Macrothink Institute™

Environmental Management and Sustainable Development
ISSN 2164-7682
2015, Vol. 4, No. 1

Household Energy Appliances in Cameroon

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Received: December 2, 2014 Accepted: December 20, 2014

doi:10.5296/emsd.v4i1.6716 URL: http://dx.doi.org/10.5296/emsd.v4i1.6716

Abstract

Many households in Cameroon live in energy poverty. Thus, energy usage and energy efficiency have become increasingly important in Cameroon. An important step towards improving building energy efficiency is knowledge about household energy appliances. In Cameroon, the construction sector is mostly informal, presenting huge challenges for stakeholders including clients or dwelling owners to establish quality factors of household energy appliances for use in various building projects. Furthermore, studies about household energy appliances are scarce. The aim of this study is to investigate household energy appliances in relation to energy efficiency in dwellings. To achieve this aim, 15 dwellings in the political capital Yaoundé of Cameroon were surveyed. Given the wider nature of building energy efficiency and the limited research materials about the same, the scope was limited to typology of household energy appliances, typical dwellings' characteristics and energy consumption pattern. Some factors that have influence on energy consumption/pattern such as occupants' daily activities were also considered. Although this study is still in its preliminary stages, the findings reported here can be useful in conducting detail research in the future.

Keywords: Building, Cameroon, Household energy appliances, Energy poverty.

1. Background

Globally, the built environment is known for its high energy and material consumption levels. Consequently, it is pivotal in driving sustainable energy economy for countries especially the developing countries including Cameroon, where development is highly needed. In Cameroon, the cost associated with the provision of energy is not affordable. It has been estimated that in Cameroon, the grid-connection cost of an electricity line for a distance of 100m with two poles of 8m or 9m, amounts to electricity bills of about 7 years and 14 years for high and low energy households respectively (Nfah et al., 2010). The most basic product kerosene common amongst the poor strata is hugely expensive. It costs averagely 350 FCFA (US$0.7) per litre (LAfrica, 2012). Also, electricity shortages are quite common (ARSEL, 2011). Unpredictable electrical incidences and unaccounted electrical bills is a regular daily occurrence (ARSEL, 2011). Inconsistent and insufficient power supply is too common (Nkwetta et al., 2010). This is further exacerbated by the fact that second-hand appliances have over flooded the market in most developing countries (Kenfack et al., 2011). The efficiencies and performances of second handed appliances are often unknown and unreliable. With the increase awareness of climate change impacts, the need for building sustainability and renewable energy systems have emerged although not so common with the local population. Irrespective of the sources of energy, detail knowledge about household energy appliances is required for decisions related to their use in building projects. Such knowledge is highly valued and needed by project teams or members early-on in the design process, working in collaboration to meet the needs of a client or clients. Unfortunately, the conventional design process of buildings is a linear process, in which the architect makes a number of design decisions with little or no consideration of their energy implications and then passes on the design to the engineers who are responsible for making the building habitable through mechanical systems (Harvey, 2009). In Cameroon, it will be very conservative to say that construction process is linear as the sector is dominated by informal practices (Pettang et al., 1995). Hence, established professionals such as architects, mechanical and electrical (M & E) engineers are often by-passed and relatives used in delivering construction projects especially domestic buildings. This implies family members, often with limited knowledge and guidance, make decisions about building energy appliances. Therefore knowledge of (and) household energy appliances is highly needed in determining building energy loads and comfort levels especially with guidance from M & E engineers. However, peer-reviewed studies about household energy appliances in Cameroon are lacking. This scarcity of literature resurfaced in the recent third lead author meeting (LAM3) of the Intergovernmental Panel on Climate Change (IPCC) held in Vigo, Spain (5-9th November 2012) during the writing of Fifth Assessment Report (AR5) on Climate Change Mitigations recently published in 2014. One of the authors of this paper worked as a Chapter Science Assistant at IPCC supporting the writing of Chapter 9 (Building) of (AR5). The chapter investigates climate change mitigation options from buildings and is organised into four primary mitigation strategy components: (i) *carbon efficiency*, e.g. building integrated renewable energy systems; (ii) *energy efficiency of technology*, e.g. efficient equipment and building components, (iii) *systemic and infrastructure efficiency* e.g. holistic improvements in buildings, such as nearly/net zero energy buildings, integrated design process, urban planning, district heating/cooling, commissioning and (iv) *service demand reduction* e.g. behavioural and lifestyle change. Consequently, researchers from the University of Yaoundé 1 and Oxford Brookes University launched a collaborative effort to conduct a wider research about these four primary mitigation strategy components. Given that (i, iii, iv) depend on ii, household energy appliances and/or energy consumption in buildings have been chosen as a good starting point. The information about these appliances will be obtained from existing domestic dwellings which can be used in the design of new dwellings. In the first instance, without any bias, Yaoundé, where some of our research collaborators are based will be a starting point. This paper is a preliminary part of an on-going research currently being conducted in Yaoundé, Cameroon. The objectives of this preliminary study are threefold:

- to establish common household energy appliances in typical domestic dwellings in Cameroon;
- to establish the characteristics of household energy appliances;
- to investigate key parameters required for improving building energy efficiency.

To achieve the above objectives, a methodology was designed and pursued. But before describing the methodology it is imperative to provide an overview of building energy efficiency in Cameroon.

2. Building Energy Efficiency in Cameroon

2.1 Overview of Cameroon

Cameroon is located in Western Central Africa, on the coast of the Gulf of Guinea, at a latitude 3-13^{o}N. The geography of Cameroon is highly diverse and its topographic features superimpose climatic variations between its northern and southern regions (McSweeney et al., 2012). The political capital of Cameroon, Yaoundé is located in the Centre Region. Climate data about Yaoundé is also provided in Table 1.

Table 1. Yaoundé climate information [Source: World Meteorological Organization (WMO, 2013)]

Month	Mean temperature ^{o}C		Mean total rainfall (mm)	Mean number of rain days
	Daily minimum	Daily maximum		
Jan	19.6	29.6	19.0	3
Feb	20.3	31.0	42.8	4
Mar	20.3	30.4	124.9	12
Apr	20.3	29.6	171.3	14
May	20.2	28.8	199.3	17
Jun	19.9	27.7	157.1	14
Jul	19.9	26.5	74.2	11
Aug	19.3	26.5	113.7	12
Sep	19.3	27.5	232.3	20
Oct	19.2	27.8	293.6	23
Nov	19.6	28.1	94.3	11
Dec	19.5	28.5	18.6	3

Notes: 1) *Climatological information is based on monthly averages for the 30-year period 1971-2000, 2) Mean number of rain days = Mean number of days with at least 0.1 mm of rain*

2.2 Building Energy Efficiency and Construction Practice: Previous Studies

Studies about energy efficiency in Cameroon are rare. Kemajou et al. (2012) recently conducted a study determining the performance of 42 air-conditioned commercial buildings in Douala and Yaoundé. The study identified poor thermal design, lack of thermal standards and use of poor energy efficiency equipment. A major finding of the study is the possibility to save 12.3% of the national electrical energy consumption "medium voltage", representing 23% of the energy consumption of air-conditioned commercial buildings, if appropriate recommended energy saving measures are applied. Also Kenfack et al. (2011) investigated better ways of promoting renewable energy and energy efficiency in Cameroon. Kenfack et al. (2011) noted that one of the barriers to the uptake of energy efficiency is the lack of information and knowledge. They also noted that because of high cost of energy efficiency appliances, most households are using obsolete and less efficient equipment often imported from developed countries. Construction projects in developing countries have been noted for far exceeding original project schedule and cost (Frimpong et al., 2003). Construction waste is also becoming a major problem in developing countries particularly Africa. The severity of construction waste problem has been noted in the construction industries of Egypt (Garas et al., 2001), Nigeria (Wahab and Lawal, 2011) and Botswana (Urio and Bent, 2006). While the problems of cost overrun, construction delay and too much waste are also common in developed countries (albeit on a much lower scale), Integrated Project Delivery is now being recommended to overcome such challenges. In construction, integration often refers to collaborative working practices, methods and behaviours that promote an environment where information is freely exchanged among the various parties (Baiden and Price, 2011). Within an integrated team environment various skills and knowledge are seen as shared, and traditional barriers separating the design process from construction activities are removed or marginalised to improve project delivery (Austin et al. 2002; Baiden et al. 2003). By providing knowledge about emerging household energy appliances, M & E engineers who form part of the construction team can exploit and better provide advice to team members especially to clients early on in the design process. Thus, unlike budget overruns, project delays and huge construction waste quite common in developing countries (Frimpong et al. 2003; Urio and Bent 2006; Wahab and Lawal 2011; Garas et al. 2001), knowledge about household energy appliances has the potential to lead to efficient energy management in dwellings. Also, considering that the construction sector in Cameroon is noted for its informal practices, clients in most cases, families and friends can exploit knowledge about appliances in their different projects. This will undoubtedly minimise the chances of choosing inefficient appliances which in the long run will be costly and degrade the environment. The methodology used in acquiring this knowledge is described in the ensuing section.

3. Method

This study was borne out of informal discussions with experts in building energy efficiency that contributed to the recently published AR5 by IPCC and dwelling owners in Cameroon.

During the AR5 meeting in Vigo, all the experts (at least 15) involved in the building chapter of AR5 raised the issue of the lack of peer-reviewed literature about building energy efficiency from developing countries. Based on this gap, a literature review was conducted to understand the uses of energy efficient appliances in Cameroon. Despite reviewing established journal databases such as ScienceDirect (http://www.sciencedirect.com/), EI Compendex (http://www.ei.org/), EBSCO (http://www.ebsco.com/index.asp), it emerged that no peer-reviewed studies existed about household energy appliances in Cameroon. As a result, it became necessary to gain detail understanding about household energy appliances in Cameroon. Consequently, a quantitative research method was adopted where a survey was designed to cover 4 main areas. The first addressed the characteristics of domestic buildings. The second covered the number of, and information about the households or residents. The third was about the types of household energy appliances. The fourth was about the energy consumption pattern of the appliances in the domestic dwellings. In total 15 dwellings were identified and surveyed. Due to the complexity understanding building types in the informal construction sector, the 15 dwellings chosen were those that fall into the different categories of dwellings defined by the Ministry of Housing and Urban Development (MINHUD) of Cameroon. MINHUD categorises domestic dwellings according to the following minimum requirements: 1) Gross Floor Area (GFA) usually denoted (T1: GFA≥ 20m2, T2: GFA≥32m2, T3: GFA≥62 m2, T4: GFA≥89 m2, T5: GFA≥106 m2, T6: GFA≥130 m2). 2) All the dwellings except T1 must contain a kitchen, corridors, lounge and dining room. 3) T1 and T2 should contain 1 bedroom while T3, T4, T5, and T6 should contain 2, 3, 4 and 5 bedrooms respectively. 4) T1, T2, and T3 should contain 1 toilet each, T4 and T5 should contain 2 toilets while T6 should contain 3 toilets.

Furthermore, only dwellings where occupants willingly agreed to participate in this survey were considered. Given that most households may be involved in various formal and informal activities, the survey was conducted for the first week of April 2013. There is no special consideration for the month of April as its climate data does not significantly differ from those of other months (see Table 1).

4. Analysis and Preliminary Findings

As discussed in the preceding section, 15 dwellings were targeted. After the first week (1-7 April) of the survey, 12 respondents provided feedback. For data protection purposes, the respondents' houses are denoted as YJ, ES, DJ, MD, SN, TD, KM1, KM2, KM14, ZM, NJ and MV. A preliminary analysis indicates some of the requested data or information has not been provided. Consequently, a report on the most comprehensive although work in progress will be provided. This includes the building characteristics (Table 2) and the household energy appliance with their power rating (Table 3).

Table 2. Dwelling characteristics

Dwelling ID	Type	No of rooms	Construction year	Ownership type	GFA (m^2)	Wall type	Floor finish	Roof cover	N^o of households	Job of head of family	Annual electric energy bill (FCFA)	Gas (bottle) /month	Monthly kerosene consumption (litre)
YJ	T6	04	1997	owner	156	cement blocks	ceramic tiles	zinc	11	teacher	118 800	01	03
ES	T3	02	1990	owner	60	Mud-bamboo mixture	smooth cement	zinc	05	business	60 000	0.5	01
DJ	T5	03	2005	owner	120	earth blocks	concrete slab	zinc	07	teacher	10 000	01	01
MD	T6	05	2002	owner	225	cement blocks	ceramic tiles	concrete	11	medical doctor	*	02	*
SN	T6	04	*	owner	200	cement blocks	cement blocks	zinc	04	topographer	264 000	01	0.5
TD	T1	01	*	tenant	24.5	adobes	concrete slab	zinc	07	rebar bender	120 000	01	00
KM1	*	03	1995	owner	*	cement blocks	ceramic tiles	zinc	06	business	*	0.5	01
KM2	T2	02	1985	tenant	40	cement blocks	smooth cement	zinc	06	business	36 000	0.5	01
KM14	T2	04	1995	owner	40	cement blocks	ceramic tiles	zinc	06	business	50 000	01	01
ZM	T6	03	2002	owner	200	cement blocks	marble and ceramic tiles	zinc	09	civil servant	264 000	01	01
NJ	T4	05	*	owner	100	earth blocks	concrete slab	zinc	08	pensioner	60 000	0.5	02
MV	T4	03	1997	tenant	100	cement blocks	smooth cement	zinc	11	teacher	192 000	0.5	1.5

Table 3. Household power rating (W)

Appliance	YJ	ES	DJ	MD	SN	TD	KM1	KM2	KM14	ZM	NJ	MV
Freezer	√	√	×	×	×	×	×	×	×	170	×	×
Fridge	264	×	√	√	√	√	×	×	50/150	93	×	118
Pressing iron	176	2200	2000	1400	√	1000	√	√	450/650	√	√	1200/1300
DVD (CD+ video player)	525	25	25	100	√	√	√	√	√	√	√	25
Simple radio	√	×	×	100	×	√	√	√	√	10	√	90
Complete radio (Simple radio +DVD)	525				√	×		×	×	14	×	
Television	594	60	57	√	√	√	√	√	40/120	100^130	√	√
Bulb	100	11	305	√	100	75	√	60/25	40/120	100	75	75
Laptop	550	×			60	×	×	×	90/130	60	×	√
Telephone charger	132	×	12.28	√	75	×	×	×	2-5	75	×	10
Electrical water coil	143	60	×	×	×	×	×	×	×	×	×	×
Computer	×	×	×	√	×	×	×	√	150/300	×	√	√
Fan	×	√	×	×	×	√	×	×	×	√	×	×
Vacuum cleaner	×	×	×	×	1600	×	×	×	×	√	×	×
Microwave	×	×	×	800	√	×	×	×	×	1250/1350	×	×
Gas and electrical oven	×	×	×	×	√	×	×	×	×	×	×	×
Food blender/mixer	×	×	×	×	√	×	√	×	×	400	×	350
Coffee maker	×	×	×	×	√	×	×	×	×	×	×	×
Washing machine	×	×	×	×	√	×	×	×	250/600	2300	×	×
Fluorescent bulbs	×	×	×	×	×	×	×	×	×	√	×	36
Voltage regulator	×	×	×	×	×	×	×	×	×	×	×	√
Bush lamp	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Gas cookers	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

√: In the dwelling but power rating is not available

×: Is not in the dwelling

a/b: a range from a to b, e.g. 1200/1300 denotes a range between 1200 to 1300

a^b: This means power rating of two appliances of the same type in a dwelling; in this case television 1 & 2 in ZM with power ratings 100W & 130 W

4.1 Categories of Household Activities

It emerged from the survey that, one cannot straightforwardly predict a pattern of work of household occupants. For example, a household whose head works in the public service or government department will likely have the same pattern on all the five working days of the week. The week-end pattern may be different as the household head is likely to spend the whole day indoors or attending some local meetings which are often periodical and regular. On the other hand, a taxi-driver may have to leave from home very early at 5.30am and may return home at 12:30pm for break and go back to work and will finally return at 10:30pm. This pattern can be the same during the week. On week-ends, taxi-drivers tend to be too busy as this is their peak job periods and are likely going to be working. From Table 2, the type of professionals of home owners and tenants are teachers, businessmen, medical doctors, re-bar benders, topographers, pensioners. The working patterns of these professionals are likely to be significantly different and can affect the energy consumption pattern of household energy appliances.

4.2 Categories of Household Energy Appliances

Based on Table 3, most of the appliances consumed electrical energy. The only two non-electrical energy sources are lamps that use kerosene and gas cookers that use cooking gas. It is important to note that, heating the house using thermal or electrical energy is not common in Yaoundé, partly because of very good climatic conditions as can be seen in Table 1. Also, information and communication technologies (ICT) appliances are common. Some examples are computers, laptops, phone chargers, etc. From Table 3, it can be noted that there is a great disparity in the power rating of most of the appliances; perhaps an indication of lack of standardisation. For example, the power rating for pressing irons in the houses YJ, DJ and TD are 176W, 2000W and 1000W respectively. Although there was great disparity in some of the power ratings, a cross validation with appliances in Roaf et al. (2012) was conducted. Though some differences emerged, the results were of the same order. For example, the power ratings of a pressing iron, microwave oven and fluorescent bulb are 1000W, 1000W and 50W in Roaf et al. (2012) respectively. Similarly, based on Table 3, their respective ratings are 1000W (dwelling TD), 800W (dwelling MD) and 36W (MV). Table 3 also reveals that common appliances such as telephone chargers and electrical water coils were not in some houses, e.g. ES. Upon further discussion with the occupants of house ES, it emerged that they have very friendly neighbours from whom they can easily borrow electrical water coils and telephone chargers. This implies that, some movable items can be moved and used in different houses depending on their good neighbourhood relationships or social network.

4.3 Household Energy Consumption Pattern

One of the objectives of this study was to determine the daily energy consumption pattern or hourly energy loads. At the current stage of this study, the only dwelling with the most complete information is ZM. So its daily energy load for Wednesday is examined and presented in Tables 4 & 5.

Table 4. Daily consumption pattern for dwelling ZM on Wednesday

Appliance	Power (Watt)	Duration of use (hours)	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5
Freezer	170	24	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Television 1	100	6							■	■	■	■	■	■												
Television 2	130	5	■											■	■	■				■						
Bulb	(75)**	7	■												■	■	■	■	■	■						
Laptop	60	2	■	■																						
Telephone charger	(2)**	7																		■	■	■	■	■	■	■
Fan	(115)***	9																■	■	■	■	■	■	■	■	■
Fluorescent bulbs	(36)**	1	■																							

**: Power rating for this dwelling was not provided, so values for similar dwellings in this survey have been used

***: Fan power rating was not provided by any dwelling occupant

Based on Table 4, the hourly energy load is determined by using the formula Energy=Power (Watt) X Duration (hour) for each appliance being used during the hour. The total energy load is obtained by summing the hourly energy loads for the appliances being used at a particular hour. The results over a 24 hour period are presented in Table 5.

Table 5. Total hourly energy load or energy consumed on Wednesday

Hour of the day	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1	2	3	4	5
Energy (Watthour)	471	230	*170*	170	170	170	*270*	*270*	270	270	270	400	375	375	245	360	360	422	287	287	287	287	287	287

From Table 5, the maximum energy load of 471 Watt.hour occurs at 6:00am while the minimum occurs between 8:00am and 11:00am in the morning. The former coincides with the hour most appliances are likely to be in used as occupants prepare to leave the house for their daily activities. The minimum occurs when most occupants are likely to have left the house and busy in their different places of work.

5. Discussion, Challenges, Further Research and Conclusion

This study commenced with a presentation of the background, where the rationale as to why knowledge on household energy appliances in Cameroon was required. Subsequently current building energy efficiency was examined vis- à-vis construction project management practices. A methodology was also presented. The preliminary results have been examined.

Three main challenges were encountered during the survey. Firstly, most of the 15 respondents were very reluctant to provide hourly energy consumption pattern for the 24 hours of a day over the whole week of the survey. Currently, while this study is still on-going, there are discussions behind the scenes to persuade them to do so, albeit within ethical constraints. Secondly, most of the appliances do not have any information or data written on them, such as energy rating, carbon saving, efficiency, average lifespan, etc. This is an indication most of them are either too old or from very doubtful sources. Thirdly, the most significant challenge is the electricity cuts that occurred during the survey week. As already reported, electricity cuts are quite common. On Thursday, Friday and Saturday in ZM dwelling, electricity supply was interrupted over some periods.

The preliminary findings reported here will serve as a basis for further research. Although some of the appliances' power ratings were compared with standard UK appliances in Roaf et al (2012), in future, to reflect reality, Cameroon-based suppliers will be surveyed to obtain appliances' characteristics. The outcome of such a survey will be used to validate those currently being obtained from dwellings' owners/occupants. Based on the validated appliances' characteristics, studies will be conducted to determine key indicators such as energy, greenhouse gas emissions and carbon savings for typical dwellings mentioned in this paper. In addition to this, affordability will also be calculated. Also, more of similar studies will be conducted in the months of December and January where most festive activities such as Christmas and New Year are celebrated and energy demand is likely to be high or characteristically different from other months.

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