

## EFFECTS OF THE USE OF SMARTPHONES ON THE POWER CONSUMPTION OF AN OFFICE BUILDING IN IKEJA, LAGOS

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**Abstract:** The rising number and increased use of smartphones has necessitated inquiries into how much energy is required to keep these phones powered up. With smartphone users in Nigeria at 21 million and average usage time of 3 hours per day, it is sure to place a burden on the electric grid. This paper studies the effect of smartphone usage on the power consumption of an office building in Ikeja. The building is a two storey 1220 sq.m. Office space occupied by over 70 employees, all of whom have smartphones. Work hours are between 8 am and 5 pm, that is 9hours  $\pm$  30 minutes. Employees' phone usage and charging patterns were recorded. Average charging period was 3 hours. The data of the Energy consumption patterns were then compared to total electricity consumption of the building which included the cooling, lighting, computers, servers and other IT infrastructure. It was discovered that the smartphones contributed about 2.56% of total energy consumed in the building. The results showed that although smartphones consumption did not place too much of a burden on the electricity consumption of these buildings, it however added to cost of running the building over time, with the business bearing the cost of this electricity.

**Keywords:** Energy analysis, Smartphones, Office buildings, Power grid

### INTRODUCTION

Smartphones are mobile phones with advanced features and a more powerful processing power. They are used as a medium of communication between entities by means of calls, SMS, social media platforms and chat messaging. Smartphones also run powerful apps that can be used for purposes for which a PC can be used for. They can be used for anything from writing a book to playing games up to organising political rallies. It is the computer in the hands of everybody. Most smartphones are charged in buildings. Buildings account for 30% of all the final energy consumed and 55% of global electricity demand [1]. Half of this energy is used for cooling purposes in tropical countries [2]. It is difficult to say what percentage of this remaining half that smartphones and the IT infrastructure contribute. Although, charging a smartphone does not use a lot of electrical energy, yet, it is deduced that the large user base of the smartphones means that the combined energy usage is considerable [3]. Since phones are generally charged in buildings, the increased power consumption from smartphones will have implications on the buildings' energy demand, energy cost and on the environment. While smartphones are useful, they also pose very unique energy challenges. As people keep spending more time with their smartphones and more phones are added to the market daily, it is imperative that we know how much power the smartphone is drawing from the grid. This is so that we can model energy demands and conservation strategies for the future around this information. Nigeria has a smartphone user base of 21 million people as of 2017, with the main concentration of users in the urban areas [4]. With the introduction of cheaper, fairly used smartphones and a desire to own a smartphone among a huge majority of people, this number is expected to rise.

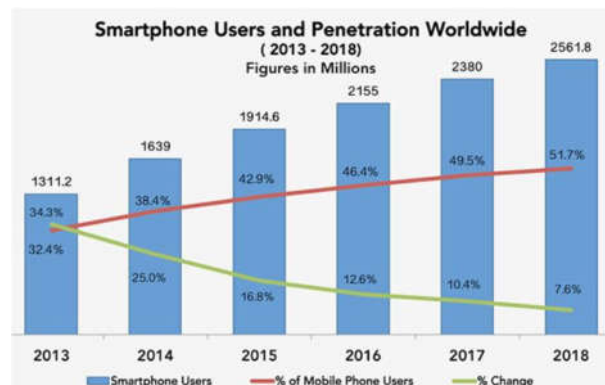


Fig.1. Worldwide active smartphone users Forecast 2013-2018 (source: eMarketer, Dazeinfo, Mahajan, Salmi)

## 1.1. Smartphone Power Consumption

Smartphone power consumption is usually measured through a variety of means. Most researchers follow one of three routes: using a hardware based measurement, which is the most accurate [5], running an energy profiling software or utilising an external measurement software running on a PC connected to the mobile phone usually called the device-under-test (DUT) [6]. These methods are then used to examine the power consumption of the different components of the smartphone entity. Power use was affected by the network, type of device, the application run on the system and the user [7]. With the user being the biggest factor [8] and the GSM module and display consuming the most energy [9].

On the other hand, since users charge their phones mostly from an AC-based wall chargers [10], the power of smartphones was computed using a slightly different method by Heikkinen and Nurminen [3]. Using the power of charger as a basis to compute the power of smartphones, they were able to assess the energy power and cost for a year. According to them, power consumption in a smartphone is influenced by three main factors: the usage pattern of the phone, the recharging behaviour of the phone user and the charger power utilisation in different states (recharging, idle, and no-load). The first two factors depends on the phone user while the third is entirely dependent on the type of charger. The charger connected to the grid may either be *recharging* a phone, in a *no-load* state i.e. connected to the grid but not charging a phone or in an *idle* state wherein the phone is fully charged and so draws power directly from the grid or is the battery allowed to drop so that charging can begin again.

## 1. METHODOLOGY

The hardware or, in this case, charger based measurement seemed appropriate for our study. In the first place, office spaces in Nigeria are very restrictive and there are usually security concerns with analysing IT gadgets. Furthermore, since our study involves the general cost that the smartphone charging incurs, it is fit that we analyse the energy gotten straight from the grid and not that which is consumed in running applications. Finally, this method is very straightforward and less intrusive.

For the purposes of this study, the power drawn from the charger should give us a fair view of the power consumed by the smartphones. On this account, our study uses a method similar to that employed by Heikkinen and Nurminen [3]. Power consumption was measured using charger specification and time of use. Only period when phone is plugged in was considered as the purpose of our study revolves around smartphones and their power intake.

### 1.1. The Building

Situated in the business area of Ikeja, the building, formerly called GM Motors is a 1220 sq. m. two story building. It is currently used by MDS Logistics, a logistics company which is one of the subsidiaries of the UAC Group. The lower floor is 400 sq.m while the middle floor is 520 sq.m and houses the majority of staff in the building. The highest floor houses the management and is 300 sq.m.



Fig.2. The office building

The building is powered by electricity from another company, UAC Dairies which ensures a constant supply of power 24/7, with an average downtime of 4 minutes every day. Due to this, the building runs no generator and subsequently makes no allowance for diesel costs. This is good for our research as the power cost is homogenous that is, electricity always costs the same regardless of the method the supplier is using. Moreover, the 24 hours supply eliminates the problem of shortage of supply.

The building houses 52 staff and around 20 support staff including security and cleaners. Since all of them use at least one smartphone, this brings total number of phones onsite to 72. Most workers arrive work between 7:30am to 8:30am with the greater number immediately plugging in their smartphones to the power supply. From the consumption pattern that was provided for the building, it averages a consumption of 1200kWh monthly with power cost at ₦2,083.33/kWh, which is 100 times the cost of electricity from the public grid which is around ₦20-40/kWh. This huge difference is attributed to the cost of running a diesel generating set for the constant power supply.

*Table 1. Power consumption pattern of building over a period of six months*

<b>Month</b>	<b>Power consumption (kWh)</b>	<b>Cost (₦)</b>
Nov-17	1,228	2,558,333
Dec-17	1,296	2,700,000
Jan-18	1,189	2,477,083
Feb-18	1,109	2,310,417
Mar-18	1,175	2,447,917
Apr-18	1,213	2,527,083

## 1.2. Data Collation

Data needed was gotten from two main means: first by requesting that employees fill a short survey online of their charging habits and secondly by observation and record taking.

The Assets and Services department which is responsible for managing the building provided us with information regarding power consumption of the building within a space of six months. The types of phone, charging hours, battery capacity were logged in for a period of six months. Survey was done by means of forms. Questionnaires were designed with the information needed in mind. Options were given to participants to choose from rather than using open ended questions to facilitate ease of answering questionnaires. Information requested on the survey were as followed:

1. Specification of charger: input and output voltage, current rating.
2. Phone specifics: battery capacity, time to get from 0% to full charge.
3. Charging time: number of hours of charge every working day.

Observations and interviews were also carried out to validate the results obtained from the survey.

## 1.3. Phones and Chargers

The smartphones in the building run the Android OS and the iPhone OS. The phones were classified according to charger specifications and usage time not according to manufacturer.

The charger specification groupings are listed below:

Table 2. Charger distribution

S/N	No of chargers	Output Voltage (V)	Current (A)	Power (W)
1	12	5	2	10
2	17	5	1.55	7.75
3	8	5	0.75	3.75
4	21	5	1	5

We had 58 chargers to 72 smartphones because some people did not own phone chargers and used the chargers of others to power their phones.

The phones surveyed is given by the table below:

Table 3. Phone distribution

Battery Capacity (mAh)	No of phones
<2000	17
2000 – 3000	22
3000 – 4000	27
>4000	6

#### 1.4. Mathematical Models

Data was collected over a period of six months.

The data was modelled mathematically as to give the following:

1. Power taken up by a charger is given by:

$E_{charger} = I \times V \times t$ , where E is the energy of the charger in which I is the rated current in Ampere, V the voltage in volts and t is the time in hours.

2. Power of the battery is given by:

$E_{battery} = \text{Battery capacity} \times \text{rated voltage}$ , with the battery capacity in mAh. This value gives the total energy that the battery will pull from zero to full charge.

3. Overall efficiency of charger to battery is given by the equation

$$\eta_{overall} = \frac{E_{battery}}{E_{grid}}$$

This is given by 14 % from research [11]. This means that only 14% of energy from the grid in a smartphone is converted to useful work. This was used in cases where the battery capacity was unknown.

4. Finally, the estimated cost was given by multiplying the power by the unit cost of electricity. This is given by the equation:

$$\text{Cost of Energy} = \sum E \times \text{unit cost of power (₦/kWh)}$$

Where E is the energy consumed in kWh. With unit cost of power given as: ₦2,083.33/kWh

## 2. RESULTS AND DISCUSSION

Power cost of smartphones compared to building electricity is given as between 2.45% to 2.53% of building electricity consumption for the period of the six months. With mean charging cost of around 3% of building monthly electricity cost. This shows that the smartphones presents a considerable energy sink. Thus, providing an opportunity for cost savings improvement.

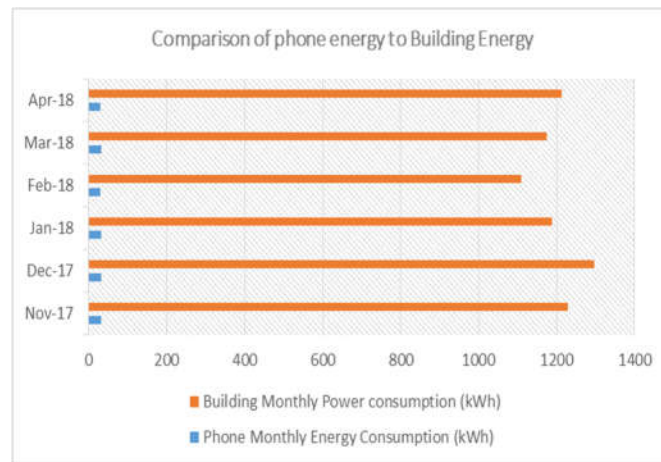


Fig.3. Phone power consumption compared to the building consumption over period of research

From the monthly power consumption as shown in Fig. 3. December has the largest use which may be explained by people working overtime to meet the annual target. February is the lowest on account of the lesser number of days in that month.

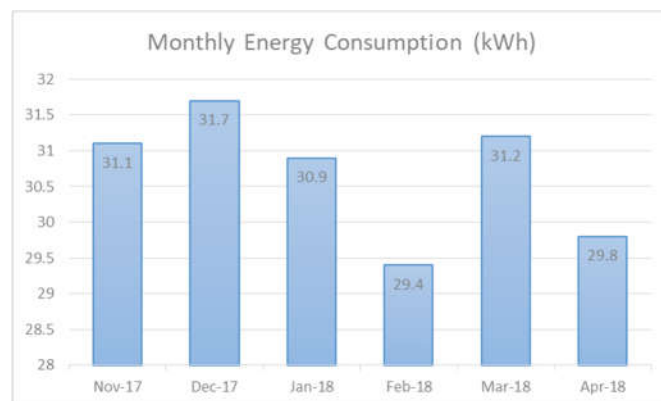


Fig.4. Typical daily consumption pattern

It was also discovered that the time of charging averaged 2h 30 minutes across the participants. Respondents also charged their phones in two parts: first time to boost it up to full charge and the second time to top it up with some others going up to three charging cycles. Another group of respondents, about 19% of the respondents did not have chargers and charged phones only once because they had to borrow chargers from their owners. In all, peak charging

period was between 8:30am to 10:00am, when people are arriving work and 2:30 to 4:00 as shown in Fig. 4., perhaps because they want to top up the battery before leaving work.

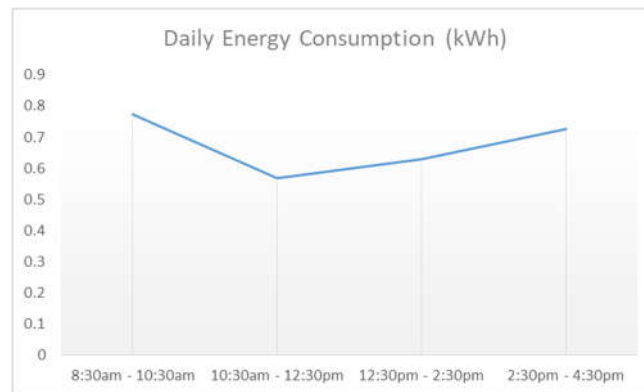


Fig.5. Typical daily consumption pattern

### 3. CONCLUSION

From the research, the charging of smartphones contribute 2.56% to the overall consumption and cost of building energy. This shows that smartphone charging cost is considerable enough to impact consumption and cost of a building. Peak charging time of 8:30am to 10:30am suggests an opportunity of efficiency improvements. Average monthly cost of charging phones in the building, given the building's cost of electricity of ₦2,083.33/kWh is ₦66,000 per month.

With this information, further research will need to be done in the areas of energy savings of smartphones in building management. These findings indicates room for potential studies to find out smartphone consumption in residential areas and for whole locales, especially urban areas. Our research has followed a simplified approach in reaching our conclusion. However, further research may go into analysing chargers to identify and eliminate losses in order to make them efficient.

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