledgements

This study was undertaken and funded under the auspices of the UNHABITAT project: Energy efficiency in buildings in East Africa, with support from the project: Energy and low income tropical housing, funded by EPSRC/DFID/DECC as part of the energy and international development programme.

References

Adeyemi, K. and Asere, A. (2014) A review of the energy situation in Uganda, *International Journal of Scientific and Research Publications*, 4(1), 1-4.

Aldossary, N. A., Rezgui, Y. and Kwan, A. (2014) Domestic energy consumption patterns in a hot and arid climate: A multiple-case study analysis, *Renewable Energy*, 62(February), 369-378.

Bloomfield, E. (2014) Village level energy access in East Africa, *East Africa Regional Smart Villages Workshop*, Arusha.

Chaiwiwatworakul, P., Chuangchote, S. and Rakkwamsuk, P. (2015) Energy use in domestic buildings in Thailand, *Working Paper*, King Mongkut's University of Technology Thonburi (KMUTT), Bangkok.

Chidebell-Emordi, C. (2015) The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria, *Energy Research & Social Science*, ***5***(January), 9–19.

Fischer, C. (2008) Feedback on household electricity consumption: A tool for saving energy?, *Energy Efficiency*, 1(1), 79-104.

Griffiths, J. F. (ed.) (1972) *World survey of climatology: Climates of Africa*, Elsevier Science Publishing, London.

Iwaro, J. and Mwasha, A. (2010) A review of building energy regulation and policy for energy conservation in developing countries, *Energy Policy*, 38(12), 7744-7755.

Karekezi, S. and Kithyoma, W. (2003) Renewable energy in Africa: Prospects and limits, *The Workshop for African Energy Experts on Operationalizing the NEPAD Energy Initiative*, Dakar, Senegal.

Kazoora, G., Olweny, M., Aste, N. and Adhikari, R. S. (2015) Energy consumption trends of residential buildings in Uganda: Case study and evaluation of energy savings potential, *5th International Conference on Clean Electrical Power (ICCEP)*, Taormina, Sicily, 695-700.

Kingsolver, B. (1998) *The poisonwood bible*, ed., Faber and Faber, London.

Kulabako, F. (2013) "Uganda slow at seizing solar energy opportunity amid high energy costs". Available from: Daily Monitor <http://www.monitor.co.ug/Business/Prosper/Uganda-slow-at-seizing-solar-energy-opportunity/-/688616/1723532/-/7fr6yrz/-/index.html> (accessed 15 August 2015).

Kwong, Q. J., Adam, N. M. and Sahari, B. B. (2014) Thermal comfort assessment and potential for energy efficiency enhancement in modern tropical buildings: A review, *Energy and Buildings*, 68(January), 547-557.

Lee, L. Y.-T. (2013) Household energy mix in Uganda, *Energy Economics*, 39(September), 252-261.

Myles, R., Olesen, G. B. and Nathan, S. (eds.) (2007) *Sustainable energy technologies solutions for poverty reduction in South Asia*, International Network for Sustainable Energy (INFORSE)–South Asia, New Delhi.

NationMaster (2003-2015) "Countries compared by energy > Electricity > Production > Per capita. International statistics at NationMaster.com, CIA World Factbooks. Aggregates compiled by NationMaster. (Assessed 2001-2008)". Available from: NationMaster <http://www.nationmaster.com/country-info/stats/Energy/Electricity/Production/Per-capita> (accessed 24 June 2015).

Pérez-Lombard, L., Ortiz, J. and Pout, C. (2008) A review on buildings energy consumption information, *Energy and Buildings*, 40(3), 394-398.

Rogers, E. M. (1995) *Diffusion of innovation*, Fourth ed., The Free Press, New York.

Sebbit, A. M., Higenyi, J. K. D. and Bennett, K. (2001) National domestic energy survey for Uganda, *International Domestic Use of Energy Conference*, Cape Town, 237-241.

Sokona, Y., Mulugetta, Y. and Gujba, H. (2012) Widening energy access in Africa: Towards energy transition, *Energy Policy*, 47(June), 3-10.

Tillmans, A. and Schweizer-Ries, P. (2011) Knowledge communication regarding solar home systems in Uganda: The consumers' perspective, *Energy for Sustainable Development*, 15(3), 337–346.

Tipple, A. G. (1994) The Need for New Urban Housing in Sub-Saharan Africa: Problem or Opportunity, *African Affairs*, 93(373), 587-608.

Uganda Bureau of Statistics (2014) National population and housing census 2014, Uganda Bureau of Statistics, Kampala.

UMEME (2014) Annual Report, UMEME Ltd., Kampala.

United Nations Centre for Human Settlements (UNHabitat) (1988) Energy audit manual for use in the operation of buildings, United Nations Centre for Human Settlements (UNHabitat), Nairobi.

Wilson, L. (2012) "Average household electricity use around the world". Available from: Shrink That Footprint <http://shrinkthatfootprint.com/average-household-electricity-consumption#wU48frYrixyCbsK2.99> (accessed 21 June 2015).

Yohanisa, Y. G., Mondola, J. D., Wright, A. and Norton, B. (2008) Real-life energy use in the UK: How occupancy and dwelling characteristics affect domestic electricity use, *Energy and Buildings*, 40(6), 1053–1059.

"Zimbabwe to ban electric water heaters to save power" (2015) Available from: BBC <http://www.bbc.com/news/world-africa-34416210> (accessed 2 October 2015).