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Evaluation of Energy Supply and Demand Side Management for Residential Buildings in Ekiti State, Nigeria

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Abstract

Ekiti State is an agrarian state located in south western part of Nigeria. The injected power to the Ado-Ekiti and the entire state are 25MW and 37.6MW respectively. The estimated power demand for Ado Ekiti and Ekiti state were 29.01MW and 224.116MW respectively. The distributed power to the consumers is characterized with shortcomings which include: in-adequate supply, poor voltage regulation, improper usage, illiteracy and wastage. The power generation in Nigeria is presently inadequate which to match the estimated power demand of 15,000MW with a population of over 170 million citizens. This paper evaluates the energy utilization in Ado Ekiti metropolis, the wastage and its economic implication as well as effective means of its management. The use of direct interviews, administration of questionnaires, measurements of current and voltage with clamp multimeter, and simple mathematical approach were used for the purpose of evaluation. Recommendations were made with the aim of reducing energy waste from mean value of 10.84% to 2% in order to reduce the cost implication such that the huge financial waste can be injected to other parts of the economy as well as the management of energy in Ekiti state.

Keywords: Energy; Waste; Consumers; Power supply; Demand; Management

Introduction

The insufficient power generation in Nigeria which could not match the power demand of the consumers in the country has culminated into incessant power failure with underdevelopment [1]. The inadequacy in power supply has not been properly utilized and managed there by resulting into wastage of energy. With over 170 million people and a high rate of population growth, Nigeria needs to create 40 to 50 million additional jobs between 2010 and 2030 [2]. The power generation reduced to 1,580.6MW on March 9th, 2016 and suddenly increased to 4,387MW after few days. When an expectation of a peak value of 5,000MW was at sight, the generation level reduced to 2,800MW due to gas pipeline vandalism based on information from the Nigerian Electricity Regulatory Commission [3]. On the 10th August, 2017, 6807MW was recorded as the current available generation capability with the wheeling capacity of 6700MW by Transmission Company of Nigeria currently constrained by Distribution Companies inability to take load [4]. Nigeria has increased its power generation capacity above 7000MW and the government is determined to realize its target of 10,000MW generation capacity [5]. The injected power to the Ado-Ekiti and the entire state are 25MW and 37.6 MW respectively. The estimated power demand for Ado Ekiti and entire Ekiti state were 29.01MW and 224.116MW respectively [6]. Energy is the ability to do work. It can neither be created nor destroy. Energy can be conserved [7] and is the capacity of a physical system to perform work [8]. Energy is critical for human existence and when used efficiently and wisely, can provide an important means of reaching sustainable development goals. Management is the act of getting people together to accomplish desired goals and objectives using available resources efficiently. Management functions include: Planning, organizing, staffing, leading, or directing, and controlling, an organization or effort for the purpose of accomplishing a goal [9]. When it comes to energy saving, energy management is the process of monitoring, controlling and conserving energy in a building or organization [10]. The following steps are crucial to proper energy management: metering your energy consumption and collection of data; finding opportunities to save energy and estimating how much energy each opportunity could save; taking action to target the opportunities to save energy; tracking your progress by analyzing your meter data to see how well your energy saving efforts have worked [10]. The pillars of industrial energy management are: monitor the facility, monitor production, capture energy consumption, model, control, respond, and score card [11]. Methods of measuring energy management success are: consolidate energy data using gateways; take a deeper look into power systems; and use historical data as a baseline [12]. The global share of electricity use in overall energy end-use demand rose from 9.4% to about 14% between 1976 and 1996. In countries belonging to the Organization for Economic Co-operation and Development (OECD), it rose from 14.3% to 18.3% over the same period. Global and regional statistics indicate the average per capita consumption of electricity is now 7500 kWh/year in OECD countries as compared with 482 kWh/year in Asia (excluding China which is 822 kWh/year), 490 kWh /year in Africa and 1402 kWh/yr in Latin America [13]. An industrial customer begins to buy electricity from third party suppliers; many are discovering that deregulation does not necessarily result in reduced costs. For some, poorly negotiated contracts, defaulting suppliers, and failure to understand the actual contract terms have actually resulted in higher costs and subsequent misunderstanding [14]. Improving energy efficiency and reducing energy demand are widely considered as the most promising, fastest and cheapest and safest means to mitigate climate change [15]. Government will play a decisive role in boosting energy efficiency. By focusing energy policies, developing nations could dramatically reduce the growth energy demands over the next twelve years without impairing

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economic growth [16]. Demand Side Management (DSM) includes energy efficiency and demand efficiency and demand response, works from the other side of the equation instead of adding more generation to the system; it pays energy users to reduce consumption [17]. Energy demand management also known as demand side management is the modification of consumer demand for energy through various methods such as financial incentives and behavioral change through education [18]. Demand Side Management in the United Kingdom operates at three levels; Management commitment, investment in Electrical Energy measures, documentation of efficiency improvements [19].

Methodology

This paper evaluates the energy utilization of appliances by consumers and equipment in Ajilosun and Odo-Ado areas of Ado Ekiti metropolis in Ekiti State, Nigeria. A clamp multimeter was used to measure the current and voltage consumed by each appliance. The administration of 120 questionnaires was used and only 105 were returned representing 87.5%. On getting to the meter board of each house, the clamp multimeter was set to the maximum current range of 1000 amperes a.c, the measurement was taken for red phase, yellow phase and blue phase respectively. Starting from the top with the electrical power consumption and running time of electrical equipment and appliances in the domestic residential buildings in Ajilosun and Odo-Ado areas of Ekiti State. Energy consumed are seen to be Energy Utilization while energy consumed by the electrical equipment but are not used such as the electrical bulbs that are on when not needed and other appliances are switched on but not used are regarded as Waste Energy. Both energies are calculated by using the number of available equipment, period of utilization and rating of the electrical equipment. This is done by simple mathematical approach by multiplying the three data together to get the energy utilized by each of the equipment. This research was carried out for five days on each street in Ado-Ekiti, Ekiti State. The following equations are used to determine the energy utilized and energy waste as well as total energy consumed of buildings in these areas. The mathematical equations are:

$$E_U = R \times N \times T \quad (1)$$

Where E_U- energy utilized, R- rating of equipment, T- period of equipment usage.

$$U_{EU} = \frac{E_T}{D} \quad (2)$$

$$U_{EU} = \frac{E_T}{D} \quad (3)$$

Where U_{EU}- mean of utilized energy, ET- total energy used, D- total number of days.

$$U_{EW} = U_{EC} - U_{EU} \quad (4)$$

Where U_{EU}- mean of utilized energy, ET- total energy used, D- total number of days.

$$\%EU = \frac{U_{EU}}{U_{EC}} \quad (5)$$

$\%_{EU}$- percentage utilized energy, U_{EU}- mean of used energy, U_{EC}- mean of total energy consumption.

$$\%EU = \frac{U_{EU}}{U_{EC}} \quad (6)$$

$\%_{EW}$- percentage waste energy, U_{EW}- mean of waste energy, U_{EW}- mean of total energy consumption.

Results

The equation (1) and (2) were used to determine the energy utilization (Eu) and mean of total energy consumption (UEC) respectively. The mean of utilized energy was calculated by equation (3), the mean of waste energy was calculated by equation (4), the percentages of utilized energy and that of waste energy were calculated by equations (5) and (6) respectively. The results were functions of ratings of appliances, the period of utilization based on the availability of power supply in the areas under research study. The Tables 1-6 show the evaluation process and results of the energy utilized and energy waste of different areas. From the summary table, the day one for Odo-Ado with energy utilization of 427,381.2Wh, energy waste of 88,740Wh, and total energy of 516,12Wh is the maximum. The minimum occurs on the fifth day with energy consumption of 174,118.2Wh, energy waste of 15,660Wh and total energy of 189,778.2Wh. From the summary table, the day one for Ajilosun with energy utillization of 434,064Wh, energy waste of 36,210Wh, and total energy of 470,274Wh which is the maximum of the five days analysis. The minimum occurs on the fifth day with energy utilization of 290,256Wh, energy waste of 35,985Wh and total energy of 326,241Wh.

Discussion

This paper evaluates the demand side management of Odo-Ado and Ajilosun streets of Ado –Ekiti metropolis with densely population and they are the commercial and residential areas of the city. From the Tables 1-6, it is obvious that power supply to those areas do not exceed three hours in a day. Appliances and equipment used by domestic consumers were considered and their quantities from one residential building to another were carefully observed for the sake ofanalysis. Table 1 shows the daily electrical energy utilization and its running time for appliances andequipment at Odo- Ado area of Ado-Ekiti. The energy utilization for day one was estimated to be 427,381.2Wh. Table 2 shows the waste energy estimated to be 88,740Wh while Table 3 shows thetotal energy estimated to be 337,418.5Wh, the energy waste

S/N	Electrical Equipment	Equipment ratings (W)	Equipment quantity	Period of usage (Hour)	Energy utilized EU(Wh)
1	Electric stove	1200	13	3	46,800
3	Electric iron	1000	28	3	84,000
3	Electric Cooker	1300	30	3	117,000
4	Freezer	170	15	3	7,650
5	Television	80	32	3	7,680
6	Radio	60	37	3	6,660
7	Air Condition	1150	7	3	24,150
8	Fan	50	35	3	5,250
9	Computer desktop	300	15	3	13,500
10	Laptop	100	36	3	10,800
11	Chargeable lamp	3.7	42	3	466.2
12	Water heater	900	10	3	27,000
13	blending machine	700	15	3	31,500
14	Energy saving bulb	85	35	3	8,925
15	Incandescent bulb	100	120	3	36,000
Total					427,381.20

Table 1: Daily Electrical Energy Utilization and Running Time Chart of Electrical Equipment and Appliances in Residential at Odo-Ado, Ado-Ekiti.

S/N	Electrical Equipment	Equipment ratings T, (W)	Equipment quantity, N	Period of usage, T, (Hour)	Energy utilized EU(Wh)
1	Incandescent bulb	100	65	3	19,500
2	Energysaving bulb	85	80	3	20,400
3	Laptop	180	15	3	8,100
4	Television	110	24	3	7,920
5	Refrigerator	600	6	3	10,800
6	Electric Iron	1000	12	3	36,000
Total					88,740

Table 2: Wasted Energy at Odo-Ado Street, Ado-Ekiti.

Number of Days	EnergyUtilized/ day Eu(Wh)	Waste Energy Ew(Wh)	Total Energy ET (Wh)
One	427,381.20	88,740	516,121
Two	337,418.50	54,576	391,994.50
Three	276,903	37,115.40	305, 018.4
Four	272,314.80	13,536.60	285,851.40
Five	174,118.20	15,660	189,778.20

Table 3: Summary Table of Energy Waste, Energy Utilization and Total Energy for Odo-Ado.

S/N	Electrical Equipment	Equipment (W)	Equipment quanity	Period of usage (Hour)	Energy utilized (Wh)
1	Electric stove	900	10	3	27,000
2	Electric Iron	1000	8	3	24,000
3	Electric Cooker	1300	15	3	58,500
4	Refrigerator	600	16	3	28,800
5	Microwave	1000	9	3	27,000
6	Pumping machine	2,100	15	3	94,500
7	Radio	80	21	3	5,040
8	Television	110	20	3	6,600
9	Air conditional	1,150	9	3	31,050
10	Fan	50	24	3	3,600
11	Computer Desktop	300	22	3	19,800
12	Laptop	180	30	3	16,200
13	Water heater	1200	8	3	28,800
14	Chargeable lamp	44	32	3	4,224
15	Energy saving bulb	85	90	3	22,950
16	Incandescent bulb	100	120	3	36,000
Total					434,064

Table 4: Daily Electrical Energy Utilization and Running Time Chart of Electrical Equipment and Appliances in Residential at Ajilosun, Ado-Ekiti.

S/N	Electrical Equipment	Equipment rating T,(W)	Equipment quantity, N	Period of usage, T, (Hour)	Power consumed
1	Incandescent bulb	100	25	3	7500
2	Energy saving bulb	85	22	3	5,610
3	Laptop	180	7	3	3,780
4	Television	110	4	3	1,320
5	Refrigerator	600	5	3	9000
6	Electric Iron	1000	3	3	9000
TOTAL					36,210

Table 5: Energy Waste at Coca-Cola Area, Ajilosun.

was 54,576 while the total energy wasput at 391,995 Wh. The detail of the remaining three days can be viewed from Table 3. Similarly, Table 4 shows the daily electrical energy utilization and its running time for appliances and equipment at Ajilosun area of Ado-Ekiti. The energy utilization for day one was estimated to be 434,064Wh. Table 5 Shows the waste wasted energy estimated to be 36,210Wh, Table 6 shows the total energy estimated to be 470,274Wh. For day two, the energy utilization was 363,885, the energy waste was 38,100 Wh while the total energy was estimated to be 401,985 Wh. The detail of the remaining three days was presented in Table 6. It is imperative to note that the mean of total energy utilization for Odo-Ado area was calculated to be

Number of Days	Energy Utilization, Eu (Wh)	Energy Waste, Ew, (Wh)	Total Energy, ET (Wh)
One	434, 064	36,210	470,274
Two	363,885	38,100	401,985
Three	388,302	32,910	421,212
Four	335,232	41,859	377,091
Five	290,256	35,985	326,241

Table 6: Summary Table Of Energy Waste, Power Consumption and Total Energy For Ajilosun Street, Ado-Ekiti.

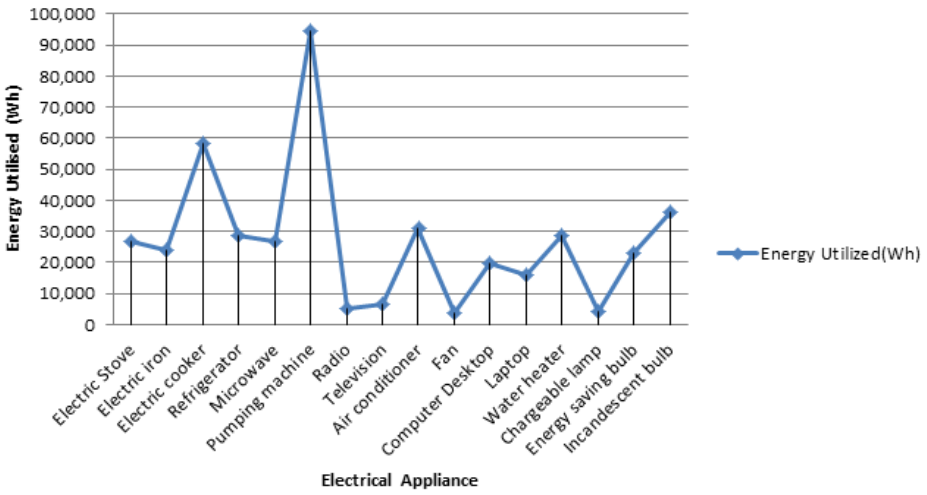

Figure 1: Plot of energy utilized by electrical appliances in Odo- Ado, Ado-Ekiti.

337,752.7Wh while that of Ajilosun was 399,360.6Wh with a difference of 61,607.9 Wh. The mean of utilized energy forOdo-Ado and Ajilosun areas were 295,827.14Wh and 362,347.8Wh respectively with a difference of 66,519.86 Wh. The mean of waste energy for the areas were 41,925.56 Wh and 37,012.8Wh with a difference of 4,912.76Wh. The percentage of utilized energy for Odo-Ado and Ajilosun areas were estimated as 87.59% and 90.73% respectively. The percentage of waste energy of Odo-Ado and Ajilosun were calculated as 12.41% and 9.27%respectively. Figure 1 shows the running time for appliances and their level of energy utilization. This plot shows that the minimum energy utilization was at 3,600 Wh, the mean value was 26,711.3Wh and the maximum was 94,500Wh for fan, microwave or electric stove and pumping machine repectively.

Conclusion

The percentage of used energy for Odo-Ado and Ajilosun areas were estimated as 87.59% and 90.73% respectively. The percentage of waste energy of Odo-Ado and Ajilosun were calculated as 12.41% and 9.27% respectively which is huge and can be managed and re-invested into the energy sector and other parts of the economy. The energy in these areas could be properly managed through public enlightenment of domestic consumers on the mode of utilizing their appliances and equipment in order to increase the percentage of energy usage and reduce the percentage of waste energy and equivalent financial loss that could be re-invested on the energy sector.

Recommendation

The demand side management is extremely vital to the growth of any country, therefore, the following recommendations were made;

1. The energy waste of the areas under consideration should not be more than 1-2% as against the mean value of this research work estimated to be 10.84%.
2. There should be proper enlightenment of Nigerians in the areas of energy usage in such a way that the consumers should be de-energized their equipment and appliances when they are not in use which will in turn reduce energy wastage.
3. The economic implication of energy waste is huge and a reduction in it will revolve such funds in other sectors of the economy and more importantly, energy sector.

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