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Rationing of Electricity in Maputo City Residences through Education and Awareness Actions

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ABSTRACT

The level of rational use of electricity consumption by households in Mozambique is very low. This paper assesses whether, with the implementation of education and awareness actions through the door-to-door method, is possible to change the consumption habits and rationalize residential electricity consumption in Maputo city, Mozambique. The data was collected through questionnaires, observations, and interviews related to the habits of electricity consumption, the use of electrical equipment, and consumption of household appliances. This was followed by awareness creation on the use of electricity. The results show that after the campaign, the level of knowledge of the measures of rational use of electricity by consumers was increased by 55.3%, the level of adoption of the measures learned was increased by 30.5% and the monthly household consumption was decreased by 16.8%. Household consumption depends on the electrical equipment, and replacement of at least one 60W incandescent lamp in each residence with a 15W fluorescent lamp could bring a significant reduction in energy consumption. For example, the annual consumption of each family can be reduced by 94KWh and 23GWh in the entire City. The low level of rational use of electricity in Maputo city is due to lack of knowledge of the measures and little adoption of the known measures, use of inefficient equipment, low availability of the efficient equipment in the local markets, high cost of efficient technologies, and houses that offer few opportunities for rationing.

Keywords: Rationing, Electricity consumers, Habits, Awareness, Maputo, Mozambique.

1. INTRODUCTION

The Mozambican domestic sector is responsible for the consumption of 48% (448.7 GWh/year) of available electricity and consumed as if was an inexhaustible resource. And with the annual increase in the number of consumers, the industrial revolution and the increase in electrical equipment in homes, influenced by the exponential increase in the number and the improvement in the living conditions of the population, in recent years there has been a scarcity of electricity, making necessary to remedy current consumer behavior.

With regard to the history of electricity demand in Mozambique, should be noted that, in 2015, the peak in the system managed by EDM (Electricidade de Moçambique, the Mozambique's State-owned Power Utility) was 875 MW, compared to 831 MW in 2014 (Fig 1). This accounts

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for an increase of 5.3%, after an average annual growth of 11.6%, in the previous five years and considerable growth is also expected in the future (ALER, 2017).

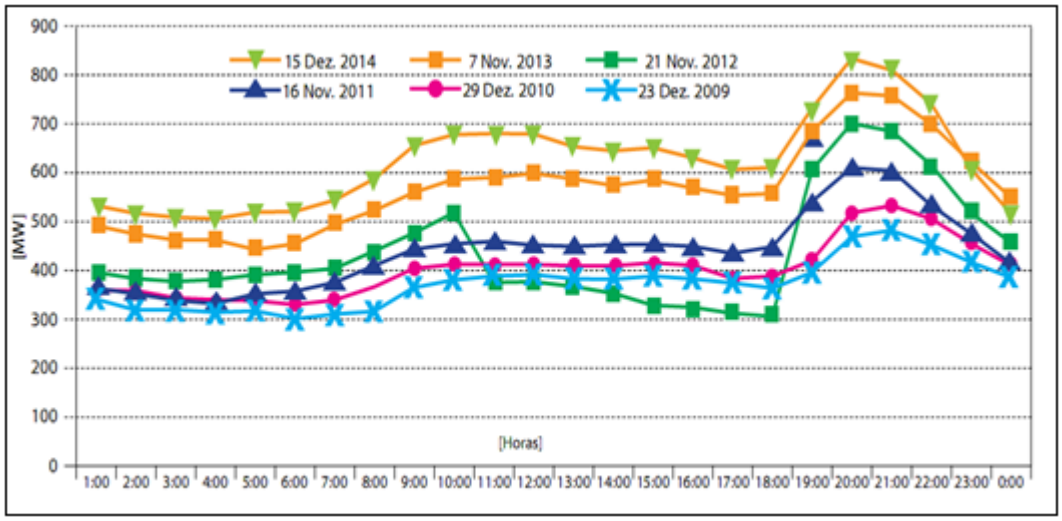

Figure 1. Some scenarios illustrating the evolution of electricity demand in some lines of the network in Mozambique. Source: EDM (2014).

Due to deficits in the summer of 2012, EDM suffered the 1st electricity shortage (170 MW deficit), which resulted in massive interruptions in the period from 7:00 pm to 8:30 pm, a period considered peak (EDM, 2016). The other shortage, one of the most critical was recorded in 2014. During the day, came to function well above its capacity, with a slight relief in the interval from 1 am to 8 am. The highest saturation of the line was registered between 6 pm to 10 pm, where the load deficit reached to 177 MW. The last notable deficit occurred in the EDM B08 line, recorded in the first half of 2015, in the northern region of Mozambique. It may be a deficit that arose due to the increase in the tip of the 220KV B08 line system, with a thermal limit of 118 MW? In June, the line peaked at 123.7 MW (06/06/2015) and the remaining deficits were recorded in July (22/07/2015) with a peak of 125.4 MW and in August (21/08/2015) with a peak of 128.3 MW. All these cases were at 7 pm (EDM, 2016).

To overcome or resolve the scenarios described above, the government is obliged to make major investments related to the construction of new power stations or acquire electricity with other private or independent producers. Construction of new power stations, besides being expensive, they create considerable environmental and social impacts. To build a hydroelectric dam, it necessary to make some changes in the ecosystem and in the regional economic activities (Reis and Carvalho, 2012). Regarding acquisition of additional electricity, the increasing use of

electricity produced by IPP (Independent Power Projects), EDM had to pay increased unit price, which reached upto 3.56 USD/kWh in 2015 (ALER, 2017).

The consequences of these recurring investments is the design of strategies that allow sustainability or the return of achievements, one of which and the most frequent is the constant increase in tariffs, a measure that directly affects consumers.

One the sustainable solutions to overcome these restrictions (scarcity and constant increase in tariffs), as recommended in several studies, is to adopt measures to rationalize the use of electricity. Rationalization is a measure that aims i) to reduce the consumption of electricity, ii) to provide energy without loss of comfort on the part the consumer, iii) to provide some relief on the monthly expenditure of energy, iv) to control the demand for energy, and v) to preserve the environment (GE, 2011). In this context, governments, researchers and the electricity sector, globally are producing energy and implementing energy efficiency (EE) actions or policies.

In relation to the concrete activities of EE, several policies and actions are underway in the world, developed with different methodologies and formulated or established according to the habits of consumers, type of equipment in use, type of houses, monetary fund, climatic conditions and supported by specific laws (Dias et al., 2004; Pimentel et al., 1999; Hass, 1997). Energy efficiency actions include research designed to study the factors that influence domestic electricity consumption and outline policies that lead to reduced consumption (Brown, 2001).

The status of energy consumers and energy consumption in Maputo revealed that there is lack of communication between EDM and customers, high prices for efficient equipment. Also, lack of knowledge of the measures and gains that can be obtained when adopted are the main barriers that reduce household consumption. However, there are studies that report that these barriers can be overcome with the implementation of an education and awareness campaign, activities that consist of the dissemination of measures and other information that influence their adoption, including incentives. Many studies were conducted to analyze the behavior Vs consumption relationships, based on the bottom-up or top-down models, which subsequently, through family consumption patterns, EE policies are outlined, in particular education (Holtedahl and Joutz, 2004). What is still underlined is that, even in countries where EE research and actions have been underway for a long time, it is recommended to implement awareness actions for rational use, whether passive or active. Mullaly (1998) studied behavior of the use of electricity by members of the Australian family and concluded that awareness has a considerable influence

in the consumption of electricity in the homes. Similar conclusions were drawn by Yohanis (2012); Hitchcock (1993); Fabi et al. (2012); Druckman and Jackson (2008); Brounen et al. (2012); Bedir et al. (2013); Musango (2014); and Attari et al. (2010). For Lopes (2015), behavior is a key factor to be considered in the transition to the use of any technology or in projects related to EE, because, to positively implement any technology or EE project in the electricity sector, is necessary, before, the consumer's awareness.

With regard to awareness, this activity is carried out by companies or other entities and content is formulated based on the results of the research. The most interesting thing, however, to understand that, in order to develop any education and awareness initiative, is necessary to first identify the services that should be prioritized (lighting, refrigeration, television or more) in this type of activity and the factors of which the consumption depends. However, despite the importance that EE activities assume for the sustainable development of a country, is worrying that in Mozambique, until then, there is no concrete national program and a law that supports ongoing programs (EDM, 2016). The first sign of the implementation of gender programs was with the creation of the EE Directorate at EDM, in 2012, whose objective was to optimize electricity, for reduce deficits, environmental impacts and economic costs (EDM, 2012).

The scenario is even worse in the research sector, as has not been found a consistent study of EE or that has studied the national reality mainly that has analyzed the consumption of electricity in homes, which made it difficult to contextualize the topic under discussion in the national context. What is even more worrying is that, despite so many actions and studies that defend the awareness of consumers, this activity is little prioritized. And in view of all these scenarios and because the non-economic use of electricity is real, this study is proposed, whose central question is to evaluate whether the actions of education and awareness, through the door-to-door method, can change the habits of consumption of Maputo consumers and rationalize electricity in homes.

2. METHODOLGY

2.1. Description of the Experience

To achieve the research objective, awareness actions using the door-to-door method are applied to consumers in the three least efficient neighborhoods in Maputo city, whose total sample is 177 (heads of household). Information about the samples (177) and the least efficient neighborhoods, the level of knowledge and the adoption of measures of rational use of electricity by the 177

consumers (before the campaign), the elasticity of household appliances, the consumption (in lighting) in 177 houses (before the campaign) are obtained. The study reveals that lighting is the most potential service to save electricity. Therefore, the savings potential is determined only in lighting, including the comparison of consumption (before and after the campaign).

After the campaign, through a questionnaire, form, interview and observation, consumption habits and specifications of consumers' electrical equipment are recorded. In addition, the deductive method is used to define average power of some electrical equipment or appliances.

The reduction rate of household electricity consumption (in lighting) is obtained considering the following relationship (Bastos, 2011):

$$PC\ (\%) = 100 - \left(100 \times \frac{\text{Current consumption (KWh)}}{\text{Previous consumption (KWh)}}\right) = 100 - \left(\frac{\text{Current power (W)}}{\text{Previous power (W)}} \times 100\right) \quad (1)$$

2.2. Methods

The average energy consumption in homes (in lighting) after the campaign is estimated based on the "bottom-up" model, the view or in the adaptation of the equation suggested by Reddy (1994). The results are obtained from the quantity of which the lamps are turned on 6 hours a day and the power of the lamps. The average monthly consumption of each lamp ($E_{\text{each lamp}}$) is determined by the following equation:

$$E_{\text{each lamp}} = \text{Service Power (w)} \times \text{Frequency of Use (h)} \times 30 \quad (2)$$

The average monthly energy consumption (in lighting) of each residence (E_R), is estimated based on the following mathematical expression:

$$E_R = E_{\text{lighting}} = E_{\text{incandescent}} + E_{\text{fluorescent}} + E_{LED} \quad (3)$$

E_{lighting} is the lighting consumption for each residence.

The average monthly consumption of each neighborhood (E_{neigh}), in lighting is determined by the equation 4, and the total average monthly consumption of the three neighborhoods, also in lighting (E) is estimated by equation 5.

$$E_{neigh} = \sum E_{\text{lighting}} \quad (4)$$

$$E = \sum E_{neigh} \quad (5)$$

3. RESULTS AND DISCUSSION

Firstly, it should be noted that the results of education and awareness actions depend on people's level of awareness or ignorance. The main point was whether these actions could really raise awareness in the city of Maputo and, if so, how much energy could be saved. These questions are discussed below with reference to three neighborhoods considered to be least efficient in the city of Maputo.

3.1. The level of knowledge and adoption of measures

After the awareness actions (P2), the level of knowledge of the measures in the three neighborhoods increased in the order of 55.3%, that is, from 18.9% to 74.2% (Fig 2).

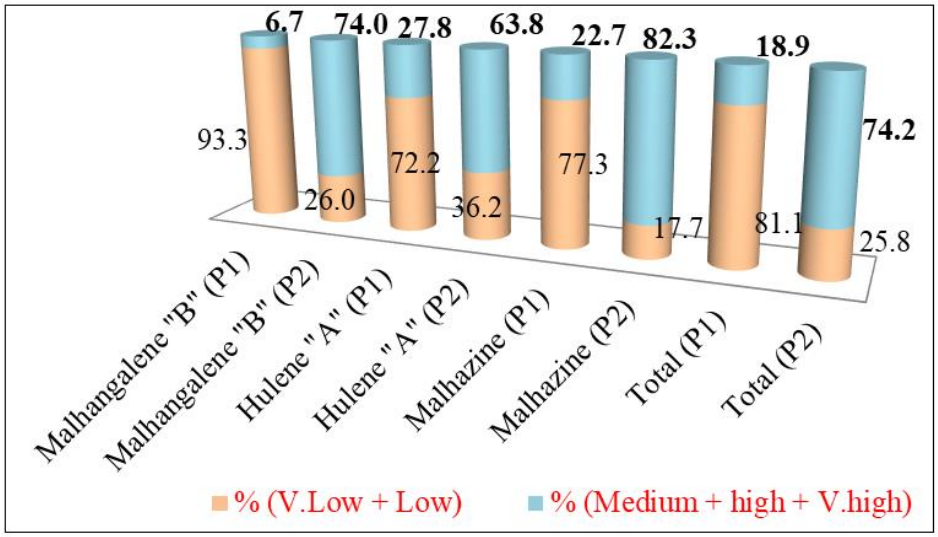

Figure 2. Percentage distribution of the level of knowledge of measures of rational use of electricity (before and after education and awareness actions).

It should also be noted that the level of knowledge of the residents' measures, in each of the three neighborhoods, has also improved (Fig 2). In Malhangalene “B”, the level of knowledge went from 6.7% to 74% of the neighborhood sample; in Hulene, more than 36% of customers knew about the measures; while in Malhazine, the number of customers with knowledge of rational use measures increased by 59.6%.

It true that the level of knowledge of the measures has increased (Fig 2), but the level of implementation of these measures, in the three least efficient neighborhoods, remains worrying, as it remains below 40% (Fig 3). Even so, the results are seen as encouraging, since the level of implementation of the measures in the 3 least efficient neighborhoods, before the campaign (P1),

was in the order of 5%. And after the campaign (P2), the level increased by 30.8%, that is, it went from 5% to 35.8% (Fig 3).

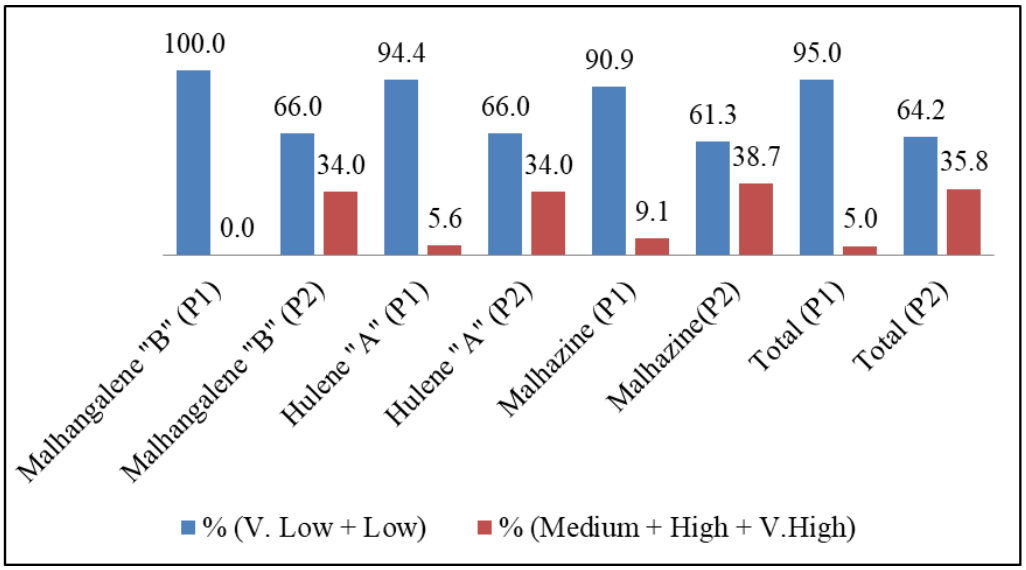

Figure 3. Level of implementation of measures in three (3) less efficient neighborhoods (Before and after the education and awareness campaign).

Table 1. Distribution of television channel audience in Maputo. Source (Chapala, work in progress).

	TELEVISION			
Neighborhood	***TVM***	***STV***	***MIRAMAR***	***TV.SUCESSO***
Maxquene	4	8	49	2
Urbanização	10	17	40	1
Malanga	21	39	19	3
Malhangalene “B”	8	24	36	3
Mavalane “A”	18	9	48	4
Hulene “A”	1	3	33	2
Laulane	9	9	42	1
Jardim	24	39	18	3
Benfica	15	24	32	3
Malhazine	2	3	53	0
Total	112	175	370	22

From these results, it is concluded that the challenge is enormous, as it can be observed that there are consumers who know the measures, but do not implement them. Perhaps we agree with Weber (1997) that, to overcome this situation, it is necessary to develop more awareness

campaigns with the help of television channels or radios. They are the media most viewed and heard by consumers. In Maputo, for this case, the most preferred means of communication by residents is television. TV Miramar is the one with the greatest potential for the dissemination of good ways to consume electricity (Table 1). And the television program most watched by families is "Balanço Geral", coincidentally the television mentioned above (Fig 4).

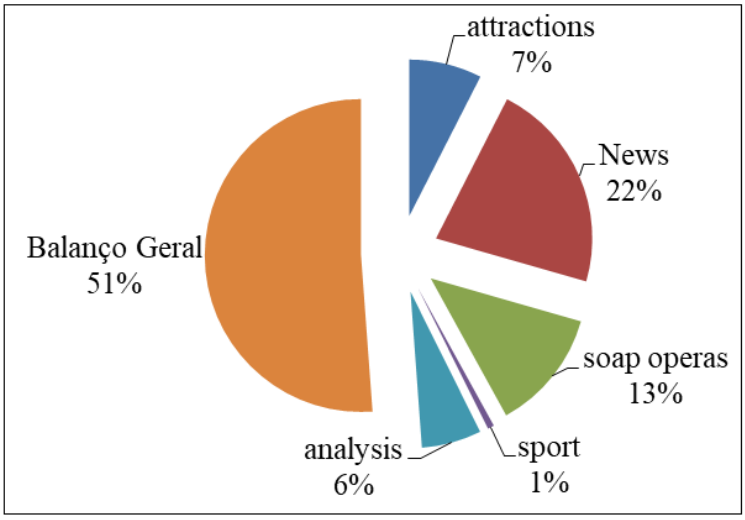

Figure 4. Distribution of some television programs most viewed by residents.

"Successo" television is one that has the least potential for awareness of the use of electricity (with 3.2% of the total sample). TVM is the other TV channel with the least audience, watched by 112 residents (16.5% of the total sample). In relation to television programs, sports programs are the least preferred or least potential for the dissemination of EE measures. News programs, from all televisions, can also be exploited to disseminate good practices in the use of electricity (Fig 4).

In addition, banning the sale of incandescent lamps or making them more expensive in domestic markets and promoting the sale of appliances with labels may be the solution to increase the level of energy efficiency in homes in Maputo city. And for that to happen, energy efficiency must be prioritized in energy projects (Santini and Sheuer, 2015) and teaching consumers to save their electricity must be one of the priority actions for energy companies (Bertoldi and Rezessy, 2006), which does not happen in Maputo. Teaching the population to save electricity in homes should be seen, on the part of the government, as one of the ways to support it to face the successive tariff changes. In Maputo, the lack of communication between EDM and its consumers is evident.

And, for Allen and Janda (2006); and Michel (2007), the lack of communication between energy companies and consumers creates an unhealthy environment for the adoption of EE measures.

For many people, price and brand are factors that influence the purchase of a new device, not efficiency. In relation to price, we have the example of fluorescent lamps, whose high initial purchase cost acts as a major impediment for consumers to exchange them for incandescent lamps. However, to overcome these barriers, Yohanis (2012) argues that it is necessary, whenever possible, to provide adequate information to the public about the quality and efficiency of the devices. On the other hand, the government must facilitate the production of efficient and quality devices and help consumers, especially low-income consumers, to replace the old and inefficient ones with the new and efficient ones (Nadel, 2007). Another example is solar panels, which also play an important role in saving electricity in homes (Druckman and Jackson, 2008), but in Maputo, this equipment is sold at high prices. And, for its acquisition, the government should allow or create conditions for payment in loans.

3.2. Electricity Saved

The analysis is based only on lighting, because, in addition to the equipment's elasticity - equipment consumption, which indicated this service as a priority for EE actions, the following aspects are considered: It easy to change a lamp and not a glacier; And the results of saving other equipment are long term and are obtained through the implementation of campaigns and the mandatory use of labels on home appliances. This sense, after the action of awareness, the level of use of fluorescent lamps in Hulene "A" registered an increase of about 58. While in Malhangalene "B", the level of use of this type of lamps increased from 156 to 186, an increase in the order of 30. And in the three neighborhoods, the level of use of fluorescent lamps registered an increase in the order of 104 lamps.

In addition, was possible to verify that the use of these lamps in the patios is predominant, in comparison with other compartments. About the use of LED lamps, it should be noted that there was an increase of 45 lamps. Malhangalene “B” customers are the ones that most adopted LED lamps, with the purchase of another 21 lamps, followed by customers from Malhazine district who exchanged 13 less efficient lamps for others of the LED type.

About the level of use of incandescent lamps, it should be noted that, after awareness, 139 lamps were replaced by efficient lamps. Malhazine's customers are the ones that have most reduced the use of incandescent lamps and Hulene's are the ones that have reduced the use of this type of

lamps. Consumers in the "A" neighborhood of Hulene are the ones who saved the least (143.82 KWh), while Malhazine consumers are the ones who saved the most energy, totaling 943.38 KWh (Table 2).

Table 2. Lighting savings potential.

Neighborhood	***Installed power (KW) in lighting***								***Total Consumption (KWh)***		***Potential for rationalization***	
	Fluorescent		***LED***		***Incadescent***		***Subtotal***					
	P1	***P2***	***P1***	***P2***	***P1***	***P2***	***P1***	***P2***	***P1***	***P2***	***KWh***	***%***
Malhangalene "B"	2.528	3.178	0.11	0.298	10	6.55	12.638	10.026	2274.84	1804.68	470.16	20.7
Hulene "A"	0.162	1.146	0.117	0.194	8.32	6.46	8.599	7.8	1547.82	1404	143.82	9.3
Malhazine	1.725	1.848	0.144	0.23	28.3	22.85	30.169	24.928	5430.42	4487.04	943.38	17.4
Total	4.415	6.172	0.371	0.722	46.62	35.86	51.406	42.754	9253.08	7695.72	1557.36	16.8
Average electrical load (KW) in lighting									51.406	42.754		

Note: P1= 1st study phase, before the education and awareness campaign.
P2= 2nd study phase, after the education and awareness campaign.

However, the amount of electricity saved (1557.36 KWh) can be seen as insignificant, but if the campaign involves various activities, such as equipment labeling, introduction of incentives or other programs and more consumers, the results can be significant. With the results of the campaign, it became clear that, in order to considerably reduce consumption in the homes of low-income families, it is necessary to adopt the incentive policy, distribution of low-consumption light bulbs, for example. For this, authors such as Reddy (1994), Bedir et al. (2013), Fabi et al. (2012) and Mullaly (1998), argue that it is the responsibility of the governments to trigger their social support plans or funds.

With the distribution of efficient lamps to the population the state can relieve a significant electrical charge. Offering 3 lamps to each customer, for example, at a cost of 200MT each, with 1,346,019 customers distributed across the country, the State would spend approximately 800 million MT to reduce the annual load of 156MW (351GWh) during the period peak. In other words, it is being said that the state would save approximately 19.2 billion MT, which would be used to build a 156 MW plant and prevent the emission of approximately 351000 tonnes of carbon dioxide.

For the city of Maputo, the State may reduce the electrical charge by 75% (up to 29MW), consumption corresponding to 99GWh, save approximately 3 billion MT and avoid the emission of approximately 62 250 tonnes of CO2.

The lighting service proved to be important to cover electricity demand in Maputo, and this service is responsible for 11 GWh per month. Most of the lighting is through incandescent lamps (60, 100 watts). And, with the same technical potential for rationalizing lighting in table 1 (16.8%), is understood that, by increasing awareness for all domestic customers in Maputo (253799), 61562 lamps of 60 W can be exchanged for many different. If the exchange is made for 61562 fluorescents of 15W, the consumption of electricity in homes in the order of 0.49 GWh can be reduced.

Finally, it should be noted that the awareness campaign benefited more the residents who carry out the activities in their homes, as they took place on working days, from 8 am to 5 pm. And in order to obtain more gain from these activities and further reduce electricity consumption in Maputo residences, is recommended to implement them in schools, neighborhoods and in the public and private work sectors. In the case of schools, studies recommend giving lectures, creating short courses and inserting energy efficiency content in curricula. Schools should prioritize these activities because, according to Dias et al. (2004); and Teixeira (2008), it through schools that is possible to guarantee that the habit of making energy use available is present in many consumers, including in the next generations.

4. CONCLUSIONS AND RECOMMENDATIONS

The results of the research show that, the implementation of awareness campaigns for the rational use of electric energy through the door-to-door method is one of the solutions to reduce the domestic consumption of electricity in Maputo City. In fact, with the campaign carried out in the three least efficient neighborhoods in the city, it was possible to increase the level of knowledge of the measures by more than 50%, increase the degree of implementation of these measures six times and the reduction of consumption by more than 10%.

However, with more campaigns, both by the proposed method, in schools as well as by the use of radio, television and newspapers, the level of rationalization of the use of electricity in Maputo can be greatly improved. And during the campaigns, in addition to raising awareness of changes in electricity consumption habits, it is important to promote efficient appliances.

It is worth mentioning that the amount of energy saved was obtained from the lighting service, where, after the campaign, some consumers exchanged their incandescent lamps for others with low consumption, which makes us understand that incandescent lamps are some of the most elastic equipment in the sector domestic market in the city of Maputo.

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