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Article

Accepted Version



Tete, K. H. S., Soro, Y. M., Sidibé, S. S. and Jones, R. V. ORCID: https://orcid.org/0000-0002-2716-9872 (2023) Urban domestic electricity consumption in relation to households' lifestyles and energy behaviours in Burkina Faso: findings from a large-scale, city-wide household survey. Energy and Buildings, 285. 112914. ISSN 1872-6178 doi: 10.1016/j.enbuild.2023.112914 Available at https://centaur.reading.ac.uk/110785/



To link to this article DOI: http://dx.doi.org/10.1016/j.enbuild.2023.112914

Publisher: Elsevier BV

**Interactions between residential electricity consumption and urban households' lifestyles in Burkina Faso: Findings from a large-scale, city-wide household survey**

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**Abstract**

Information on actual domestic electricity use in Burkina Faso, where the urban zones and residential sector account for 74% and 33% respectively of the total electricity use, remains very challenging to find, as little research currently exists. This study aimed therefore, to provide the first ever insights into the actual urban residential electricity use. A survey with 387 households, the first large-scale, city-wide household electricity study undertaken in Burkina Faso to the authors' knowledge, was conducted in the city of Ouagadougou. Information on the households' characteristics and behaviours were collected to yield a first comprehensive analysis on the actual city-scale domestic electricity use. Findings demonstrated an average electricity use of 2395 kWh/year by households. Cooling accounts for almost 40% of the total domestic electricity use, followed mainly by cooking and food preserving (23%) and information-communication-entertainment (19%) activities. Three groups of consumers were then formed based on their electricity use level, to investigate interactions between electricity use and households' lifestyles. The study's findings lay therefore, the foundations for a better understanding of actual urban domestic electricity use patterns and could help to develop more suitable policies and actions targeting energy conservation in the residential sector.

**Keywords:** Urban households, City-scale survey, Lifestyle and activities, Electricity consumption, Energy behaviour, Burkina Faso.

**Abbreviations and acronyms**

| | |
|---|---|
| AC | Air-Conditioner |
| AEC | Active Electricity Consumption |
| CRECS | China Residential Electricity Consumption Survey |
| DHW | Domestic Hot Water |
| FCFA | Franc of the African Financial Community |
| HRP | Household Responsible Person |
| HVAC | Heating Ventilation and Air-Conditioning |
| ICE | Information Communication and Entertainment |
| LEC | Lighting Electricity Consumption |
| RECS | Residential Electricity Consumption Survey |
| SEC | Standby Electricity Consumption |
| S.d | Standard Deviation |
| TEC | Total Electricity Consumption |
| UEMOA | West African Economic and Monetary Union |

## 1. Introduction

Economic growth, global development, as well as poverty eradication are recognised as the main challenges of most developing countries in the sub–Saharan Africa region, and access to modern forms of energy and their services are considered prerequisites for reaching such objectives [1–3]. In Burkina Faso, the demand for primary energy grew at an average rate of 6.67% from 2010 to 2018, while electricity demand increased at a higher rate of 8.36% per annum [4,5]. Such rapid growth in electricity demand is mainly due to the progress in urbanisation, which has increased on average, 4.13% per annum since 2010 [6]. Urban zones that account for 26.35% of the population are responsible for 74% of the total electricity use, as appliance ownership and use is higher [6–8]. The generation capacity is however struggling to keep up with such a growth in demand [9]. This results in frequent power outages, especially in hot periods, despite the recent increases in energy imports from neighbouring countries [9]. Sustainable electricity supply is therefore a long-term challenge that the country faces, with urbanisation expected to reach 32.5% in 2030 [10].

The residential sector, which accounts for 72% of total primary energy and 33% of total electricity use in the country [4], is therefore, one of the most contributing sectors to greenhouse gas emissions due to the high prevalence of fossil fuels (47%) and imports (45%) in the country's energy mix [4,9]. This sector is therefore, a key target for implementation of safer and cleaner energy resources and greener energy production methods [11,12]. Furthermore, improving consumers' behaviours and implementing suitable energy efficiency policies, measures and programs are also crucial for demand reduction whilst avoiding rebound effects experienced in other countries [13–16].

In short, effective strategies are needed to improve energy provision and use, and as a result, the living conditions of households in Burkina Faso. However, to do so, it is essential to have accurate data about the lifestyles and energy behaviours of households, which are widely considered as the main aspects that effect residential energy consumption patterns [17,18].

Residential energy consumption has been widely investigated across the world, either at the micro (i.e. household) or macro level (i.e. national), with the studies covering aspects like households' characteristics and lifestyles [19–22], energy source choices [23–25], appliance ownership and use [26–30], and households' energy behaviour [31–34]. At national levels, research is also being conducted, for example, the residential energy consumption survey (RECS) is conducted every 4-5 years in the U.S.A. [35], as well as China Residential Energy Consumption Surveys (CRECS) [36,37]. Furthermore, at a supranational scale, studies are also carried out, for instance, the "manual for statistics on energy consumption in households" [38] a joint effort between European Union (E.U.) member states.

However, much less is known about residential energy consumption in the global south. African studies, in particular sub-Saharan, are limited, with only a few studies conducted, for example, in Ghana [26,39,40], South Africa [41–43], Nigeria [44–46], Ethiopia [47] and Niger [48]. The studies are often conducted at a city or rural zone level, with sample sizes varying from 60 to 539 households.

In Burkina Faso, studies on residential energy consumption are almost non-existent. Apart from studies by the national institute of statistics (INSD/BF) on living conditions of the population [49], which gathers some data on household energy expenditure, no other studies have been conducted. To address this research gap, this study undertakes a residential electricity consumption survey within 387 households in the city of Ouagadougou. To the authors' knowledge this is the first large-scale, city-wide household electricity study undertaken in Burkina Faso.

More specifically, the study will address the following research questions:

1. What are the socio-demographic characteristics, lifestyles and energy behaviours of households in Ouagadougou, Burkina Faso?
2. What are the ownership and saturation rates of typical household appliances, and how much do they contribute to electricity consumption?
3. How do households' socio-demographic characteristics, lifestyles and energy behaviours influence their electricity consumption?

## 2. Methodology

### 2.1 City of Ouagadougou

Ouagadougou, known colloquially as "Ouaga", is the capital and largest city of Burkina Faso and the cultural, economic and administrative centre of the country. The city is located in the central region of the country at latitude 12°21'58" N and longitude 01°31'05" W [50]. The city is located in the Sudano-Sahelian climatic zone, which gives the climate, a hot and dry character, with average monthly temperatures ranging from 25°C in December to 33°C in April [51]. The average relative humidity is 48.5%, and the rainfall varies from less than 50 mm in the dry months (December to April) to about 200 mm in August [51]. In addition to being the largest city in the country, Ouagadougou is home to 45.4% of the country's urban population, with a size of 2,453,496 inhabitants grouped in 12 districts and 55 sectors [6]. The city was therefore chosen because it gives a good representation of urban areas in the country and can also serve as a basis for predicting the characteristics of electric consumption of the other urbanising areas of Burkina Faso in the future.

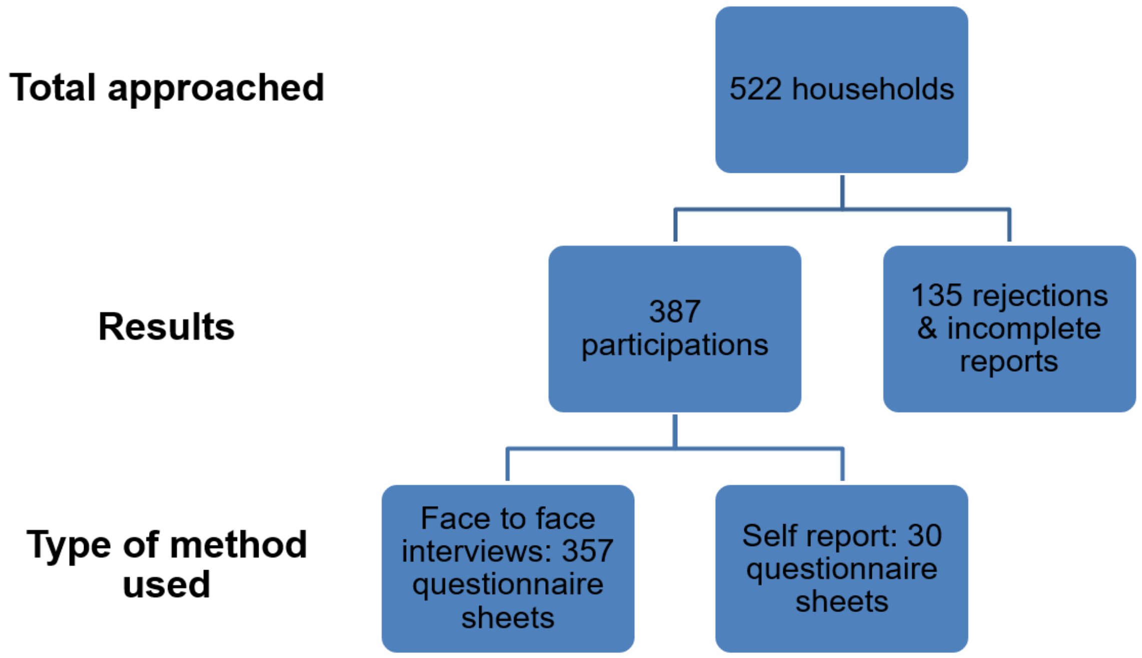


**Fig. 1.** Framework of the survey methodology

### 2.2 Survey design and data collected

Questionnaires were used to collect data as they have been identified as a suitable method for gathering data [52] and are often used in energy consumption studies [53]. The survey sample size (**n**) was determined as 384 at a 95% confidence interval and a 5% margin of error (**e**) [54]. Random sampling was used in the survey to ensure that each household had an equal chance of being selected. However, the selected households surveyed in each district depended on the readiness of the respondents to participate. Throughout the sampling process, attention was also paid to selecting samples with different household backgrounds and domestic economic levels. The in-person interview was the primary data collection method (**Fig. 1**), as it was identified as the most common completion option and the method that produced the highest response rate [53]. Nevertheless, some households preferred to self-report the questionnaire sheets. Responses were obtained from 387 households out of the 522 households approached (74.1% participation rate) from September 2021 to February 2022, following a pilot test of the questionnaire in August 2021. As the city of Ouagadougou consists of 12 districts, the overall sample size was made of a combination of the sample sizes in the districts, and the number of selected houses was proportional to the total number of households in the corresponding district.

**Table 1** shows the characteristics of each district, the number of surveyed households and the final sample size. It can be noticed a general overestimate of the number of people per household in the districts regarding the results of the survey when compared with those of the country's last census (RGPH, 2019) [55].

**Table 1.** Structure of Ouagadougou and number of surveyed households

| N° District | Area (km²) | Population size | Number of households | Number of people per household | Number of surveyed households | Number of people per surveyed household |
|---|---|---|---|---|---|---|
| 1 | 18.65 | 102 016 | 25 771 | 4.0 | 23 | 6.0 |
| 2 | 12.70 | 83 436 | 20 203 | 4.1 | 23 | 4.8 |
| 3 | 60.56 | 311 406 | 66 595 | 4.7 | 56 | 5.0 |
| 4 | 82.81 | 207 647 | 49 088 | 4.2 | 36 | 6.0 |
| 5 | 21.40 | 129 984 | 33 115 | 3.9 | 28 | 5.3 |
| 6 | 29.00 | 222 854 | 49 619 | 4.5 | 39 | 6.5 |
| 7 | 32.68 | 282 837 | 70 180 | 4.0 | 32 | 5.5 |
| 8 | 66.57 | 152 880 | 36 098 | 4.2 | 15 | 4.9 |
| 9 | 88.27 | 336 483 | 79 889 | 4.2 | 34 | 3.9 |
| 10 | 27.96 | 263 969 | 63 579 | 4.1 | 45 | 4.9 |
| 11 | 48.30 | 254 928 | 62 221 | 4.1 | 44 | 5.8 |
| 12 | 44.13 | 66 826 | 15 811 | 4.2 | 12 | 6.2 |
| **Total** | **533.03** | **2 415 266** | **572 169** | **4.2** | **387** | **5.4** |

The survey content, as shown in **Table 2,** consisted of seven main items characterising households' lifestyles and behaviours regarding electricity use: household and dwelling characteristics, appliances ownership and use, daily life activities, electricity use and energy behaviours, and other various elements.

**Table 2.** Items covered by the survey's questionnaire

| Items investigated | Content or description |
|---|---|
| Household characteristics | Family status and size, total income, family members' age and relation to the HRP, education level, employment status. |
| Dwelling characteristics | Building type, number of storeys, period of construction, numbers and usage of rooms, floor area, tenure type, and presence of HVAC and DHW systems. |
| Appliances ownership and use | Number and characteristics of appliances, pattern of use per type of day (weekdays/weekends) and appliance purchase condition (new / used / mixed). |
| Daily life activities | Presence and daily life activities related to household appliance use (cooking, lighting, Information, communication and entertainment, cooling and others). |
| Electricity use | Electricity sources, monthly electricity consumption (amount and cost) and electricity account information. |
| Energy Behaviour | Awareness and practices of energy conservation, awareness of appliance labelling and influence on purchase, awareness and behaviours of standby consumption. |
| Others | Level of satisfaction with utility services, frequency and duration of power outages and load shifting preferences for load curtailment to avoid power outages. |

### 2.3. Data processing

In order to understand the patterns of electricity consumption and the influence of households' appliance and daily life activities on electricity use, it is essential to access the household's electricity consumption breakdown. On-site measurement has been demonstrated as the most accurate solution, however, it remains a challenging activity as it is complex, expensive (high costs for initiation, operation and maintenance of sensors) [52], and requires much effort from both the participants and the researchers [38]. Therefore, to determine the electricity consumption breakdown in the surveyed households, this study makes use of more traditional survey methods, which have also been widely used in literature about residential electricity use [28,34,56–59]. Indeed, along with the number, type and other characteristics of the appliances, the participants were asked to state their daily duration of use of each home appliance. As a result, five main categories of appliances were defined corresponding to the daily life activities of the households: Cooking and food preserving, Lighting, Cooling, Information, Communication and Entertainment (ICE) and Others (**Table A1**).

With such data, the Active Appliance Electricity (AEC, kWh/year) consumption (**Eq. (1)**) is calculated as the sum of the electricity consumption of all appliances in the household while performing their primary functions [58].

$$AEC = \sum_{i=1}^{l} CC_i \times ACU_i + \sum_{j=1}^{m} P_j \times NH_j + \sum_{k=1}^{r} IEU_k \quad \textbf{(1)}$$

Where **CC** is the consumption per cycle or load (kWh/cycle or load) for appliances operating per cycle or load, such as washing machines, **ACU** is the total annual usage (cycles or loads/year), and **l** is the number of these typical appliances in the household. **P** is the nominal rated power (kW) of the appliances, like the iron, electric stove, ACs, fans etc., **NH** and **m** are respectively the corresponding annual usage (hr/year) and **m** their total number in the household. **IEU** is the annual electricity use (kWh/year) of appliances, such as refrigerators, based on their characteristics (type, volume, brand, age) and **r** their total number in the household.

The standby electricity consumption (SEC, kWh/year) was also determined (**Eq. (2)**) as the multiplication between the standby power of the corresponding appliances (kW) and the number of hours (hr/year) that they are left on standby [58].

$$SEC = \sum_{s=1}^{w} SP_S \times SU_s \quad \textbf{(2)}$$

Where **SP** refers to the power of the appliances when operating in standby mode (kW) and **SU** to the annual standby usage hours (hours/year) and **w** to the total number of standby appliances.

Also, the annual electricity use for lighting (LEC, kWh/year) was also determined as shown by **Eq. (3)** [58].

$$LEC = \sum_{x=1}^{o} LP_x \times LH_x \quad \textbf{(3)}$$

Where **LP** refers to the power of each of the households' lights (kW), **LH** and **o** respectively to the annual usage hours of each lamp (hr/year) and their total number in the household.

Finally, the household's total annual electricity consumption (TEC) was calculated as the sum of the households' active, standby and lighting electricity consumption (**Eq. (4)**).

$$TEC = AEC + SEC + LEC \quad \textbf{(4)}$$

The power ratings and features of the appliances were measured in retail stores and selected from standard products in the market following the actual characteristics of appliances (size, capacity, model, brand, age) in the surveyed households [28] due to inaccessibility for measurements in situ. Therefore, it corresponds to the Product-based measurement method for estimating standby electricity use [60]. Also, for some typical appliances that are not used every day, like weather-related ones (fans, humidifiers and air-conditioners etc.), the number of use days per year was determined based on discussion with the occupants.

Finally, the interactions between electricity use and the households' lifestyles and energy behaviours were investigated. For this purpose, households were grouped into thirds based on their TEC, which was sorted from the smallest to largest. Such a method has been used in previous studies [61–65]. The first third of the sample was referred to as the "low consumers", the second as the "medium consumers", and the last as the "high consumers" [64]. In this study, the sizes of the groups were 129 households.

# 3. Results

## 3.1. Socio-economic characteristics

48.8% of the surveyed households consisted of couples with children, 25% are (multigenerational) families, and 16.8% are single-parent families. Other household types represented 11.7%. The average household size was 5.4, with 10.1% of the participants housing up to 2 persons, 46%, between 3 and 5 persons, and 44%, 6 persons and more.

72.3% of the surveyed households' respondent person (HRP) were aged between 29 and 61 years old, 7.5% were 62 years old or more, and 7.5% were up to 28 years old. 44.4% of the HRPs were full-time employees, 3.6% were part-time employees, 31.8% had their own business, and 20.2% were unemployed or retired. The majority of the HRPs are literate (87.6%), with 46.3% reaching college education level, 33.3% secondary school and 8% only primary school. The 12.4% lasting never attended school. 70.8% of the participants earned a monthly income between 100,000 and

550,000 CFA Francs (FCFA) i.e., US$ 173-947[1], 10.3% earned up to 100,000 FCFA (~ US$ 172), 10.6% between 550,000 and 850,000 FCFA (US$ 948-1463) and 8.3% more than 850,000 FCFA (> US$ 1463).

**Table 3** shows the survey results for the main households' socio-economic and dwellings characteristics compared to those of the last census and study on the households' living condition (both in 2019) [49,55], for not only the Ouagadougou city, but also at the urban and national scales (where data available). It can be noticed for the socio-economic characteristics that the survey overestimates the proportion of single person's households and underestimates that of multigenerational families. It underestimates the households' sizes with respect to the national scale findings, and also under-represented young and middle aged HRPs with respect both to the urban and national scales' findings. Finally, on the socio-economic class of the HRPs, the study overestimates the proportions of other HRPS (retired and non-employed) with respect to the urban scale, which is the reflexion of the underestimations of the young and middle aged HRPs previously notified.

### 3.2. Characteristics of the dwellings

The average dwellings' floor area is 101.6 m². The dwellings are mostly built on one storey (88.1%), with 57.4% detached houses, 32% multi-family houses, 0.8% apartments, and 9.8% semi-detached houses. In addition, 65.3% of the participants own their dwellings, while 32% privately rent theirs and 2.6% live in freely rented dwellings. Finally, 7% of the dwellings were built before the 1980s, 29.8 % between 1980 and1990 and 63.3% after the 2000s.

[1] With a conversion rate of 580.94 from US$ to FCFA francs (March 2022)

**Table 3.** Households' socio-economic and dwellings main characteristics (%) of the study (O387) compared to the results of the 2019 census in Burkina Faso

| Characteristics | This Study | Ouagadougou (2019) | Urban scale (2019) | Country scale (2019) |
|---|---|---|---|---|
| **Family composition** | | | | |
| *Single* | 5.2 | 2.5 | n/a | 1.8 |
| *Simple couple* | 1.6 | 1.7 | n/a | 2.6 |
| *Others** | 2.6 | 2.8 | n/a | 1.4 |
| *Couple with children* | 48.8 | 44.2 | n/a | 54.2 |
| *Multigenerational Family* | 25.0 | 33.4 | n/a | 23.3 |
| *Single parent family* | 16.8 | 15.4 | n/a | 16.6 |
| **Household size** | | | | |
| *1* | 5.4 | n/a | n/a | 9.4 |
| *2* | 4.7 | n/a | n/a | 11.3 |
| *3* | 12.9 | n/a | n/a | 14.5 |
| *4* | 16.8 | n/a | n/a | 14.3 |
| *5* | 16.3 | n/a | n/a | 12.9 |
| *6+* | 44.0 | n/a | n/a | 37.6 |
| **Construction type** | | | | |
| *Multi-family house* | 32 | 32.3 | 31.1 | 17.9 |
| *Apartment block* | 0.8 | 2.5 | 1.6 | 0.6 |
| *Semi-detached house* | 9.8 | 9.3 | 7.7 | 3.0 |
| *Detached house* | 57.4 | 56.0 | 59.6 | 78.6 |
| **Tenure type** | | | | |
| *Others* | 0.1 | 1.0 | 1.1 | 1.2 |
| *Free rented* | 2.6 | 9.4 | 8.2 | 4.6 |
| *Privately rented* | 32.0 | 24.6 | 27.4 | 10.9 |
| *Owned* | 65.3 | 65.0 | 63.3 | 83.3 |
| **Age of the HRP (Years old)** | | | | |
| *~ 28* | 7.5 | n/a | 22.1 | 23.4 |
| *29 - 39* | 18.6 | n/a | 31.6 | 27.2 |
| *40 - 50* | 31.0 | n/a | 21.9 | 20.3 |
| *51 - 61* | 22.7 | n/a | 17.4 | 13.9 |
| *62 +* | 20.2 | n/a | 7.0 | 15.2 |
| **Socio-economic class of the HRP** | | | | |
| *Others* | 20.2 | n/a | 6 | n/a |
| *Unskilled manual workers* | 3.6 | n/a | 3.5 | n/a |
| *Manual-skilled and semi-skilled* | 8 | n/a | 15 | n/a |
| *Non-manual* | 21.2 | n/a | 28.3 | n/a |
| *Own account worker / farmer* | 31.5 | n/a | 34.7 | n/a |
| *Supervisors / managers / professional* | 15.5 | n/a | 12.5 | n/a |

** Shared accommodations households.*

On the dwellings’ characteristics, from **Table 3**, it can be noticed for example for the dwellings’ type of construction that the study showed similar findings with respects to the census results for the Ouagadougou city and at the urban scale. The same can be said for the dwellings’ tenure types. However, the results for the owner-occupied dwellings and the detached dwellings are under-represented with respects to the national scale findings. This can be explained by the rural areas, which have a big share (74%) in the national population, and in which dwellings are most of the time detached and owner-occupied.

### 3.3. Appliance ownership and saturation

Two features of the appliances are defined in this section to yield a comprehensive investigation of appliance ownership in urban households of Burkina Faso: *appliance ownership and saturation*. Appliance ownership refers to households owning one or more typical appliances, while appliance saturation refers to the amount of a given appliance per household [26,66,67].

**Figure 2** shows the distribution of the number of appliances owned. Households own an average of 23 appliances (**Fig. 2 (a)**), with an average of 11 lighting fixtures (**Fig. 2 (c)**) and 12 other[2] appliances (**Fig. 2 (b)**). The number of total appliances ranged between 3 and 93. The number of lighting fixtures ranged from 2 to 50 and the number of other appliances between 0 and 59.

Appliances' ownerships are displayed in **Figure 3**. 100% of the participants own indoor lighting, and 97.7%, outdoor lighting. LED lights account for 74.9% of the total number of lighting fixtures, while ballast fluorescents, compact fluorescents and other lights share respectively 15.6%, 4.7% and 4.8%.

[2] The appliances excluding the lighting fixtures: cooking, cooling and ICE appliances.

Among the other appliances, 97.2% of the participants own at least one fan, 96.1%, at least one television, out of which 60.7% have a screen of up to 32", 20.4% have a 32 – 65" screen and 18.9% have a screen of 65" or more. Out of the 32% of participants that had at least one air-conditioner (AC), 10.7% have a 1 horsepower (hp) AC, 75.4%, a 1.5 hp AC, 10.7%, a 2 hp AC and 3.3% a 2.5 or more hp AC. Fridges are owned by 78% of the surveyed households, with 19.4% of them having a capacity of less or equal to 100 litres (L), 36.7%, a capacity between 100 and 200 L, 31.4%, a capacity between 200 and 300L and 12.5% a 300L or more capacity.

Families with dependent children and couples with and without dependent children dominated appliance ownership. Indeed, Outdoor lighting, televisions, satellite receivers and fans are owned by all couples with non-dependent children. A television is owned by almost all couples with dependent children (99.5%), while satellite receivers and fridges are owned by at least 80%. They also have the highest laptop ownership rate (59.9%). Families with non-dependent children dominated ownership of ACs (57.1%) and were followed by families with dependent children (41.1%).

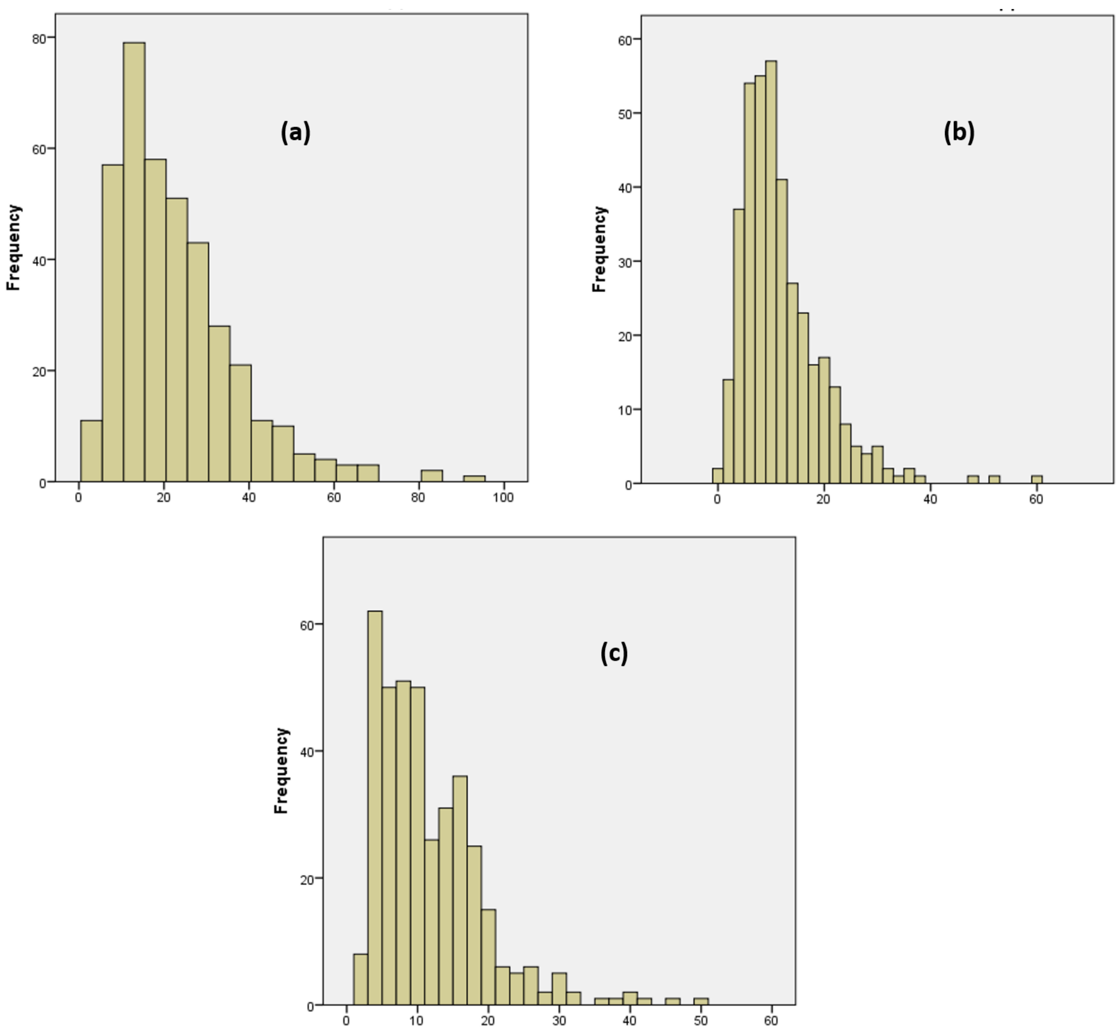


**Fig. 2.** Distribution of the total number of appliances (a), number of other appliances (b) and number of lighting fixtures (c)

**Figure 4** shows the saturation of appliances. Indoor lighting has the highest saturation rate with an average of 8.7 units/household, followed by fans (4.3), outdoor lighting (2.5), televisions (1.4) and satellite receivers (1.1). The rest of the appliances had a saturation of less than 1 unit/household, with laptops, fridges and ACs having more than a 0.5 saturation and the other appliance saturations ranging from 0.3 (iron) to 0.03 (washing machine).

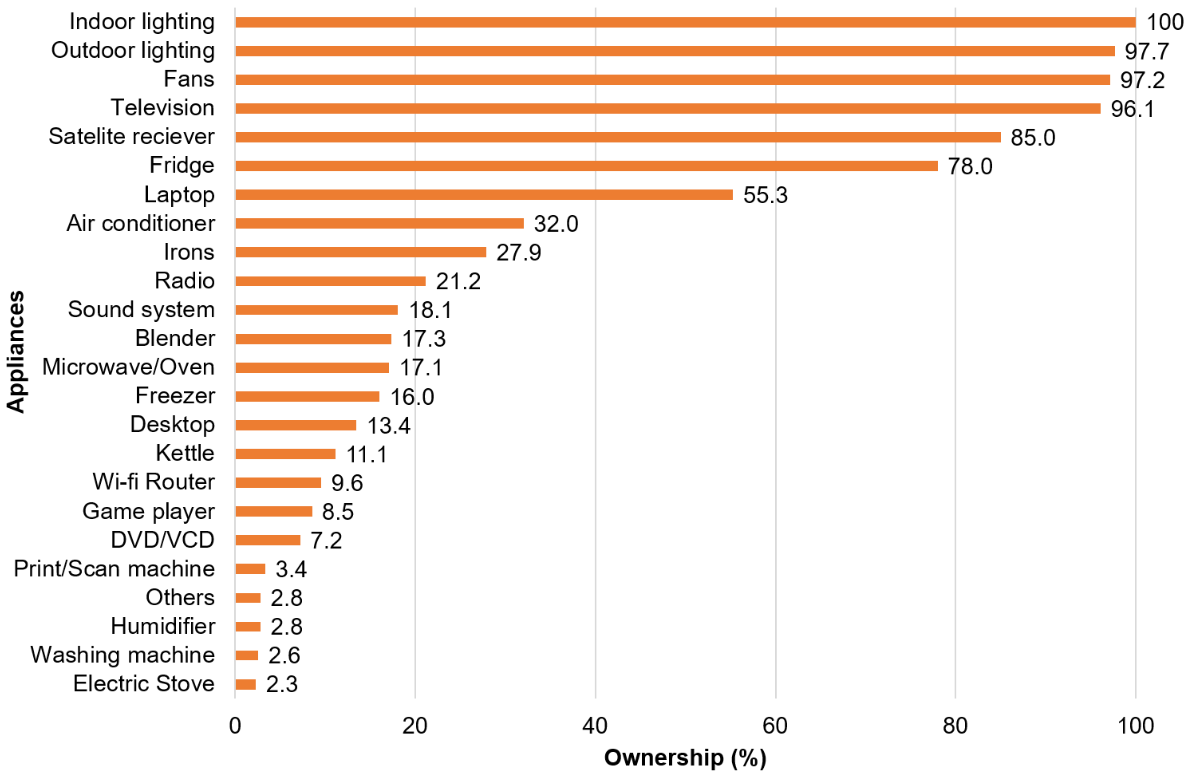


**Fig. 3.** Households' appliance ownership (%)

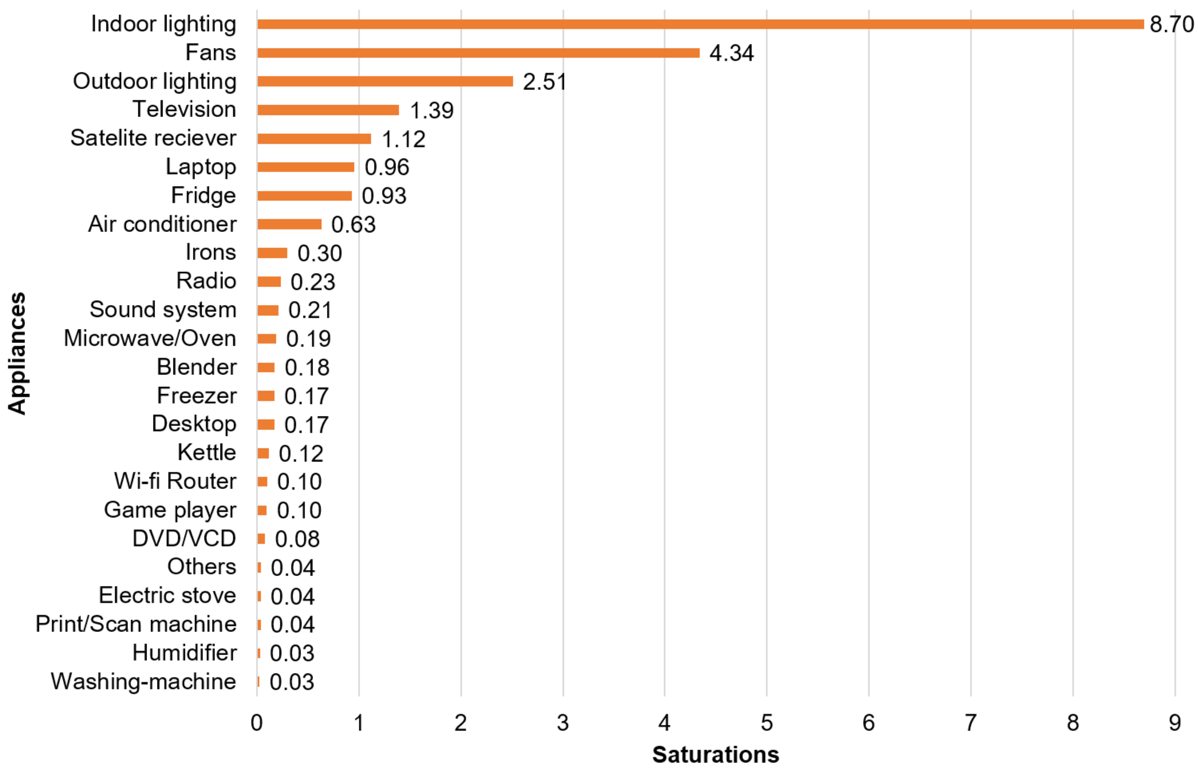


**Fig. 4.** Households' appliance saturation

### 3.4. Appliance use

The use patterns of appliances are also fundamental to understand how ownership influences electricity consumption. For this purpose, during the survey, participants were asked to indicate, on average, how long each appliance was used daily. **Figure 5** gives the average daily appliances' operating hours. After the almost unceasing operation of Wi-Fi routers (23.4 hours/day) and refrigerators[3] (21.7 hours/day), lighting, cooling and some of the ICE appliances are the most used. For the cooling appliances, fans operate for an average of 10.3 hours/day, followed by air-conditioners (5.2 hours/day) and the humidifiers (4.7 hours/day), which is a reflection of the hot and dry climate in Burkina Faso. Television (7.7 hours/day) and satellite receivers (8 hours/day) are the most used ICE appliances, followed by sound systems (4.7 hours/day). Outdoor lights (9 hours/day) operate slightly more than indoor lights daily (8.3 hours/day) due to their use at night until the morning for safety reasons. The rest of the appliances had operating hours, ranging from 3.7 hours/day (radio) to 0.2 hours/day (blender). Finally, a range of other appliances, referred to in this paper as "Others", such for example, as working machines (tailoring machines, wood piercer), sports devices and electronic pianos, demonstrated an average time of use of 3.8 hours/day.

[3] Refrigerators refer here to either fridges or freezer (which are grouped together here due to the small number of freezers)

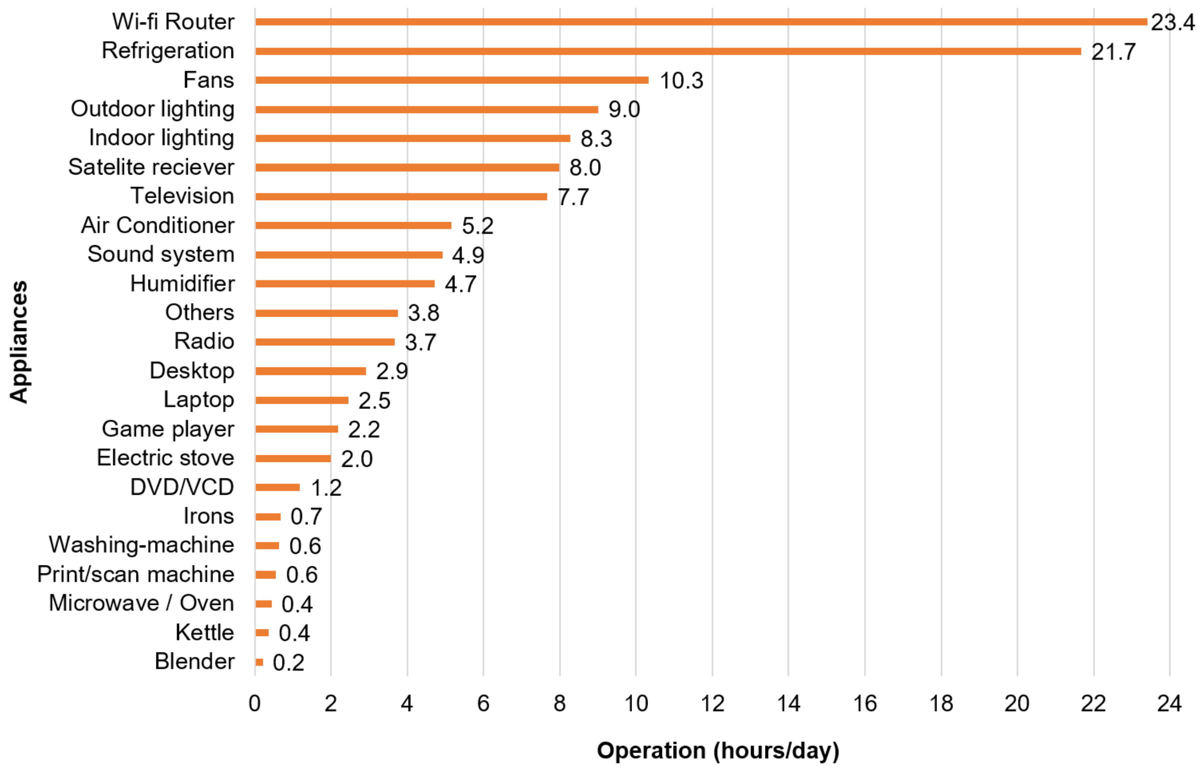


**Fig. 5.** Households' average appliance time of use per day

**Figure 6** shows the use patterns of the main appliances on weekdays and weekends. The weekday pattern of use of lighting (indoor and outdoor combined) demonstrates two peaks occurring at 05:00 and 20:00, with the first peak (05:00) corresponding to the time people wake up to prepare to go to school/work (**Fig. 6 (a)**). After that, outdoor and indoor lights are turned off until a stabilisation around 15% until 16:00. This percentage reflects households that keep the indoor lights on during the day as they choose to close curtains/blinds on doors and windows due to the very dusty character the climate can give the atmosphere. The fraction of users starts increasing at 17:00 corresponding to households returning home, as most public offices and schools close between 16:00 and 17:00. The usage keeps increasing until 20:00 where the users' fraction reaches almost 100% corresponding to people being at home doing the evening activities, and then starts to drop as people start going to bed. An almost identical use pattern can be observed for the weekends (**Fig. 6 (b)**).

Weekday use of fans also (**Fig. 6 (a)**) had two peaks, with the first occurring around 12:00 to 13:00 corresponding to some of the householders being at home during the day as well as those who return for midday breaks. The second peak occurs around 19:00 to 21:00 when most households are home, doing activities mainly in the living room with their fans turned on. At night, the pattern of use stabilises at least at 90% as households keep the fans on for sleeping between 23:00 and 05:00. The same patterns are displayed at the weekend (**Fig. 6 (b)**) except that the proportion of usage is greater as there are more people at home during the weekends. Air conditioners also displayed an almost identical use pattern as fans, albeit with fewer users at the operating times.

Weekday patterns of television use also demonstrated two peaks (**Fig. 6 (a)**), with the first one occurring around 12:00 to 13:00 corresponding also to turning-on by householders at home and those who come for midday breaks. The second peak occurs around 19:00 to 21:00 when most users are home watching TV programs. At night, the fraction of users drops corresponding to people going to bed. The same pattern is evident at the weekend (**Fig. 6 (b)**), although with an increased fraction of users as more people are home during the weekends.

Finally, refrigerators, indicated a largely unceasing use, which can be seen either on weekdays (**Fig. 6 (a)**) and weekends (**Fig. 6 (b)**). Slightly less than 80% of the users keep their refrigerators running in the night. The number of users starts increasing in the morning at 07:00, stabilises until 16:00 and then slightly increases until 20:00, corresponding to some users turning on the appliances for use for dinner. After 21:00

the fraction of users’ drops as some people prefer using only when in need, so they do not keep refrigerators on at night.

The usage patterns of the other appliances depend on the occupants' activities and behaviours. For example, some prefer to use irons in the morning before going to school/work, while others prefer to use them on the weekends to prepare all the clothes for the week. Kettles are used in the morning to make coffee/tea for drinking before leaving home, but also in the evening for the same reason or for other cooking purposes. Electric stoves and microwaves/ovens are commonly used in the evening for cooking dinners, but some houses also use them in the morning to heat food. Desktops and laptops are used mainly in the afternoon and evening when people are back home on the weekdays and by some home workers during the daytime. During the weekends, daily use increases as more people are home. Game consoles and DVD/VCR devices are used mainly during the weekends and sometimes on weekdays, especially during holidays. Washing machine users prefer to use it on weekends to wash all the clothes.

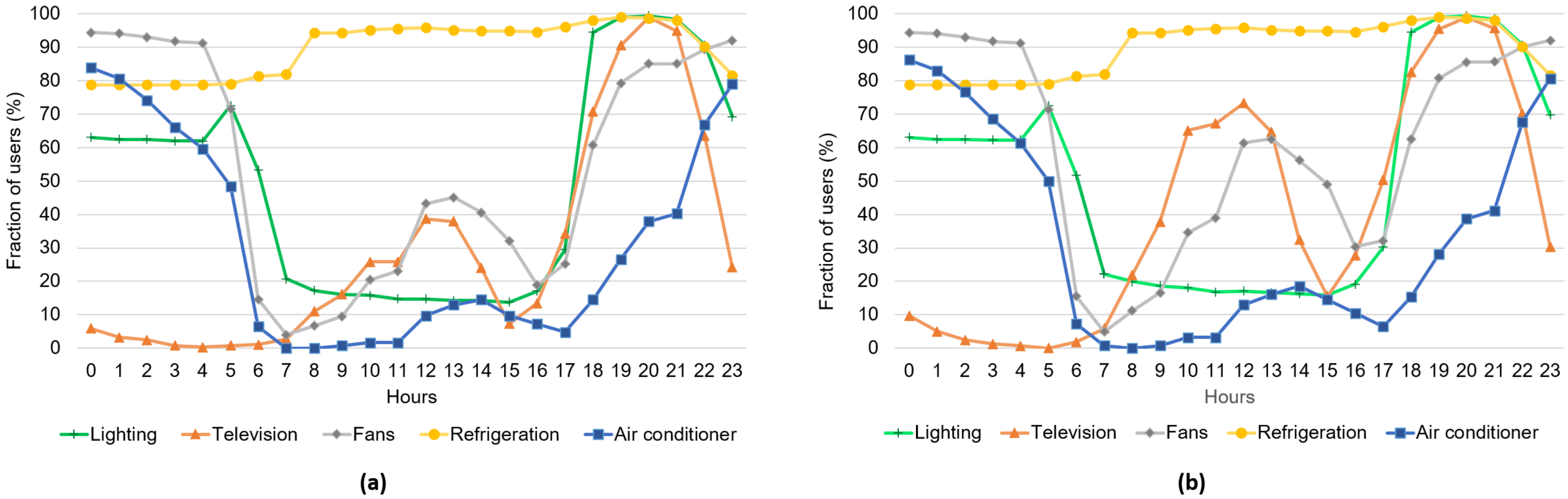


**Fig. 6.** Households' daily pattern of use for the main appliances during weekdays (a) and weekends (b)

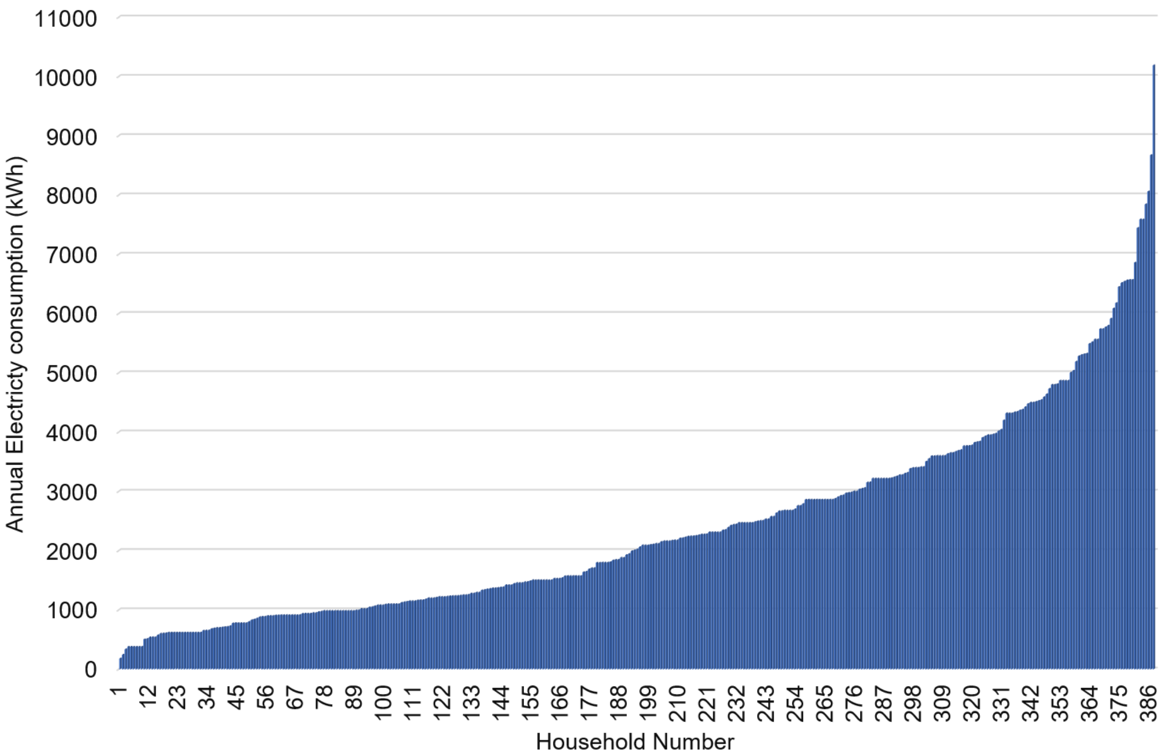


**Fig. 7.** Annual electricity use distribution for the surveyed households

## 3.5. Electricity use

### 3.5.1. Total electricity use

**Figure 7** shows the distribution of the annual recorded electricity consumption of the surveyed households obtained from the consumers' electricity bills. On average, a household consumes 2395 kWh/year (standard deviation of 1687), with consumptions ranging from 181 kWh/year to 10188 kWh/year. The average consumption corresponds to 295,631 FCFA/year (509 US$/year) spent on electricity, equivalent to at least 10% of the annual income of 42% of the participant and at least 6% of the annual income of 68% of the participants. The first 25% of the participants consume at most 1079 kWh/year, while the last 25% consume at least 3254 kWh/year. The average consumption per capita is equivalent to 496 kWh/year, with the "single person" households showing the highest consumption per capita (884 kWh/year), while the multigenerational families, which have the largest average household size (9 persons/household), showed the lowest consumption per capita: 379 kWh/year.

### 3.5.2. Electricity use breakdown

In order to determine the electricity consumption breakdown, the method explained in **section 2.3** and **Eqs. (1) to (4)** were used. The theoretical mean annual electricity consumption (TEC) was 2 573 kWh/year, 7.4 % greater than the mean annual recorded electricity consumption. At the aggregated level, the theoretical aggregated electricity use of the overall sample is 6.2% higher than the aggregated measured electricity use. With regards to such estimations, it was judged therefore useful to proceed with the electricity use breakdown. **Figure 8** shows the average annual electricity per appliance[4]. Due to their higher ownership, saturation, and operating hours, appliances such as air-conditioners (1833 kWh), fans (369 kWh) and refrigerators (up to 519 kWh) demonstrated high consumptions. However, appliances like electric stoves (1027 kWh), kettles (392 kWh), irons (314 kWh), microwaves (312 kWh) and washing machines (294 kWh) also demonstrated significant electricity uses due to their high operating powers. The other appliances displayed values from 278 kWh/year (television) to 19.89 kWh/year (radio).

**Figure 9** shows the breakdown of TEC per appliance and activity for the households. Again, ACs remained the major consuming appliance (**Fig. 9 (a)**), accounting for 24.6% of the total electricity use, followed by refrigerators (16.7%), fans (15.1%), lighting fixtures (14.5%) and televisions[5] (13.5%). The rest of the appliances accounted for the remaining 15.6%.

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[4] The average annual electricity per appliance refers here to the average for the households in which this typical appliance is present.
[5] The televisions are considered jointly with the satellite receivers here.

Cooling was the most significant consuming activity with a share of 39.9%, (**Fig. 9 (b)**), followed by food cooking and preserving (22.7%), ICE (19.1%) and lighting (14.5%) activities. The other activities represented only 3.8% of TEC.

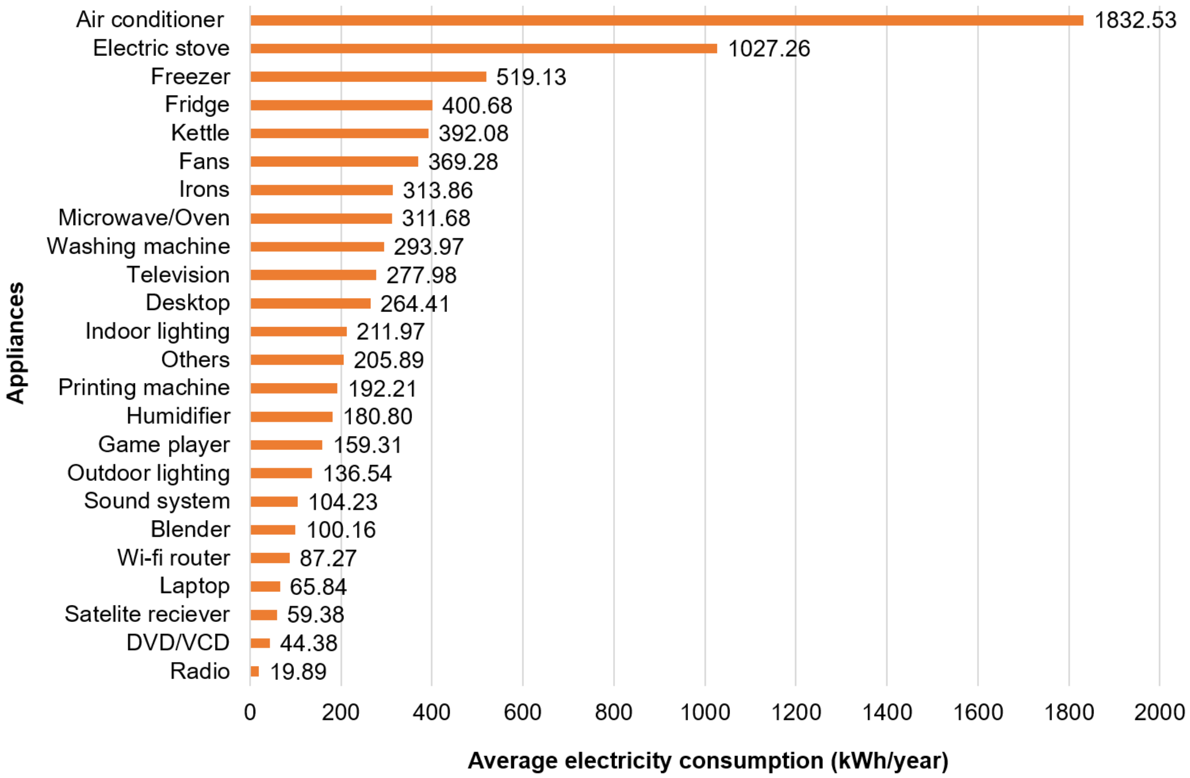


**Fig. 8.** Average annual electricity consumption per appliance

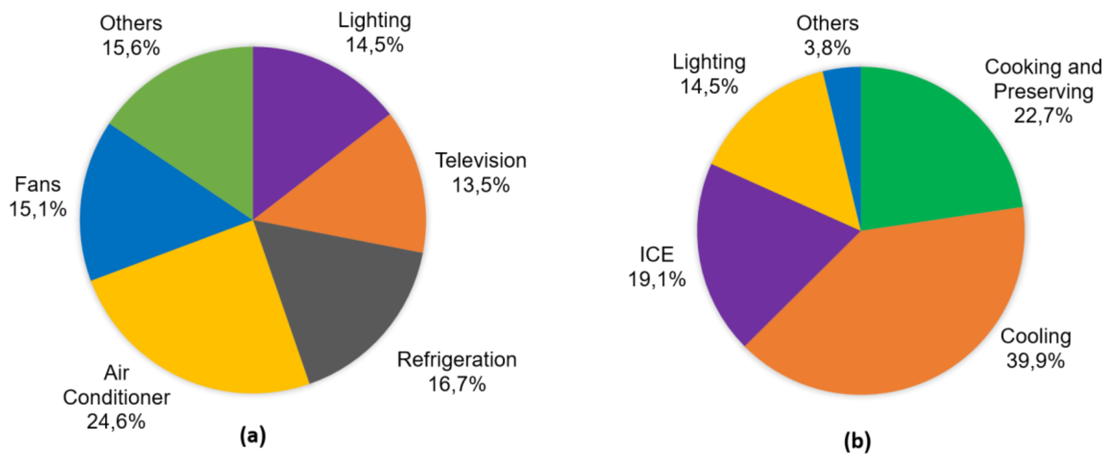


**Fig. 9.** Electricity consumption breakdown by appliance types (a) and activities (b)

### 3.6. Energy behaviour and electricity use

The literature has demonstrated the energy-saving potential related to occupants and their behaviours to be around 10-25% in residential buildings [68]. However, seeking occupants' behaviour modifications for energy consumption reduction involves complex interactions of technical and social phenomena [69,70]. In this section, the energy behaviours of the participants and their interactions with electricity use were investigated. With the methodology described in section 2.3, three groups of consumers based on their annual electricity consumption were formed, namely the low, medium and high consumers. **Table 4** gives the electricity consumption statistics for the three groups along with those of the overall households. In average, the medium consumers use more than twice the electricity used by the low consumers, while the high consumers more than twice the electricity used by the medium consumers and little less than five times that of the low consumers.

**Table 4.** Descriptive statistics of electricity consumption

| Statistics (kWh) | Low consumers group (n=129) | Medium consumers group (n=129) | High consumers group (n=129) | Overall sample (n=387) |
|---|---|---|---|---|
| Mean | 870 | 1976 | 4339 | 2395 |
| Standard deviation | 252 | 465 | 1406 | 1687 |
| Minimum | 181 | 1252 | 2862 | 181 |
| Maximum | 1250 | 2862 | 10,188 | 10,188 |

For the electricity use break-down, air-conditioners remain the main consuming appliances for the high consumers (33.6%), followed by refrigeration appliances (15.1%) and other appliances (16.7%). However, for the low and medium consumers, fans (25.8% and 20.6% respectively) were the more significant appliances, followed by refrigerators (20.3%) and televisions (20.5%) for the medium and low consumers respectively.

Regarding the activities, like for the overall sample, cooling, remained the leading activity despite the group (up to 44.7%). However, cooling is followed by cooking/preserving for the medium and high consumers due to their higher ownership and use of the refrigerators and other kitchen appliances. Whereas, the use of ICE appliances was the second most significant activity for the low consumers. The low consumer group, which consists mainly of low incomes households (82% of them earn up to 250,000 FCFA francs, 430US$, monthly), cannot easily afford to buy air-conditioners and other cooking and preservation appliances.

#### 3.6.1. Energy conservation awareness and practice

Out of the overall sample, 35.9% declared not to be aware of energy conservation. 41.9% did not undertake any energy conservation actions, whereas 27.4% did so regularly, and 30.7% sometimes. **Figure 10** shows the practical actions of energy conservation undertaken by the households. Most of the low consumers do not practice energy conservation (50.4%), while for the medium group this share is 47.3%. In comparison, the high consumers, which consist mainly of households headed by advanced literate persons (68.2% of them went to university/college), have a smaller number of households practising no energy conservation actions (28.7%), with the rest (71.3%) undertaking mostly, basics actions like turning-off unused appliances and unplugging standby appliances when not in use, but also some advanced actions like installing typical[6] efficient lighting fixtures and solar PV/water systems.

[6] Efficient lights other than the LED lights, which already have a high saturation in the sample due to a project of the Energy Ministry that consist of substituting fluorescent and other inefficient lights with 3 LED lights per household in the main urban cities of the country within which Ouagadougou.

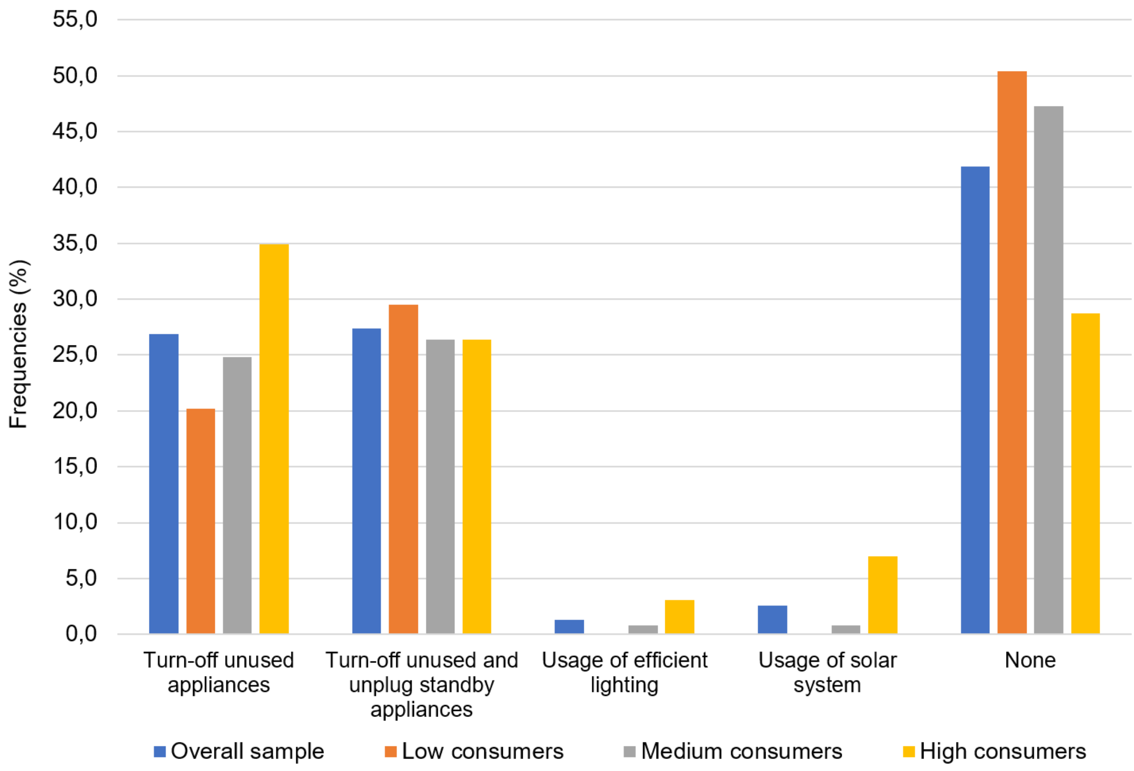


**Fig. 10.** Energy conservation actions practiced in the households

### 3.6.2. Standby electricity consumption (SEC)

In addition to awareness and practices of energy conservation measures, SEC was specifically investigated as a feature of households' energy conservation behaviours. Participants were asked about their awareness of the standby mode and if they unplug their standby appliances when not in use. The survey results were used to determine the SEC of the households. The method explained in **section 2.3** and **Eq. (5)** was used. The average, maximum, minimum, and standard deviation values for the number of standby appliances, standby power, usage time, and electricity consumption are given in **Table 5** for the overall sample and the groups of consumers.

The high consumers, as it may have been expected, tend to have more standby appliances (7). This translates into higher average standby power (17.9 W) and usage time (8.4 hours/days) per household for this group and, therefore, into a higher SEC (53.4 kWh/year).

**Table 5.** Standby power, usage time and electricity consumption

| Standby features | Statistics | Overall sample | Low consumers | Medium consumers | High consumers |
|---|---|---|---|---|---|
| **Number of standby appliances** | Mean | 4.6 | 2.6 | 4.1 | 7.1 |
| | St. dev. | 3.3 | 1.6 | 2.2 | 3.9 |
| | Minimum | 0.0 | 0.0 | 0.0 | 1.0 |
| | Maximum | 30.0 | 9.0 | 13.0 | 30.0 |
| **Standby power** | Mean | 12.6 | 8.3 | 11.6 | 17.9 |
| | St. dev. | 9.8 | 4.7 | 9.3 | 11.5 |
| | Minimum | 0.0 | 0.0 | 0 | 5.0 |
| | Maximum | 80.0 | 32.0 | 80.0 | 75.0 |
| **Standby usage time** | Mean | 4.6 | 2.1 | 3.3 | 8.4 |
| | St. dev. | 6.9 | 3.3 | 3.5 | 9.9 |
| | Minimum | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 48.6 | 24.9 | 18.7 | 48.6 |
| **Standby electricity consumption (kWh/year)** | Mean | 29.5 | 14.1 | 21.0 | 53.4 |
| | St. dev. | 47.5 | 22.3 | 22.3 | 70.0 |
| | Minimum | 0.0 | 0.0 | 0.0 | 0.0 |
| | Maximum | 434.3 | 146.9 | 112.5 | 434.3 |

**Table 6** show the SEC breakdown per appliance for the overall sample and groups of consumers. For higher consumers, the desktop had the highest share, within the total SEC (44.7%), followed by satellite receiver (17.1%), laptop (14.9%) and televisions (9.3%). For medium and low consumers, satellite receivers had the highest share (more than 30% for the two groups), followed by laptops and televisions. The television (24.2%) had a higher share than the laptop (12.7%) for the low consumers, while the latter (21.3%) has a higher share than the television (19.1%) for the medium consumers. The other appliances accounted for less than 10%.

**Table 6.** SEC breakdown (%) by appliance

| SEC breakdown (%) | Low consumers | Medium consumers | High consumers | Overall sample |
|---|---|---|---|---|
| Television | 24.2 | 19.1 | 9.3 | 14.0 |
| Satellite receiver | 39.7 | 34.7 | 17.1 | 24.9 |
| Desktop | 10.7 | 14.3 | 44.7 | 32.1 |
| Laptop | 12.7 | 21.3 | 14.9 | 16.1 |
| Radio | 5.8 | 6.4 | 2.9 | 4.2 |
| Sound system | 5.1 | 2.4 | 5.2 | 4.5 |
| DVD/VCD | 1.6 | 1.0 | 0.9 | 1.0 |
| Game console | 0.4 | 0.7 | 3.5 | 2.3 |
| Printing machine | - | - | 0.7 | 0.4 |
| Kettle | 0.0 | 0.1 | 0.1 | 0.1 |
| Microwave/Oven | 0.0 | 0.0 | 0.6 | 0.4 |
| Washing machine | 0.0 | 0.0 | 0.1 | 0.1 |

Finally, **Table 7** shows the share of the SEC within the TEC for the overall consumption and the share of SEC within the TEC for each appliance. The SEC represents 1.2% of the TEC for the overall sample, with a slightly higher share for the low consumers (1.6%) than the other groups (1.1% respectively). For the share of SEC within TEC per appliance, radios stand out from other appliances as SEC represents more than 25% of the TEC for radios, either within the overall sample or the consumer groups. Within the low and medium consumers, radios are followed by laptops, satellite receivers and desktops, while for the high consumers, the order is inversed.

**Table 7.** Share of the SEC within the TEC for overall use and per appliance

| Share of SEC in TEC (%) | Overall sample | Low consumers | Medium consumers | High consumers |
|---|---|---|---|---|
| **Total SEC** | **1.2** | **1.6** | **1.10** | **1.11** |
| Television | 1.4 | 2.3 | 1.6 | 1.1 |
| Satellite receiver | 13.0 | 16.2 | 12.4 | 12.1 |
| Desktop | 18.1 | 10.7 | 7.1 | 23.9 |
| Laptop | 12.8 | 18.4 | 13.2 | 11.9 |
| Radio | 31.6 | 26.9 | 36.4 | 30.9 |
| Sound system | 8.6 | 12.7 | 13.5 | 7.5 |
| DVD/VCD | 8.9 | 5.9 | 10.5 | 10.7 |
| Game Console | 4.5 | 1.4 | 4.0 | 4.9 |
| Printing machine | 1.6 | - | - | 2.7 |
| Kettle | 0.1 | 0.0 | 0.1 | 0.1 |
| Microwave/Oven | 0.2 | 0.0 | 0.0 | 0.3 |
| Washing machine | 0.3 | - | 0.0 | 0.3 |

### 3.6.3. Appliance behaviours and satisfaction with electricity utility

Detailed results of appliance behaviours and satisfaction with electricity utility are provided in **Appendix B,** with only the key findings presented below. In relation to appliance purchasing, almost all of the participants (92.2%) prefer to purchase and use new appliances, while a few prefer second-hand (3.1%) and mixed[7] appliances (4.7%). Regarding appliance energy performance, a high proportion of the medium and low consumers (at least 79.8%) did not know and, therefore, did not purchase their appliances according to their energy performance labels. High consumers had a higher awareness (41.1%) of energy performance labelling of appliances, with 28% considering this criterion when purchasing appliances. Price is one of the main other influencing factors for purchasing appliances regardless of the consumer group (**Fig. 11**). For low (50%) and medium (39.2%) consumers, price is the main criterion, while

[7] For some appliances, they prefer buying new ones, while for some they prefer buying second-hand ones.

high consumers mostly prefer using price in combination with other factors such as brand/design (36.8%).

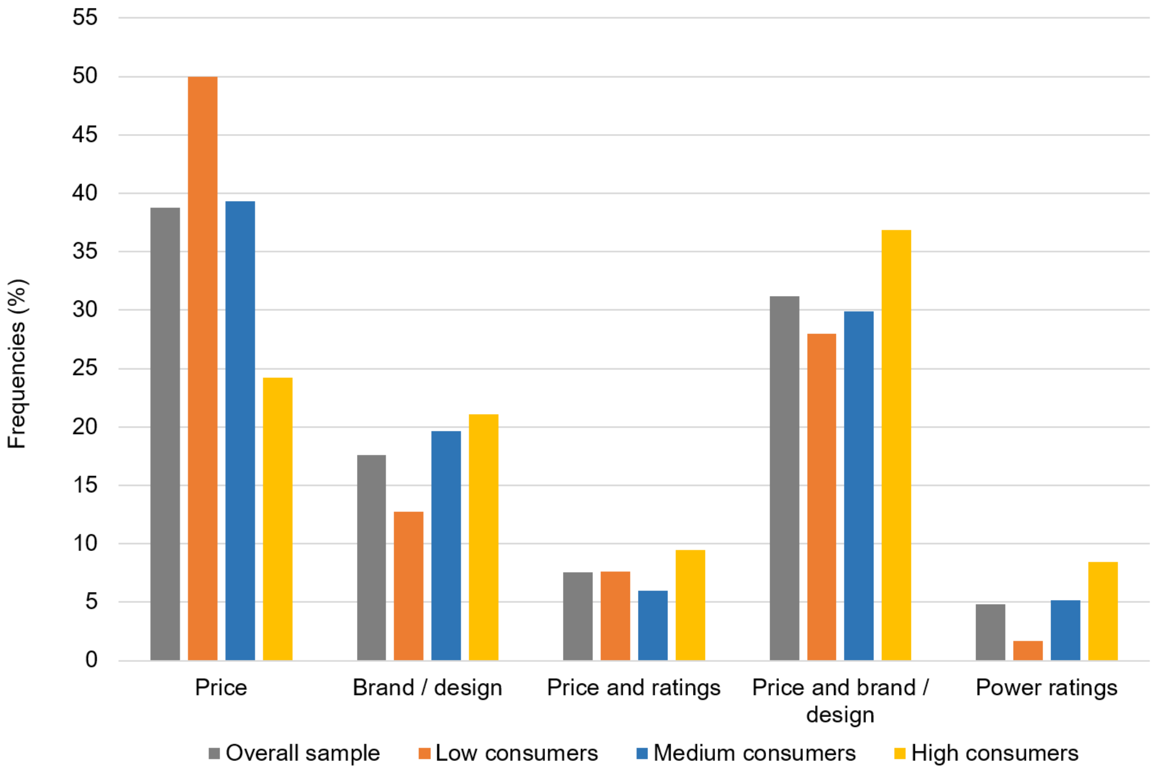


**Fig. 11.** Other influencing factors for appliance purchase

Participants were asked to indicate which appliances they would like to include in potential load shifting actions to help the utility services prevent temporary power supply curtailing during critical hours of use. **Figure 13** shows that refrigeration appliances were the primary preference within the low (50%) and medium consumer groups (44.3%). Following refrigeration appliances, medium consumers prefer turning off cooling appliances (37.7%), while low consumers prefer turning off television (24.2%). ACs were the first preference for load shifting among high consumers (49.3%), followed by refrigeration appliances (24.7%), televisions (15.1%) and fans (11%).

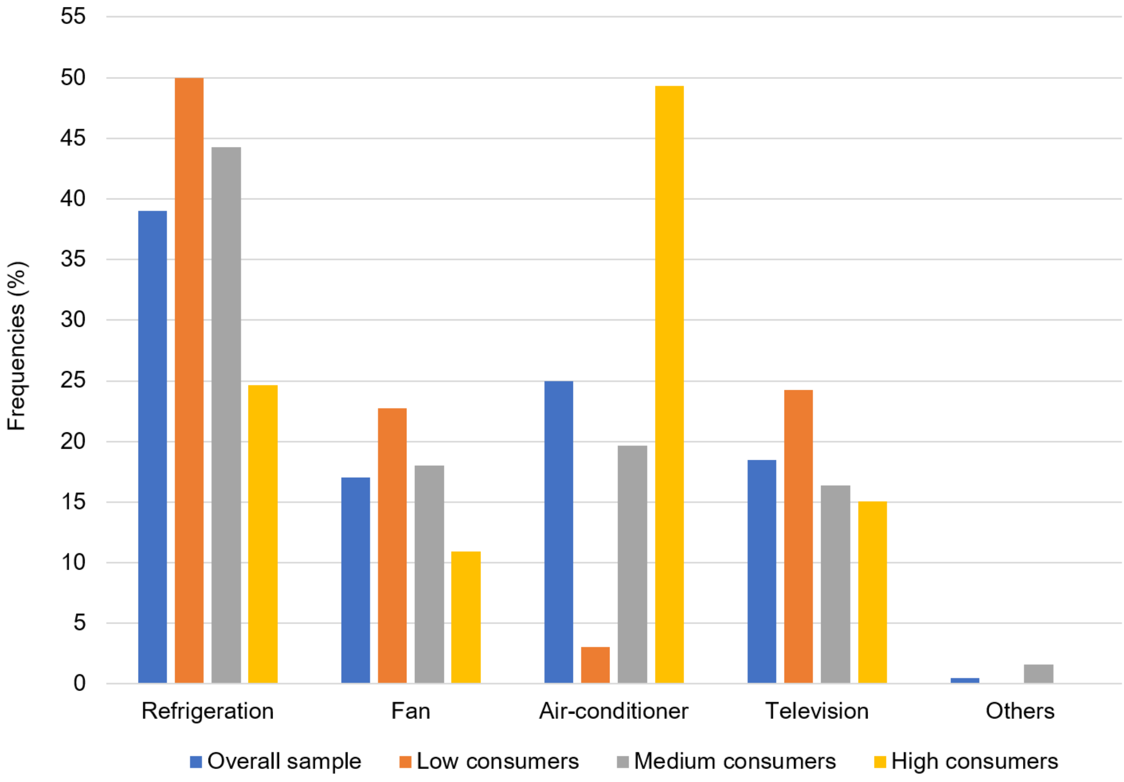


**Fig. 12.** Appliance preferences for load shifting

Finally, consumer satisfaction with the services provided by their utility company was assessed. It emerged that the majority of the participants were more or less satisfied (34.4%) or satisfied (25.6%) with the utility services. However, 30.7% were unsatisfied or not at all satisfied. Finally, few indicated that they were very satisfied (1%) or neutral (8.3%). The same tendency was observed for each group of consumers.

## 4. Discussion and policy implications

While most existing literature has investigated residential electricity consumption in developed countries, this study contributes to improving the limited body of literature on developing countries by providing information on the interaction between households' lifestyles and electricity use in urban zones of Burkina Faso. A discussion of the key findings and the policy implications are discussed below.

The results demonstrated that most households own common appliances, such as lighting fixtures, televisions, fans and refrigerators. Their price, which was also found to be the most influential factor affecting appliance purchases, probably explains the high levels of ownership, as the price for buying these types of appliances are cheaper than those for ACs or heavy machineries for example. However, with the expected increase in urbanisation and economic status of households, it is likely that the saturation of these common appliances will increase, as well as their affordability. This may lead to higher electricity demands in future.

Furthermore, the survey demonstrated that most households generally did not have information about possible energy conservation they could implement at home and more specifically about the energy performance ratings of appliances. Therefore, actions such as awareness campaigns and policies to encourage the purchase of more efficient appliances could be a significant opportunity in Burkina Faso. In 2014, a joint regional energy efficiency program (PREE, 2014-2021) was launched by the UEMOA countries, for which, one of the main objectives was to increase the use of energy-efficient electrical appliances by consumers. As a participant of such an initiative, Burkina Faso launched a primary law within the energy sector and many decrees regarding energy efficiency for residential appliances in 2017. However, energy performance rating labels have not yet successfully been implemented in the appliances market as initially foreseen by the project.

Despite households in Burkina Faso having similar levels of ownership and saturation rates of common domestic appliances as other countries and specifically developing ones [26,71], electricity use was lower when compared to them [26,28,58,72,73]. This could be attributed among other things to the high tariffs used by the electricity utility and the lower performance of the electricity grid within the country. Indeed, the electricity utility, the only one in the country, has one of the highest electricity tariffs in the West-African region [7]. Also, the grids' performance is among the worst, with an average of 84 interruptions, accounting for 60 hours/year of outages for customers [5]. This likely leads into the significant level of customer disappointment observed in this study. Improving generation capacity with high penetration of renewable energy, could be explored to make electricity services more affordable for the consumers. Some solutions like off-grid generation and distribution, as well as individual distribution kits may further help improve efficiency in the use of electricity by avoiding losses.

Three groups namely the low, medium and high consumers were created to analyse interactions between households’ lifestyles and electricity use. Most likely due to the hot and dry environment, weather-related appliances such as fans and air-conditioners demonstrated extensive use by households. Fans that are more affordable for purchasing are widely used by the low consumers and some of the medium consumers, while air-conditioners are used more by high consumers. This translates into cooling being the most electricity consuming activity among all the groups. Results showed that households with fans consumed 1.5 times more electricity than those with no cooling appliances. This increases up to 5 times more when households own ACs. Therefore, attention should be paid to ownership and use of weather-related appliances, when planning for future increases in electricity demand and opportunities for energy efficiency. Some alternatives, such as improving the buildings’ fabric energy performances through materials/technology to reduce heat gains [74–76], could be considered, but affordability of such solutions remains challenging for the population, along with a lack of research on their effectiveness in hot and dry climates, even in urban zones [77,78].

Furthermore, the government has initiated incentive policies to increase the integration of renewable energy systems, such as solar domestic hot water or photovoltaic systems, as an alternative to fulfil the energy consumption needs of households. However, their saturation is still limited, as demonstrated by the study, despite the considerable potential that Burkina Faso has for using such technologies. This low uptake may be explained by issues of affordability and consumers' trust about the systems' performance. Further policies and initiatives, possibly including incentives, needs to be considered and implemented by the government.

Awareness and incentive measures should also be maintained for lighting fixtures. Through the Energy Ministry, the government initiated a campaign for substituting fluorescent and other inefficient lights with 3 LED lights per household in the main urban cities of the country in 2018. The campaign is expected to be progressively extended throughout the country to eventually reduce the national power demand by 19.9 MW. Such initiatives, have been demonstrated as a valuable mean for electricity access increase, if well planned [79]. However, this study demonstrated that non-efficient lighting was still present in 24% of the participants' households. Effort should therefore be maintained to achieve a 100% share of efficient lights to reduce lighting electricity use, which accounts for 14.5% of the Total Electricity Consumption (TEC), and also encouraging households to switch off lights when not in use.

Furthermore, attention should also be paid to Standby Electricity Consumption (SEC). Although this represents only 1.2% of the TEC, the ICE appliances were found to account for the majority of SEC (96%) which are more generally affordable appliances, and as income levels increase in future, a higher share for SEC could occur. This was demonstrated in the study with low consumers who, despite being made up of low-income households, showed high ownership levels of ICE equipment leading to a higher share of SEC. Education and information could be enhanced to avoid increasing SEC in future.

The study also demonstrated a general lack of understanding of good practices for energy conservation. Indeed, 35.9% of the participants declared they were not aware about energy conservation, whilst amongst those that were aware, 6% did not practice it and 30.7% not regularly. Furthermore, 80% of the participants were not aware about energy performance labelling. Here also education and information campaigns about energy conservation/efficiency could be implemented.  Televisions appear to be good medium for transmitting such information, as the survey demonstrated a high ownership and significant daily usage. Furthermore, the low consumers who demonstrated more exposure to lack of information about energy conservation, also had high ownership rates and usage of televisions. In addition, implementing information and education campaigns in school programs and administration/services information could be a further avenue. Finally, possible financial incentive measures to increase saturation of efficient appliances could be considered, as most participants in this study indicated that they preferred to purchase new appliances, and price was the most important factor influencing appliance choice.

Finally, the results indicated that most high consumers prefer to sacrifice their thermal comfort, instead of experiencing power outages, as the AC (49.3%) was identified as their main preference for load shifting during critical demand periods, followed by refrigerators (24.7%). Whereas, low and medium consumers designated refrigerators (50% and 44.3%) as their principal element for load shifting, followed by the television (24.2%) for the low consumers and AC (19.7%) for the medium consumers. These findings perhaps indicate the understanding of the consumers on the potential impact of curtailing the use of these appliances on their electricity load. It also showed a willingness to cooperate in demand side management measures/programs. The results suggest that appliances, like ACs, refrigerators and televisions could serve as first targets for such initiatives.

### 4.3. Limitations of the study and future research

In order to fill the significant gap on residential electricity consumption in developing countries with hot and dry climates, this study provides several insights on the interaction between urban households' lifestyles and electricity use in Burkina Faso. However, the findings are limited by some restrictions given below.

First, even if the sample size targeted was reached, it remained low and was designed as this due to constraints like costs. As a result, it overestimates and underestimates in some cases, the results when compared to the characteristics of the true populations. This puts some concerns on its representativeness. Future large-scale surveys are therefore, needed to have a consistent and representative sample size in order to have a clear analysis on the results obtained from this study.

Second, even if the methodology used for determining the electricity use and its breakdown for the surveyed households has been shown to be reliable in previous studies, this method is subject to issues like information-reporting and appliances operation modes. Some households indeed, even after agreeing to participate, may feel observed, and this may have led to differences between actual characteristics and behaviours and those reported. Some also could have underestimated or overestimated their appliance usage patterns, which led to the individual differences. Future research should encompass in-situ measurements for not only guarantying accuracy, but also investigate trends in use and characteristics of domestic electricity use.

Finally, although limitations exist the value of the current study's findings stands. The study can serve as a reference for forthcoming studies in Burkina Faso and other developing hot and dry climate countries. Also, it provides valuable insights for energy planners, designers, and policymakers as some information like TEC breakdown and SEC were unveiled. This could help set priorities and determine targets for designing and implementing energy policies in the residential sector.

## 5. Conclusion

This study collected data on the urban households' characteristics and behaviours between September 2021 and February 2022 within 387 households in the city of Ouagadougou, to provide insights into the urban residential electricity consumption in Burkina Faso. To the authors' knowledge, this is the first-ever study conducted to provide information on city-scale electricity consumption in Burkina Faso. The key findings of the study were:

- Couples with children and multigenerational families who represent 71.5% of the surveyed households, are the dominant family typology within urban households of Burkina Faso. The average size per household is around 5.2, with the households headed mostly by Men and ages of HRPs laying between 29 and 61. Most of the HRPs are literate, and 70.8% of the households earn incomes between 100,000 and 550,000 FCFA francs (US$ 173-947). The average dwelling floor area is estimated as 101.5 $m^2$, with most (89.4%) consisting of detached and multi-family dwellings, and having an average of 6 rooms.

- At least 78% of the households own “essential” appliances, such as fridges, fans, televisions, satellite receivers and lighting fixtures, which operate at least 7.7 hours a day. On the other hand, more powerful and non-common appliances, such as air-conditioners are owned only by up to 32% of the participants and are used for an average of up to 5.2 hours daily. Lighting fixtures showed higher saturation, while essential appliances are owned at around 1 unit/household.
- Households use, on average, 2395 kWh/year, while per capita and floor area ($m^2$), the consumption is around 422 kWh and 23.58 kWh, respectively, which are lower values in comparison with other survey studies globally reported in the literature. For the electricity use breakdown, weather-related appliances, like fans and air-conditioners contribute the most to the total electricity consumption (TEC) accounting for 15.1 and 24.6%. As a consequence of this, cooling activities use the most electricity (39.9%), followed by cooking/preserving, information-communication-entertainment (ICE), lighting and then other activities.
- In order to investigate the interactions between electricity consumption and lifestyles and energy behaviour, three groups of consumers, namely the low, medium and high consumers, were formed based on their annual electricity consumptions. The average TEC were 870, 1976 and 4339 kWh/year for the low, medium and high consumers respectively. The findings suggest that even if cooling remains the most consuming activity for all the consumers, air-conditioners are the leading consuming appliances among the high consumers, while fans play the same role among the low and medium consumers. Also, cooling is closely followed by ICE activities for the low consumers, who own and

showed a high share of ICE appliances in their TEC due to their easier affordability. This also leads to a higher share of standby electricity consumption (SEC) within the TEC for this group, with ICE appliances being responsible for 96% of SEC.

- Finally, the study demonstrated a general lack of knowledge and good practices of energy conservation amongst the households. There appears to be a need to increase information and education campaigns in Burkina Faso to support future energy efficiency actions and policies.
- Overall, the results of this study increase understanding of households' lifestyles, their patterns of appliance ownership and use, and residential electricity consumption. Potential actions and policies were discussed and these could be used by stakeholders in the energy sector, such as policy makers, grid operators, and building designers. This study may also serve as a reference for the characteristics, behaviours and patterns of electricity consumption of other growing cities in Burkina Faso or other hot climate developing countries with similar contexts and characteristics.

**CRediT authorship contribution statement**

**Komlan Hector Seth Tete**: Conceptualization, Investigation, Methodology, Data processing, Software, Analysis, Writing – Original draft.

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**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data availability**

Data will be made available on request.

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## Appendix A. Activities and appliances of the households

**Table A1** below shows the five activities considered for this study and the appliances included in each activity.

Table A 1. Activities of the households and corresponding appliances

| **Activity** | **Appliances** |
|---|---|
| Cooling | Air-conditioner, fan, humidifier |
| Cooking/Food preserve | Electric stove, fridge, freezer, microwave/oven, kettle, blender. |
| ICE | Television, satellite receiver, sound system, game Console, Wi-Fi router, desktop, laptop, radio, DVD/VCD, printing/scanning machine |
| Lighting | Indoor and indoor lighting fixtures |
| Others | Washing machine, iron, others |

## Appendix B. Households' appliance purchase and use behaviours and electricity utility satisfaction

**Table B1 – B2** below show the households' appliance purchase and use behaviours as well as their satisfaction upon services provided by utility company.

Table B 1. Households' appliances purchase behaviours

| **Appliances' purchase behaviours** | **Behaviours Features (%)** | **Overall sample** | **Low consumers** | **Medium consumers** | **High consumers** |
|---|---|---|---|---|---|
| Appliance purchase condition | New | 92.2 | 89.9 | 92.2 | 94.6 |
| | Second-handed | 3.1 | 5.4 | 3.1 | 0.8 |
| | Mixed | 4.7 | 4.7 | 4.7 | 4.7 |
| Awareness of appliance labelling upon energy performance | Yes | 26.4 | 20.2 | 17.8 | 41.1 |
| | No | 73.6 | 79.8 | 82.2 | 58.9 |
| Influence of energy performance labels on appliance purchase | Yes | 15.8 | 9.3 | 10.1 | 27.9 |
| | No | 84.2 | 90.7 | 89.9 | 72.1 |
| Other factors influencing appliances purchase | Price | 38.8 | 50 | 39.3 | 24.2 |
| | Brand/design | 17.6 | 12.7 | 19.7 | 21.0 |
| | Price and ratings | 7.7 | 7.6 | 5.9 | 9.5 |
| | Price and brand | 31.2 | 28.0 | 30.0 | 36.8 |
| | Ratings | 4.8 | 1.7 | 5.13 | 8.4 |

Table B 2. Households' appliances use behaviours and satisfaction upon utility services

| **Appliances' use behaviours** | **Behaviours features (%)** | **Overall sample** | **Low consumers** | **Medium consumers** | **High consumers** |
|---|---|---|---|---|---|
| Awareness of SEC | Yes | 52.5 | 41.1 | 47.3 | 69 |
| | No | 47.5 | 58.9 | 52.7 | 31 |
| Satisfaction upon utility services | Not at all satisfied | 9.0 | 9.3 | 10.1 | 7.8 |
| | Not satisfied | 21.7 | 20.9 | 20.2 | 24.0 |
| | Neutral | 8.3 | 10.1 | 7.0 | 7.8 |
| | More or less satisfied | 34.4 | 34.1 | 33.3 | 35.7 |
| | Satisfied | 25.6 | 24.0 | 28.7 | 24 |
| | Very satisfied | 1.0 | 1.6 | 0.8 | 0.8 |
| Appliances preferences for load shifting | Refrigerators | 39.0 | 50.0 | 44.3 | 24.7 |
| | Fans | 17.0 | 22.7 | 18 | 11.0 |
| | ACs | 25.0 | 3.0 | 19.7 | 49.3 |
| | Televisions | 18.5 | 24.2 | 16.4 | 15.1 |
| | Others | 0.5 | 0.0 | 1.6 | 0.0 |