

Research article

The Effects of the Introduction of Prepayment Meters on the Energy Usage Behaviour of Different Housing Consumer Groups in Kitwe, Zambia

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Abstract: This paper is based on research conducted in Kitwe, Zambia on the effects of the introduction of prepayment meters on the energy usage behaviour of domestic consumers in the Low, Medium and High Income categories. The research was motivated by the fact that there is very little information that exists on the subject not just in Zambia but world-wide. The paper has identified some key issue vis-a-viz: behavioral change as a result of the introduction of the prepayment meters, debt recovery and reduction of pilferage, disconnection of consumers and alternative energy sources and feedback. The data was collected in Kwacha (Low Income), Ndeke (Medium Income) and Parklands (High Income). This was both quantitative and qualitative data. Quantitative data was collected through structured questionnaires of which 151 were collected in total as follows: 59 (Kwacha); 50 (Ndeke) and 42 (Parklands). The qualitative data was collected through detailed interviews conducted with four households in each of the three household categories. The major findings are that there is general satisfaction from the households on the introduction of the prepayment meters citing control over expenditure and no disputes on bills as the main reasons. Many of the households also reported an improvement in their budgeting for electricity and there seems to have been a drop in the numbers of households with historical debt. Many households in Ndeke and Kwacha reported spending less on electricity after the introduction of the prepayment

meters which has been attributed to the fact that they are no longer on flat tariffs and also they are now able to conserve electricity as they are more conscious about expenditure on the same. Many households in Ndeke and Kwacha also reported being disconnected because they run out of credit due to lack of money. Rationing was also reported to be actively being used by households in Ndeke and Kwacha as a way of extending their credit in times when they do not have money to buy credit. Disconnections and rationing were not widely reported in Parklands as households there are not stressed with expenditure on electricity. This is because the people in Ndeke spend twice as much on electricity (as a proportion of their income) as do those in Parklands. The expenditure by households in Kwacha is even more so. Finally, the study has found that 21% of all the households have moved from using electricity for cooking to charcoal. This is likely to have some negative consequences for the environment as it might lead to deforestation. It is strongly recommended that a study be done on this subject to establish the true impact of this switch from electricity to charcoal by households.

Keywords: Prepayment meters; Electricity consumption; Housing; Kitwe; Consumer Behaviour; Energy Saving; Zambia

1. Introduction

While cities command a progressively dominant position in the global economy as centers of both production and consumption, this fast urban growth particularly in the developing world is outstripping the capacity of most cities and urban centers to supply adequate basic services such as water, shelter and electricity to the public [1]. With respect to electricity supply, deficit is commonly evidenced by a high rate of electric power outages, electricity thefts and use of wood fuel. In Zambia, urban households are the second largest consumers of energy produced from electricity, with the mine sector leading in the demand-side hierarchy. Notwithstanding, household energy consumption is mainly reliant on wood fuel which is consumed in the form of firewood or charcoal. At the national level, wood fuel accounts for over 70% of the total energy utilised by households [2]. While the Zambian government has historically supported the use of clean energy (as noted in various policy documents such as the Poverty Reduction Strategic Paper, Fifth and Sixth National Development Plans, and Vision 2030), the country has faced numerous challenges in the efficient and effective supply of electricity to urban households.

Electricity supply to different customer groups in Zambia is the mandate of the Zambia Electricity Supply Corporation (ZESCO). ZESCO was incorporated in 1969 and by law it is the sole agency that has been tasked by the government to generate, transmit, distribute and supply electricity. However, ZESCO has faced many demand-side and supply-side challenges which include:

- Electricity thefts resulting in unaccounted for losses on the part of the supplier;
- High expenses incurred through the provision of salaries and logistical support for meter-reading field staff;
- Late delivery of post-paid bills to households resulting in debt accruals on the part of households and constricted revenue collection on the part of the supplier;
- Arbitrary usage of electricity in households, and;

- Constrained customer relations in the event of erroneous billing and during disconnection and reconnection procedures [3,4]

These challenges prompted ZESCO in 2002 to pilot the technology of using prepayment meters in Emmasdale Township in Lusaka [3]. According to ZESCO the system has several advantages for the consumers as well, principal amongst which would be: no accrued debt, ability to control usage, ability to buy as little credit as K20.00¹, no reading of meters (which can be a disturbance to the households) and no monthly bills (which in some cases have been contested by consumers) (www.zesco.co.zm).

After the success of the pilot in Lusaka the system was rolled out to other parts of the country such as the Copperbelt Province towns and the city of Livingstone in Southern Province. This has been done in phases, thus, there are still parts of the country that have not been affected by this system. The system is not voluntary and all domestic consumers have been included in the installation from all the different income categories. In Kitwe the system was introduced in early 2010. It basically involves the replacement of the old meter with a new prepayment one which shows the consumer how much credit they have. The credit can be purchased from ZESCO outlets and from many vendors who have been licensed by ZESCO. The credit can also be bought through mobile money payment systems from mobile phone service providers and also from Banks which use technology to facilitate payment for different services. Once a payment is made the customer is given a receipt which has a 20 digit number that they input into the meter to show the credit they have. On a monthly basis there is a charge for Value Added Tax (VAT) at 16% and Excise duty at 10% as well a fixed rate for TV licence of K3.00 which goes to the National Broadcasting Services provider. Old or historical debt is recovered through deductions of 40% from each purchase that is done [3]. Different types of prepayment meters have been used by ZESCO in different townships but they all basically work on the principal of displaying the amount of credit a customer has and they disconnect when the credit runs out. The type that has been predominant in Kitwe is the one manufactured in Zambia by an Egyptian Company which is in partnership with ZESCO as well as from South Africa.

According to McKenzie [4] there is a dearth of research on prepayment meters worldwide because it has been viewed as being for low income groups. McKenzie (ibid) has argued that research in this field is important for policy dialogue. In the same vein, this research was motivated by the fact that since the introduction of the prepayment electricity meters no study has been done in Zambia to establish the effects of the new system and the response from the consumers. Although studies have been done in other parts of the world such as New Zealand, Canada, USA, UK and Australia very few studies have been done in Africa on this subject. It was thus, deemed important that research be done which will help understand the effects and response of consumers to the introduction of the prepayment meters in Zambia. There is unpublished work that has been done in Zambia by Chisanga [3]² which focused on the financial benefits accruing to ZESCO as a result of the introduction of prepayment meters.

¹ The exchange rate is US \$1.00 is equal to K6.20

² This work (which was in partial fulfilment of the requirements for an MBA degree at the Copperbelt University) was done in Lusaka's Emmasdale area (Medium Income) which was the pilot area for the prepayment system. The work was done in 2006 before the system was rolled out to the other parts of the country. Although the researcher conducted a survey of the consumers the main thrust of the work was to show the financial benefits to ZESCO of the new system.

This study looks at the effect of the introduction of the prepayment meters on the behavior of consumers in the City of Kitwe. Kitwe is the second largest City in Zambia and is one of the towns that have seen the installation of prepayment meters. It was chosen because the Copperbelt University, where most of the authors of this paper work, is based in Kitwe. Anecdotal evidence in Zambia has shown that one of the responses from the consumers to the introduction of the prepayment electricity meters has been the shift from using electrical appliances for some household activities such as cooking to the use of charcoal and firewood. Because of the negative effect on the environment that this will engender, this is one of the key issues that this paper will deal with. The current work studies the behavior of consumers from the different income categories, whereas many of the studies have concentrated on one income group. It is the hope of the researchers that this work will contribute to the better understanding of the issues around behavioral response to the introduction of prepayment meters and that should feed into the policy debate.

To facilitate better understanding of this paper, an overview of the remaining sections of the paper is provided here. Sections 1.1 to 1.5 covers some of the key issues on the subject such as the background to the prepayment meters and prepayment system, demand side management and supply side revenue generation. Section 2 deals with behavioural response of consumers to the introduction of prepayment meters covering issues such as energy conservation, use of alternative sources of energy and better budgeting, amongst others. In Section 3 the methodology is presented while section 4 gives the results and discussion thereof. The conclusion is presented in section 5 which is the final part of the paper.

1.1. Background to Electricity Prepayment Meters

According to Chisanga [3], electricity metering encompasses methods of installing and utilizing devices to measure the quantity and direction of electricity flow intended for consumption. By recording the electric energy units which a particular household has consumed, the utility company is able to determine how much the consumer should be charged by using established rates documented on the bill and made known to the consumer.

Unlike credit metering whose billing system is based on the electricity units (kilowatts) which have already been consumed by the consumer, the prepayment metering system requires the customer to pay for electricity before consuming, allowing electricity-users to consume energy only when they have credit in an electricity account because electricity “self-disconnects” when credit is exhausted [5].

Kettless [6] states that the prepayment system has been used in the United Kingdom (UK) for more than 80 years and that the system developed as a way of dealing with bad debts. In Africa, electricity prepayment meters were first introduced in South Africa in the 1980s to effectively extend electricity supply to rural low-income households [7]. Prior to the introduction of the prepayment meters, ESKOM, South Africa’s energy utility company had observed that servicing rural areas under the postpaid billing system implied high administrative costs. Furthermore, several service hiccups were noted such as the absence of postal addresses to which electricity bills could be sent; high illiteracy rates among low-income households resulting in their failure to fully comprehend the postpaid billing system [8] and inability to pay for electricity charges accumulating as a result of using the postpaid system [7]. Since then, the prepaid electricity billing system has spread to countries such as Argentina, Australia, Ghana, India, Kenya, Nigeria, the UK, Sierra Leone, Turkey

and several other countries across the world [9].

1.2. Mediating Tool Between Energy Suppliers and Consumers

It is argued that prepaid meters are technological tools which play the role of mediator between energy-producing agents and consumers. In some parts of the world, confrontations between electricity suppliers and consumers are not uncommon, as is evidenced by several documented cases in Kenya and other Asian countries. In Kenya, Miyogo et al. [8] observe that the sole energy service-provider has often sought security services in undertaking disconnections in urban slums. In retaliation, residents seek the help of criminal gangs to reconnect electricity supply after the utility company and security personnel leave. In such circumstances, prepayment meters reduce conflicts between service-provider and customer due to its unique anti-tampering design and other beneficial attributes for both the supplier and the customer. Furthermore, O'Sullivan et al. [10] note that the "mediating" role of the prepaid meter also "alters the moral landscape of payment and disconnection from an essential service." On one hand, energy supply corporations have in the recent past used household technology such as prepayment meters and smart meters to evade any social responsibility for increments in energy prices. On the other hand, households view the prepayment meters as a choice being offered by energy suppliers — choosing between immediate disconnection upon exhaustion of all electricity units and delayed disconnection whilst accruing debt [10]. However, the consumer's view of the prepayment meter as a moral choice is valid only if installation of prepaid meters in households is optional. As indicated above, in Zambia the prepayment meters are installed in all households without exception. It is also true to say in this case that the responsibility for disconnection has moved from the supplier to the consumer in the name of control. However, some studies have shown that many consumers are very happy with the switch from the post paid to the prepayment system, [4,10] citing ability to control usage of electricity as one of the main reasons. Dick [11] also reported that studies done by the regulators of the energy sector in the UK concluded that there was a very high level of satisfaction (about 90%) with the system amongst the consumers. Chisanga [3] reported 65% of the consumers indicated preference for the prepayment system as opposed to the post payment one.

1.3. Demand-Side Management of Energy

It is argued that the energy customer's ability to monitor the units of electricity being consumed gives one the opportunity to make adjustments which would ensure that available electricity units last longest. Due to the fact that most prepayment metering systems have an in-home display which gives regular feedback on the amount of energy being used, consumers are able to periodically monitor energy usage. As O'Sullivan et al. [10] rightly observe, previously abstract spending on energy services billed in arrears becomes visibly and tangibly connected to the electric appliances being used by householders, resulting in the reduction of unnecessary energy use. This is echoed by Tewari and Shah [8] in their statement that monitoring energy usage on prepaid meters enables one to economise on energy consumption through turning off high-power electrical appliances such as geysers (water heaters), lighting produced by filament-bulbs, stoves, heaters, pressing irons, and other electricity-based domestic appliances. They further observe that the control of energy use and budget management are correlated. The more one economises on energy consumption, the better they

manage their budget. Chisanga [3] showed that consumers on the prepayment system were paying less for electricity as compared to those on the old system because the tariffs on the new system were lower. In this particular case the bills were lower in part because of the lower tariffs.

However, other research such as one conducted by Brutscher [12,13] in Northern Ireland indicate that consumers with prepayment meters have an inclination to consume more electricity. This is because they have a tendency to purchase relatively small amounts of top-ups, and adjust to increases in tariffs by increasing the frequency of top-ups, rather than by increasing the amount.

1.4. Supply-Side Revenue Generation

Miyogo et al. [7] argue that in most countries where prepaid meters have been introduced, increases in revenue collection by the supplier have been noted. Notwithstanding, revenue generation has been dependent on the extent to which energy consumers exercise caution when using electricity. Additionally, revenue generation also depends on consistency of electricity supply to a given area, that is, presence or absence of lengthy load-shedding sessions [4].

The prepayment system also enables the utility company to redeem bad debts through the deduction of a proportion of the cost paid at every top-up of electricity towards the recovery of old debt. The customer is also accorded the opportunity to avoid the build-up of debt which would be the case in the post-paid billing system [8,10]. Some studies have shown that this debt can drop by as much as 80% within the first year of introduction of the prepayment system [3].

Additionally, some authors argue that installation of prepayment meters aligns electricity customers to the conventional electricity supply, hence preventing common forms of electricity thefts such as tinkering with electricity meters; making illicit connections which circumvent a meter so that household electricity consumption is undetected and; billing anomalies [14]. It has been noted that the incidence of illegal connections is higher in urban slums than other residential areas in cities [7].

1.5. Remedial Measure Against Fuel Poverty

Fuel poverty has typically been defined as “the inability of a household to afford adequate energy services, including heating to World Health Organisation (WHO) recommended temperatures, for a reasonable proportion of household income. The household income threshold used to define fuel poverty has most commonly been cited as 10% of household income expenditure...” [10]. In view of over 70% of Zambia’s total population which is described to be poor, it is expected that most households would find prepayment meters useful as they would engage in discretionary usage of electricity proportionate to the income available for energy expenditure.

However, O’Sullivan et al. [10] state that for those experiencing severe fuel poverty, prepayment metering does not provide relief when there is limited discretionary use of electricity and household budgets are constrained. In such cases, self-disconnections which occur when households completely exhaust electricity units available in prepayment meters (including emergency allowance of credit) are not as a result of choice, but are due to resource-deficiencies [4,14].

2. Behavioral Change with the Introduction of Prepaid Meters

2.1. *Energy Preservation*

The most common behavioral change noted in literature is that of energy preservation [4,8,10]. Users of prepaid meters are said to be more conscious of usage of electricity, often tying consumption to sustainability of electricity units available. According to a study undertaken in Ontario, Canada, 25% of the sampled electricity-users used about 20% less energy than they were using under the metering-and-billing system because the display segment of the prepayment meter made them aware of what they were using, which resulted in energy-saving adjustments [5]. Contrary to the energy preservation view held above, research undertaken by Quayson-Dadzie [9] in Ghana revealed that some prepayment meter users perceived prepayment meters to consume more units in comparison to traditional meters.

2.2. *Altered Quantities of Household Food Purchases*

A survey was undertaken to establish the relationship between prepayment meters and energy efficiency in Australia's indigenous households, mostly in the low-income category. It was observed that high rates of self-disconnections resulted in the households purchasing smaller quantities of food when need arises in order to avoid food spoilage in refrigerators [4]. This is because the disconnections would last long periods leading to the food in the fridge going bad.

2.3. *Elimination of Stress Associated with Bills*

Some prepayment meter users surveyed in New Zealand noted that they experienced less stress because of not having to deal with post-paid electricity bills. However, this was noted among households which were able to effectively budget for electricity consumption under the prepayment meter system [15]. Elsewhere studies have shown that consumers were happier with this prepayment system of payment than with the post paid system. The work done by Chisanga [3] indicated that 97% of the consumers indicated a preference for the new system, although the study did not deal with the question of why.

2.4. *Use of Alternative Energy Sources*

Although there is not much evidence of switching to alternative forms of energy in many studies, there is anecdotal evidence in Zambia that there is a shift from the use of electricity to either fuel wood or charcoal. In view of the already high rate of consumption of wood fuel among Zambian households this should be cause for concern because of the negative implications of such a switch on environmental sustainability due to destruction of forest reserves.

2.5. *Budgeting*

One of the main changes in behavior that has been reported in some studies [4] has been that consumers found it easier to budget under the prepayment system. Chisanga [3] also reported that 55%

of the consumers in Emmasdale in Lusaka, indicated that they found it easier to budget for electricity. Consumers are forced to budget for electricity every month because not doing so would result in them losing supply immediately.

3. Methodology

The research involved the use of both quantitative and qualitative data. This is because the nature of the information to be collected would be better understood by the use of both methodologies. Because the prepayment meters have been installed in all categories of housing it was important that the study covers all three major housing categories that are affected i.e. Low Income, Medium Income and High Income.

The quantitative data collection entailed the development of a questionnaire which covered the key aspects of the study i.e. budgeting, self-disconnection, behavioral response and feedback. The data was collected from Kwacha (Low Income), Ndeke (Medium Income) and Parklands (High Income). The type and nature of the housing categories does not vary much and all housing have been installed with Prepayment meters so it did not matter much which Townships (from respective categories) were included in the study. The households included in the study were selected by picking every 4th house in a street (the idea was to cover the entirety of each selected township). Each of the three categories was included in the study as this afforded the researchers an opportunity to establish whether there are any differences in response as a result of the different income status and lifestyle of the households.

The data collection was done by six researchers working in pairs which worked out to be one pair for each township/housing category. Only those who speak the local language (Bemba) were selected and these underwent training in the administration of the questionnaire. In total 151 questionnaires were administered — 59 in Kwacha, 50 in Ndeke and 42 in Parklands. These numbers were determined by the availability of the households as the data collection could only be done during the weekend as that is when the heads of households who were targeted were available. The numbers of households involved in the study in each category were considered to be sufficient to give a good indication of the general response of the households in that category. The data was collected in April 2014.

The qualitative data collection was done by the main author and involved conducting detailed interviews with selected households in each housing category. This was based on a detailed interview guide which was developed for this purpose and also included the four key issues identified above. Four Households were interviewed in each category and these were randomly selected. Thus, in total 12 households were included in the detailed interview.

4. Results and Discussion

The presentation of the results is largely across the different townships. This is because one of the key aims of the research was to identify any differences in the effects and behaviour across the housing categories. Thus, each table or graph is presented according to the responses from the different household income groups.

The results are categorised into four main groups. The first group is for the background data which gives a better understanding of the demographics and socio-economic characteristics of the

respondents in the three townships. The second group is for the information relating to prepayment metering in general with aspects of feedback. The third group deals with budgeting issues and includes aspects of expenditure as well as disconnections. The final group is the one that deals with the energy management by the households or what has been referred to as demand side management in the background discussion earlier.

4.1. Background of the Households

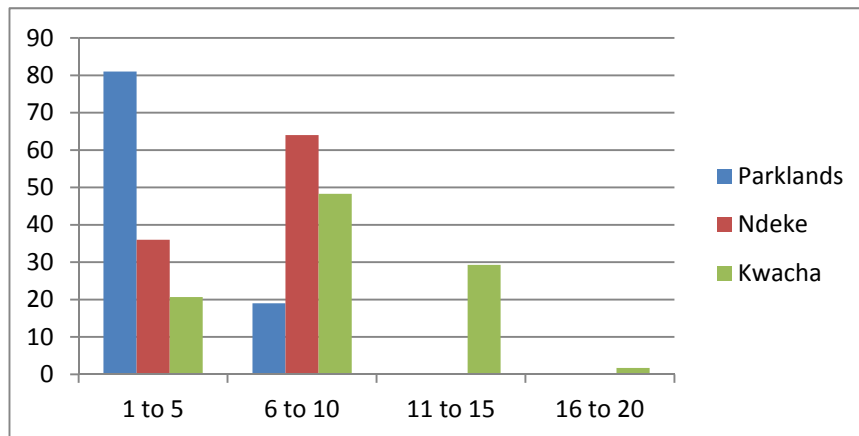


Figure 1. Total number of people in the household.

Figure 1 shows the distribution of population in the households across the three townships. The distribution of the people in the households is such that Parklands has a predominantly low numbers of people compared with Kwacha and Ndeke. In Parklands, 81% of the households reported having below five people in the household. In Kwacha on the other hand 48% of the households reported having people between six and 10 and 29% reported having people between 11 and 15 in the household. Neither Ndeke nor Parklands reported having households numbering more than 10 people.

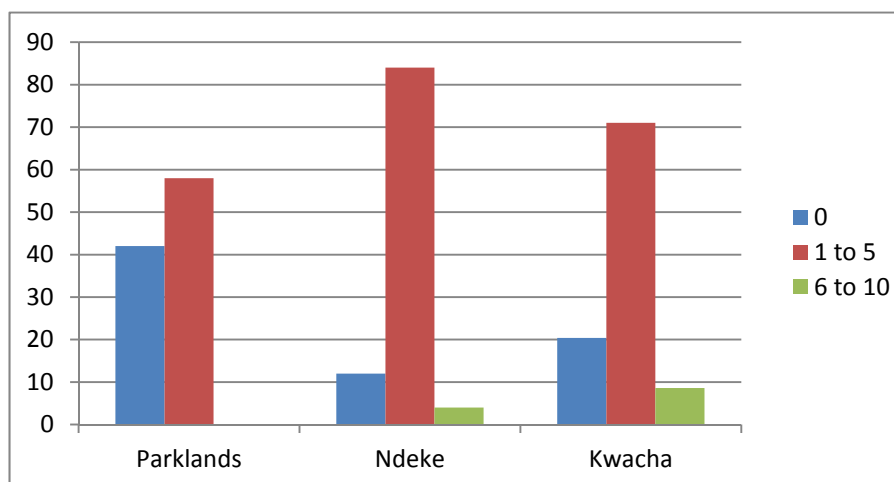


Figure 2. Number of people who stay at home.

It can be seen from Figure 2 above that Parklands reported the lowest number of people who stay at home with 42% of the sampled households in that township indicating that there is no one who stays at home during the day. Interestingly, although Ndeke has less people than Kwacha, Kwacha reported more households who do not have anyone staying at home during the day at 21% compared with Ndeke at 12%. However, almost 88% of the households in Ndeke reported that there is someone at home during the day with 84% indicating that there are between one to five people at home. These figures are higher than those reported in Kwacha at about 80% and 71% respectively. In Parklands most of the households has few people, many of who would be away from home either for work or school compared to the other two townships.

According to Table 1 below 74% of all the households sampled have monthly earnings below K5,000 with Kwacha making up the bulk of that number at 44%. Only 2% of the households reported earning above K20,000 and all of these were in Parklands. Of those who reported earning below K1,500, 71% were in Kwacha. Of those who reported earning between K5,100 and K10,000, 56% were in Ndeke while 83% of those who reported earning between K10,000 and K20,000 were households in Parklands.

Table 1. Monthly Income.

Income category (Kwacha ³)	% within income category			Total for income category
	Parklands	Ndeke	Kwacha	
Below 1,500	6%	24%	71%	27%
1,500 to 5,000	0.0%	47%	53%	47%
5,100 to 10,000	36%	56%	8%	20%
10,100 to 20,000	83%	0%	17%	5%
above 20,000	100%	0%	0%	2%

Thus, Kwacha had the majority of Low Income earners and the highest number of people who live in the Households. This is consistent with the results of other studies done earlier in low medium and high income areas of the Copperbelt Province. Refer to Malama et al. [16].

4.2. Prepayment Metering in General

The households were also asked a number of questions that related to the prepayment meters in general and also the availability of electricity credit.

All the households that were interviewed expressed satisfaction that they were on the prepayment system. This was true for all the three townships. The main reasons advanced were varied. Some indicated that the installation of meters has given them control over the amount of money they are spending on electricity. Others indicated that there is predictability over the amounts that they are spending as opposed to before when sometimes they were shocked by the bills that came from ZESCO at the end of the month. One respondent indicated *“before the meters were*

³ The name of the Zambian currency is Kwacha (K), but Kwacha is also the name of the Low Income Township. The two should not be confused.

installed, we used to live in fear of ZESCO now we are in control” and another said that *“we used to have fake bills from ZESCO”*. Yet others reported that it helps them budget for electricity now as opposed to before when they would have to wait for the bill to come from ZESCO, indicating *the system now means that you have to have the money before you can consume electricity*. Reduction in misuse or unnecessary wastage of electricity was also cited as a positive effect of the introduction of prepayment meters. One respondent said *“the impact of misuse is real and immediate”* because one can see the electricity units on the meter decrease. Another reason advanced was that some households are now better educated about the general usage of electricity in the household. One respondent told the interviewer that: *“It (introduction of prepayment meters) has been very educative because the previous system never gave you a chance to know the units (of electricity) you are consuming, now you know”*.

The results are consistent with what has been reported elsewhere see for instance O’Sullivan et al. [10] and McKenzie [4].

The households were also asked about their views on the prepayment meters. Table 2 below shows the responses for the question: Do you have any problems with your prepayment meter? Of the 6% that indicated dissatisfaction 3% were in Ndeke (this constitutes 10% of all the respondents in Ndeke). This means that the majority of the respondents (94%) indicated satisfaction with the prepayment meters they have. The reason is that some of the households in Ndeke are visited by ZESCO to check on the way the meters are working but ZESCO does not tell the households why they are checking on the meters which makes the households suspicious that ZESCO is tampering with the meters which results in the meters consuming electricity quicker. One lady reported that *“sometimes people come from ZESCO to check the meters but they don’t tell us what they are looking for. After they leave the meters consume electricity faster”*.

Table 2. Issues with the meter and availability of credit.

	% within Township			Total under each issue
	Parklands	Ndeke	Kwacha	
Those experiencing problems with the prepayment meter	5%	10%	3%	6%
Availability of electricity credit	98%	69%	47%	68%
Satisfaction with information on the prepayment meter	100%	94%	84%	92%

Another problem that has been highlighted in some studies is that some households face problems in accessing electricity credit to recharge their meters [3,4,15]. Table 2 also shows that the positive responses to the question “Are the electricity units readily available,” are quite varied across the three townships. In Parklands 98% of the respondents indicated that credit was readily available. The figure for Ndeke was 69% while that of Kwacha was 47%. Most people in Parklands have vehicles so that they can drive to the ZESCO offices in town and also other places where credit is sold. So to them, distance is not a problem. This would be a problem in Kwacha where many households do not have vehicles. Chisanga [3] reported that most of the households who took part in his study indicated that they were unable to buy credit on Sundays (93%) or during public holidays (100%). This means that there has been an improvement in availability since then. This is to be expected as the system had just been introduced and many of the problems being encountered then had not been resolved.

There is an additional problem though which was also reported by O’Sullivan [15]. This is regarding the electricity units purchasing system as some interviewees reported that sometime when they go to the shop where credit is sold, the system would be off making it difficult to access the credit when they want it. This was more widespread in Ndeke but was also reported in Kwacha.

Respondents were asked about their satisfaction with the information that is displayed on the prepayment meter. This is because elsewhere, studies [10] have shown that households prefer to have more information on their meters which would be helpful in managing their energy consumption. The results show that the majority (92%) of the respondents were happy with the information on the meter (see Table 2).

Many pieces of literature have shown evidence that feedback is an effective tool for assisting households in the management of their energy consumption [4,17,18] and [19]. McKenzie [4] identifies two types of such feedback i.e. direct through devices such as the prepayment meters and through information provided to the consumer after energy has been consumed.

Respondents were asked if they would like to see additional information on the meter that would help them make better decisions about how they consume energy. The results in Table 3 below show that respondents were generally happy with the information on the meter: 63% in Parklands, 83% in Ndeke and 67% in Kwacha said they did not need any additional information on the meter. However, 26% of the respondents in Parklands indicated that they would like to see more information on the meter in terms of the consumption of each appliance. If such information is given to the consumer they would be better placed to make informed decisions about what appliances to switch off at different times to reduce on their energy consumption (see also Table 14 below on how decisions are made on what appliances to stop using). In Kwacha, 20% of the respondents reported that they would like to have a buzzer on the meters which alerts them when they are running low on electricity units. Studies have shown that in the USA annual energy savings as a result of direct feedback can be as high as 9–12% [4]. It means that there are opportunities in Zambia for energy savings if meters that show consumption of different appliances were introduced.

Table 3. What additional information do you need to see on the meter?

	% within Township			Total under each option
	Parklands	Ndeke	Kwacha	
Consumption of each appliance	26%	4%	14%	13%
Buzzer	11%	12%	20%	15%
None	63%	83%	67%	72%

4.3. Budgeting and Expenditure

As indicated above, one of the key reasons why ZESCO introduced the prepayment system was because many consumers had accumulated debts which were threatening the survival of the company. The prepayment system ensured that households only consumed the amount of electricity which they could afford. Thus, they could not incur any more debt. As indicated above ZESCO also introduced a system of clearing the historical debt by deducting an amount equal to 40% from each purchase for those households who owed ZESCO a debt.

This section looks at how widespread the problem of debt still is and whether there has been an

improvement. It also looks at the expenditure of households on electricity. Electricity is just one of the many items that households have to spend money on. How much they spend on it will depend not only on the income of the household, availability of alternative sources of energy but also on the importance attached to it by the households. The households were asked how important electricity is in their daily activities and their response is according to Table 4 below.

Eighty six percent of the respondents in Parklands indicated that electricity is either very important or extremely important. The figure for Ndeke was not very different but Kwacha was lower at 68%. This indicates that electricity is taken to be very important in the Medium and High Income households in comparison with the Low Income ones. This is because the lifestyles in the High and Medium Income Households i.e. of watching TV, playing music, listening to the radio, using cookers, microwaves, computers, games consoles etc., means that they see electricity as being very crucial for the maintenance of that lifestyle. In Low income households on the other hand this is not the case and most of the time is spent out of doors (in High and Medium Income households most time is spent indoors). Furthermore, the presence of alternatives such as charcoal (see also Table 15 below) means that it is possible to dispense with electricity in the Low income areas.

Table 4. How important is electricity in your daily activities?

	% within Township			Total under each option
	Parklands	Ndeke	Kwacha	
Not Important	2%	8%	3%	5%
Slightly Important	2%	0%	2%	1%
Important	10%	12%	28%	17%
Very Important	31%	56%	66%	53%
Extremely Important	55%	24%	2%	24%

During the detailed interviews a number of respondents indicated that previously they had problems with payment of bills from ZESCO. As indicated above, in some cases this led to disputes and some household ended up in debt. When asked about whether they still have historical debt only 9% of all the households indicated that they have some debt with ZESCO (see Table 5). The highest number of those with historical debt was in Kwacha at 14% of the households. This is where the problem of debt was quite widespread. It would appear therefore that ZESCO has met their objective of reducing the debt it is owed by its customers. This is in line with what was reported by Chisanga [3] that the debt owed by consumers in Emmasdale dropped by 80% within the first year of introduction of prepayment meters.

One respondent in Ndeke complained that ZESCO was taking 50% of credit he was buying to cover for the historical debt that he was not even responsible for. He said that he buys credit worth K400 and ZESCO takes K200. The respondent could not produce documentary evidence that indeed he was paying 50% but this is not far from the 40% that ZESCO has indicated will go towards debt servicing for those who have debt. According to the system ZESCO uses, those living in the house where the historical debt was incurred are held responsible for that debt. This has resulted in many cases where households are servicing debts that they did not incur. This system is unfair but ZESCO argues that it is expensive for them to trace customers after they have moved house. There is need to have some serious policy discussion on this issue as the system punishes the innocent.

When asked about whether the introduction of prepayment meters has resulted in savings by the households on expenditure on electricity, 100% of the households in Kwacha said yes and 81% in Ndeke. (see Table 5). However, the figure for Parklands was much lower at 65%. During the interviews some households in Kwacha and Ndeke said that previously they had been placed on the flat tariff system and were paying K150 and K250 respectively. This had no connection with what they were consuming. However, after the introduction of the meters it has turned out that the actual consumption is lower than the tariffs they were placed on which has resulted in savings. As indicated above Chisanga [3] also notes that there are savings to be made as a result of moving from the post payment to the prepayment as a result of lower tariffs being charged on the prepayment system.

Table 5. Historical debt, Expenditure and Budgeting.

	% within Township			Total under each issue
	Parklands	Ndeke	Kwacha	
Have historical debt	10%	4%	14%	9%
Spend less than before	65%	81%	100%	84%
Budget better than before	82%	95%	100%	93%

Furthermore, because they are in control of what they spend it would appear that they are more careful about how much they consume which would result in a drop in their energy consumption as well as expenditure on electricity. Many of the households in Kwacha and Ndeke indicated that they switch to charcoal when cooking foods that take longer to cook such as dried Beans and Fish. One interviewee in Kwacha remarked “*we are now more conscious about how we use electricity compared to before*”. For Parklands on the other hand, the opposite has been the case, those who were paying less during the billing system now have to pay according to what they consume and in a number of households this is more than before. This is because for households who are on a fixed tariff could use much more electricity than they paid for. This was because ZESCO was unable to read their meters because they were defective or not present. Households in Parklands are less likely to worry about how much they are consuming because they can afford to pay more for electricity as compared to the households in the other two townships, therefore the fact that they now have prepayment meters is unlikely to make them consume less than before.

During the detailed interview, it was very clear that many households are quite happy with the new system as it gives them more control (as reported above). An offshoot of this is that they are better placed now to budget for electricity because they have the control and can decide how much to spend on electricity and as remarked by one interviewee: “*we are now better able to live within our means compared to before*”. Table 5 above, also shows that 100% of the households in Kwacha indicated that they budget better for electricity now than before. The corresponding figure for Ndeke was 95% and 82% for Parklands. It shows that all round the introduction of the prepayment meters has had a positive effect on budgeting for electricity.

Better capability to budget for electricity was cited (in the detailed interview) as one of the major benefits of the new system with one respondent saying “*before, we never used to budget but now we have to, because we have to have the money to consume the power*”.

Table 6 below shows the households’ monthly expenditure on electricity. In Kwacha, 36% of the households reported that they spend K100 and below. In both Parklands and Ndeke only 10% of

the respondents reported spending less than K100. For Parklands that is a small amount and such households would be for a single person or just two people. Of all the respondents in Kwacha 95% reported that they spend K200 or below on electricity. For Ndeke the figure is 84%. This means that most of the households in these two categories spend less than K200 on Electricity. In Parklands on the other hand 46% reported spending between K301 and K500. Interestingly, 43% of the respondents in Parklands reported spending below K200.

Table 6. Monthly Expenditure on Electricity.

Kwacha	% within Township		
	Parklands	Ndeke	Kwacha
1–100	10%	10%	36%
101–150	12%	37%	38%
151–200	21%	37%	21%
201–250	12%	4%	2%
251–300	0%	2%	0%
301–350	29%	4%	2%
351–400	10%	6%	0%
401–450	5%	0%	2%
451–500	2%	0%	0%

Table 7 below shows the average monthly expenditure. The households in Parklands spend K244 on average while those in Ndeke and Kwacha spend K166 and K118 respectively. This means that households in Parklands spend almost 50% more on electricity than those in Ndeke while those in Ndeke spend 60% more than those in Kwacha. The difference between Parklands and Kwacha was almost 140%.

Table 7 also shows the proportion of the income that is spent on electricity. It can be seen from the table that the households of Parklands spend about 2% of their income on electricity which is the lowest of the three income categories. The households in Kwacha spend over twice as much (proportionwise) on electricity as those in parklands do. This means that consumers in Kwacha and Ndeke are more likely to worry about their electricity consumption than those in Parklands.

Table 7. Average Monthly expenditure on Electricity against Average Income.

	Parklands	Ndeke	Kwacha
Average Expenditure (K)	K244	K166	K118
Average Income	K10,261	K4,070	K2,567
Proportion of expenditure on electricity	2%	4%	5%

The respondents were asked to rate the main items they spend money on in a month from the following list: Electricity, Food, clothes, Water and School Fees. A rating of 1st being the item they spend the most money on while 5th was the items they spend the least amount on. Table 8 below shows the voting patterns for expenditure in relation to electricity in comparison with the other items of expenditure. About 41% of all the respondents indicated that electricity is their 3rd major item of expenditure. However, in Kwacha over a third of the respondents indicated that it is their major item

of expenditure. In Kwacha, 97% of the households reported that electricity was their 1st, 2nd and 3rd major item of expenditure. The corresponding number for Parklands was 71% and 52% for Ndeke. Overall the picture points to the fact that although electricity is not the major item of expenditure in many households it is a major item of expenditure for many households across the three income categories.

Table 9 shows the number of times a month households buy electricity credit. Overall 62% of the respondents buy electricity credit once a month while 24% does so twice a month. This means that 86% of all the respondents buy units either once or twice a month. 72% of the respondents in Kwacha buy their credit once a month, while for Parklands that was only 43%. More households in Parklands buy credit twice in comparison with either Ndeke or Kwacha. In Parklands, 10% of the households buy credit four times a month. It appears that there is better budgeting for electricity in Kwacha than in Parklands and certainly more careful usage as the households in Kwacha make sure that the credit they have run the course of the month. Households in Kwacha and Ndeke also use other means to stretch their credit to last longer such as reducing on the use of some appliances e.g. Cookers. In the detailed interviews, the number of times a household buys credit in a month did not seem to be as much of a problem as the availability of credit. The consumers are not so worried about how many times they buy the credit as long as it is available each time they go to buy.

Table 8. How do you rate your expenditure on Electricity in relation to other items?

	% within Township			Total under each option
	Parklands	Ndeke	Kwacha	
1 st	5%	2%	36%	16%
2 nd	14%	7%	29%	19%
3 rd	52%	43%	32%	41%
4 th	24%	30%	4%	18%
5 th	5%	13%	0%	6%

Table 9. How many times in a month do you buy electricity credit?

	% within township			Total under each option
	Parklands	Ndeke	Kwacha	
Once	44%	66%	72%	62%
Twice	37%	26%	12%	24%
Three Times	10%	8%	10%	10%
Four Times	10%	0%	5%	5%

4.4. Energy Management (Demand side management)

This section deals with the way households have responded to the installation of prepayment meters. The issues covered here are disconnections, which activities have been stopped or reduced, rationing of the electricity units and switching to alternative energy sources for those who have reduced or stopped using electricity for some activities. The issues covered here are key to understanding the impact of the introduction of prepayment meters and have been covered in some

studies such as O’Sullivan [15] and McKenzie [4].

The terminology used in literature for those who run out of credit and are disconnected from the electricity system is self disconnection. It has been used in many studies e.g. O’Sullivan [15], McKenzie [4] and Brutscher [12]. In this study those who reported being disconnected expressed considerable stress that it had happened to them. Unlike in other studies where there is an option of getting emergency credit from the power company (as reported in McKenzie [4]) in Zambia that system does not exist and those who run out of credit are cutoff from supply.

Table 10. Rationing and Running out of credit.

	% within Township			Total under each issue
	Parklands	Ndeke	Kwacha	
Those who ration electricity	50%	89%	100%	82%
Those who run out of credit	17%	49%	45%	38%

Table 10 above shows the response from the households to the question “do you have to ration electricity sometimes?”. In Kwacha Township, 100% of the respondents indicated that they do ration electricity sometimes. In Ndeke the figure was also very high at 89%. However, in Parklands this was 50% of the respondents. In total 82% of the respondents indicated that they ration electricity. This is a high number and indicates that the households are aware of the need to conserve electricity which is good for demand management by the energy supplier. However, it is also true to say that in Parklands there is indifference to energy saving because generally they can afford to pay for the electricity through the month even though they have to buy credit several times (see Table 11 below). In Kwacha on the other hand there is constant pressure on expenditure for electricity which means that rationing becomes an important strategy to stretch the credit.

The respondents were also asked if they ever ran out of electricity credit and the responses are as indicated in Table 10. From all the respondents, 38% indicated that they do run out of credit and get disconnected. This is a rather high number. Ndeke reported the highest number of households who get disconnected at 49%. Kwacha was also high at 45%. However, Parklands was quite low at 17% of the respondents in that township.

It is worth noting that many of those who reported being disconnected were not disconnected for a long time. In many cases this happens for only a few hours until they buy the next credit. One household told the interviewer that “*although we run out of credit when we forget to buy we have never really had to stay without power for a long time*”. Only one interviewee reported going without power for two to three days sometimes. Because it is possible to buy credit for as low as K20 which can keep the household going until they have money to buy enough units to last them until the next month. The K20 can even be borrowed from the neighbor to be returned at a later date. One respondent wondered why ZESCO cannot introduce a system where credit can be transferred between meters much like can be done for mobile phone credit. This would enable households to borrow credit from neighbours or friends to see them through the lean times. This was in Kwacha where the communal spirit is vibrant and people depend on each other during times of hardship.

The respondents were also asked how many times they run out of units and their responses are as shown in Table 11 below. In Kwacha, 57% of the households reported running out of units on a weekly basis. In Parklands the number was also high at 50% with Ndeke having the lowest number

at 36%. It appears higher expenditure in Parklands has resulted in households running out of units more frequently than in Ndeke. This is however, not a sign that the households in Parklands are struggling to pay for electricity.

Table 12 below shows the responses to the question, why did you run out of credit? This is an important question because it gives an explanation to why households run out of credit. It can be seen from the table that none of the respondents in Parklands who reported running out of credit did so because they did not have money. The majority (86%) of those who run out credit in Parklands did so because they forgot to buy it. In Kwacha however, 96% of those who reported running out of credit did so because they had no money to buy credit. This constituted 68% of the total number of households who reported running out of credit. Quite clearly the households of Kwacha are struggling to keep up with the purchasing of credit. Interestingly, none of the households interviewed complained about the price of electricity and cited misuse of electricity as the main reason for running out of credit.

Of those who do not run out of credit one household remarked, *“No, we don’t run out of credit because we budget for electricity”*. In Ndeke 46% of the households who reported running out of credit did so because they had no money. “Other” refers to reasons other than forgetting or running out of money. Some of these reasons were cited as lack of clarity regarding who had the responsibility for buying the units. This was reported in households where there were many adults and each one is supposed to buy credit from time to time but when it is their turn they neglected to buy.

Table 11. How many times do you run out of credit?

	% within Township			Total Under each option
	Parklands	Ndeke	Kwacha	
Weekly	50%	36%	57%	46%
Monthly	0%	52%	38%	39%
6 monthly	50%	12%	5%	15%

Table 12. Why do you run out of Electricity credit?

	% within Township			Total under each option
	Parklands	Ndeke	Kwacha	
Forgot	88%	46%	0%	32%
No money	0%	46%	96%	61%
Other	12%	8%	4%	7%

Studies have shown that households who are struggling to buy electricity credit use some strategies to make the credit they have last longer so that they get more out of the credit than they otherwise would. Some such strategy is to ration the credit they have (as discussed under Table 10 above). This happens by turning off some appliances or being diligent with the way electricity is used. In this study some households reported that they stop using the cooker for cooking food which

takes long to cook such as dried beans and dried fish. Others limit the use of the Pressing Iron⁴. They switch to charcoal. Yet others reported that they make sure that lights are switched off in rooms that are not being used. One respondent in Ndeke reported that they stop using all appliances when they really need to ration and only use credit for lights. She said “*we actually don't run out of units because we can buy for as low as K20 and use it for lights only*”.

4.5. Discontinuation of the use of some appliances and switch to alternative energy sources

In the forgoing discussion the response from the households was to limit the use of some appliances e.g. cookers and pressing iron but not to completely stop. There are however, households whose response has been to completely stop using some appliances such as the Cooker and Pressing Iron. One household in Ndeke reported that they have stopped Baking and boiling water for bathing after the introduction of prepayment meters⁵. For these households, the alternative to electricity is charcoal and some of the households reported that they now regularly buy charcoal for cooking which was not the case before. Table 13 below, shows that 35% of the households in Kwacha have stopped using some appliances (specifically the Cooker) after the introduction of the prepayment meters. The figures for Parklands and Ndeke were much lower at about 12% but are still a sizeable number. Overall 21% of the population has moved from using electricity to the use of charcoal which has some serious negative impact on the environment (see also Table 15 below). It needs to be noted here that almost all the Electricity generated in Zambia is Hydro with very little being generated through diesel generators (used in remote areas not connected to the national grid) and none so far through coal.

Table 13. Have you stopped using some appliances after the installation of prepayment Meters?

	% within Township			Total
	Parklands	Ndeke	Kwacha	
Yes	12%	12%	34%	21%
No	88%	87.8%	66%	79%

The respondents were also asked about how they decided which activities or appliance to stop using. All the respondents in Ndeke and 63% in Kwacha indicated that it is through information that they got from friends (see Table 14). This is important because it is Kwacha where most of the households reported switching from electricity to charcoal and it would appear that that decision was made through informal interactions with friends and ZESCO had no role to play in it. There is very little information on consumption of appliances flowing from ZESCO to the households. Only 3% of the total number of households who took part in the study indicated that they get information from

⁴ Cookers and Pressing Irons are the two appliances perceived to be consuming a lot of electricity

⁵ Although Ndeke is a middle income Township none of the houses had Geysers installed. This means that those households who have not had Geysers installed afterwards are forced to boil water for bathing.

ZESCO. For ZESCO there is case to be made for improving the way consumers are educated as from these results there is an information vacuum which makes consumers use information (which they get informally) for decision making. This information is not always correct.

Of those who reported moving from electricity to other forms of energy as a result of the introduction of prepayment meters, 97% indicated that they moved to charcoal (see Table 15 below). The disaggregated figures for Parklands and Ndeke were 100% and 96% for Kwacha. 4% of the population reported moving to firewood which is very rarely used in urban areas. Charcoal is the easiest alternative to move to as it is readily available at the market or by hawkers who sell it from their bicycles in sacks of 20 kg and 50 kg. Firewood is not very widely used and Gas is very rarely used although the government is now promoting the use Liquefied Petroleum Gas (LPG).

Table 14. How do you decide which activity to stop?

	% within township			Total under each option
	Parklands	Ndeke	Kwacha	
Guesswork	33%	0%	0%	3%
Reading meter	67%	0%	26%	23%
Elimination process	0%	0%	5%	3%
Information from friends	0%	100%	63%	67%
Information from Zesco	0%	0%	5%	3%

Table 15. What alternative sources of Energy do you use after moving from electricity?

	% within township			Total under each alternative
	Parklands	Ndeke	Kwacha	
Charcoal	100	100%	96%	97%
Firewood	0%	0%	4%	3%

As indicated above the shift from electricity to charcoal and firewood has some very serious environmental implications because these come from trees that are cut indiscriminately. There is need to do a detailed study on the impact on the environment of the shift of 21% of the population from using electricity for cooking. Although the objective by ZESCO was to reduce the debt they were owed by the consumers and from this study that seems to have been met, there seems to be an unintended serious consequence which is the shift to the use of charcoal and the negative implications that has on the environment.

5. Conclusion

This research was aimed at making a contribution to a better understanding of the effects of the introduction of prepayment meters on the behaviour of households in Kitwe. This is because there is a dearth of information on this subject in many parts of the world and certainly in Africa. We argued that a better understanding of this subject is important for policy discussion. Certainly in this case, being a new introduction there is need to have policy discussion based on evidence from the field.

The paper has identified some key issues in this regard and these are: behavioral change as a result of the introduction of the prepayment meters, debt recovery and reduction of pilferage, disconnection of consumers and alternative energy sources and feedback.

Data was collected from three household categories that are affected i.e. High Income (Parklands), Medium Income (Ndeke) and Low Income (Kwacha). This was done through both the quantitative and qualitative methods. The results show that there is general satisfaction with the introduction of prepayment meters right across the three townships. The households indicated that the new system gives them more control over the energy usage and also they no longer have problems with bills which sometimes they were forced to dispute. The respondents also indicated satisfaction with the information on the prepayment meter although some said that they would like to see information on the consumption of different appliances and others said they would like to have a buzzer on the meter that alerts them when the credit is about to run out. An interesting suggestion made was that ZESCO should consider introducing a system which would enable the transfer of credit between meters.

There was general agreement also that the introduction of prepayment meters has led to an improvement in the budgeting and many households reported that they ration credit when it is low. However, the results also show that the households in Kwacha spend over twice as much on electricity (as a proportion of their income) as do those in Parklands. Of all the households, 38% reported running out of electricity credit and being disconnected. This problem was predominant in Kwacha and Ndeke and not so much in Parklands. In Ndeke and Kwacha the main reason given for running out of credit was lack of money to buy credit whereas in Parklands it was that they forgot to buy credit.

The number of households who reported having historical debt was low at 10% which would confirm the result from earlier work done in Zambia which reported that there has been a drop in the number of households who have debt with ZESCO. This was a major problem for ZESCO before. Many households also reported that they spend less on electricity after the introduction of prepayment meters compared to before. This was mostly in Ndeke and Kwacha where previously many of them would have been paying a flat tariff and were paying for electricity that they were not consuming. It has also been argued that because of the introduction of prepayment meters the households have reduced their consumption which could also explain this change. This is however, not the case in Parklands where expenditure has gone up which has been attributed to the fact that the people there are less stressed about expenditure on electricity as they spend a low proportion of their income on it so they are unlikely to change their lifestyles in any significant way because of the introduction of the prepayment meters.

Finally, 21% of all the respondents reported that they stopped using electricity for cooking and moved to Charcoal and firewood. This group has to be differentiated from those that have only limited the use of the appliances such as the Cooker and Pressing Iron (the two appliances deemed to consume a lot of electricity). It has been argued that this could have serious implications for the environment and is an unintended consequence of the introduction of prepayment meters which needs to be further investigated as this could lead to deforestation. Finally, and related to the above point, most respondents indicated that they base their decision making about which appliances to stop using on information from informal sources. This raises serious policy questions on the way the authorities communicate with consumers of electricity on energy efficiency.

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Conflict of Interest

The authors declare that there are no conflicts of interest related to this study.

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