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DEMAND SIDE MANAGEMENT OF ELECTRICITY CONSUMPTION OF SOME BUSINESS CENTERS IN OKADA

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Abstract: A comparative analysis was carried out between energy saving equipment and conventional non energy saving equipment in five major business centres in Okada, Edo State of Nigeria to determine the overall cost savings in Naira (₦) and hence energy conserved in Kilowatt (kWh). The data were collected through literature on previous work on demand side management, questionnaires, resource from power companies, oral interviews and internet sourcing. These data were carefully analyzed using appropriate data analysis and statistical tools in each case in order to enhance proper and effective data interpretation, the data were presented in tables and charts which led to the recommendation of the use of energy saving equipment for optimum management of the load demand.

Keywords: Demand, energy saving, load, management, optimum

Introduction

Efficient power management in a developing nation like Nigeria cannot be over emphasized. There is a global advancement in technology which in turn affects the equipments used in various business enterprises. Some would decide to hold on to the older equipments due to lack of resources or the man power for the newer and more sophisticated ones which are energy efficient. There is however need for a total embrace of power efficient equipment because on the long run it actually reduces the overheads of business enterprises. Apart from reduction in costs, using power efficient equipments is also a means to properly manage the available power generated.

It is not sufficient for a nation to just generate enough power from the source, the transmission and distribution stages also need to be well monitored to ensure that the power generated is optimally transmitted and eventually distributed to the consumers with minimal losses. It is at the consumer side that the demand side management of the available power can be put in place so as to optimize the available power since it is impossible to increase the power at this stage. There is therefore need for a demand side power analysis at the consumer end in order to efficiently utilize the distributed power. Investigation and analysis were carried out in a relative comparison using energy saving technology in five business centers in Okada.

Mohsenian-Rad *et al.* (2010) presented an autonomous and distributed demand-side energy management system among users that takes advantage of a two-way digital communication infrastructure which is envisioned in the future smart grid. This made use of game theory and formulate an energy consumption scheduling game, where the players are the users and their strategies are the daily schedules of their household appliances and loads.

Palenskyand Dietrich (2011) examined the use of energy management to optimize one of the most complex and important technical creations. It ranges from improving energy efficiency by using better materials, over smart energy tariffs with incentives for certain consumption patterns, up to sophisticated real-time control of distributed energy resources.

Strbac (2008) discussed the major benefits and challenges of electricity demand side management (DSM). The importance of the diversity of electricity load is discussed and the negative effects of DSM on load diversity illustrated. Potential benefits of DSM are also discussed in the context of generation and of transmission and distribution networks.

Gellings (1985) describes demand-side management for electric utilities and discusses the evolution of this concept for load management, strategic conservation, and marketing.

Logenthiran*et al*. (2012) presents a demand side management strategy based on load shifting technique for demand side management of future smart grids with a large number of devices of several types. A heuristic-based Evolutionary Algorithm (EA) that easily adapts heuristics in the problem was developed for solving minimization problem. Simulations were carried out on a smart grid which contains a variety of loads in three service areas namely; residential, commercial and industrial. The result showed substantial savings.

Ramchurn *et al.* (2011) introduced a novel model of a Decentralised Demand Side Management (DDSM) mechanism that allows agents, by adapting the deferment of their loads based on grid prices, to coordinate in a decentralised manner.

Khanna et al, (2016) used micro-level data collected to estimate the effects of three DSM measures empirically: tiered household electricity pricing, China Energy Label program, and information feedback mechanisms. It was found that these measures have contributed to moderating residential electricity demand growth

Shivaharinathan*et al* (2016) found that Peak demand management does not necessarily decrease total energy consumption but could be expected to reduce the need for investments in networks and/or power plants and it is one of the strategies capable of offering a supplementary mode of action that enables effective management of increasing demands for electricity.

Salpakari*et al*. (2016) presents models for optimal control of power-to-heat conversion to heating systems and shiftable loads in cities to incorporate large variable renewable power schemes. The control strategies comprised optimal matching of load and production, and cost-optimal market participation with investment analysis. A significant reduction in the net load magnitude was obtained with shiftable loads and investments to both power-to-heat and load shifting with electric heating.

Li *et al*. (2017) introduced a distributed algorithm for sparse load shifting in demand-side management with a focus on the scheduling problem of residential smart appliances. A bidirectional framework for solving the demand-side management problem in a distributed way to substantially improve the search efficiency was developed then detailed results from illustrative case studies were presented and discussed, which showed the costs of energy consumption and daily peak demand by the algorithm were reduced.

Methodology and Data Organisation

The energy consumption and efficient management at the consumers end of five business centers in Okada were considered. The data collation and analysis were thoroughly

done using questionnaires and oral interviews with the aim of evaluating the present rate of energy consumption, the efficiency in utilization as well as finding out more effective way(s) energy could be utilized in order to save cost without increasing the generating capacity from the source. The five business centers are all in the same area and supplied by the same transformer which means the source of electricity is similar to enhance a fair comparison. The power rating of all loads in each of the five business centers were determined either by calculation or directly from the device name plate, the total available load in each business center was also determined and listed in such a way to simplify the data interpretation. The same thing was done when the equipments, devices and fittings were changed to energy saving ones.
The load data collected from the five business centers were formed into tables for each and appropriate graphs were plotted for each of the business centers for analysis. Comparison was made between the various graphs, thereafter recommendations for energy savings were given with respect to each center.

Business centres comparison

Power demands (P_D) for each of the business centers were compiled from the name plates of equipments and their individual ratings for each business center for comparison. Tables 1 and 2 as well as Charts 1 and 2 show Power demands in each case, respectively.

Table 1: Power demand for conventional technology

Business Centers	Conventional power demand (kw)
A	63.372
B	48.816
C	55.392
D	82.641
E	75.439

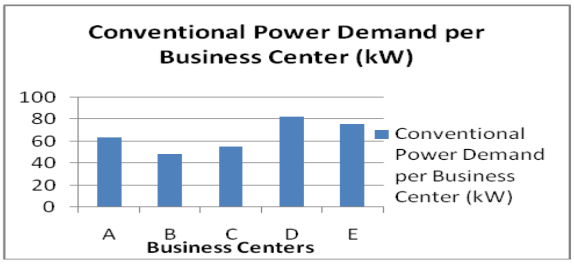

Chart 1: Power demand for conventional technology

Table 2: Power demand for energy saving technology

Business Centers	Energy saving power demand (kw)
A	46.895
B	35.148
C	41.544
D	60.328
E	53.562

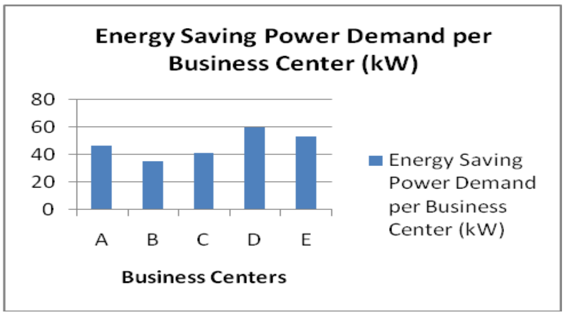

Chart 2: Power demand for energy saving technology

Power and Cost Calculations

Business centers operate averagely between 8:00am and 8:00pm in Okada except for those that run shifts, however all the five business centers considered do not run shifts. The energy consumption is therefore assumed to be for an average of twelve hours (12h) per day for all appliances and equipment in each of the business centers.`

The daily energy consumption (E_D) for each business center was calculated for both the conventional and energy saving technologies using the following;

$$E_D = P_D \times T_D \quad \text{--------------} \quad \text{(i)}$$

$E_D = Daily\ Energy\ Consumption\ (kWh)$

$P_D = Power\ Demand\ (kW)$

$T_D = Daily\ Time\ (hr)$

$T_D = 12hrs$

Thereafter the annual energy consumption (E_A) was also calculated for each center for both the conventional and energy saving technologies using the following;

$$E_A = P_D \times T_A \quad \text{--------------} \quad \text{(ii)}$$

$E_A = Annual\ Energy\ Consumption\ (kWh)$

$P_D = Power\ Demand\ (kW)$

$T_A = Annual\ Time\ (hr)$

$T_A = 365\ \times 12hrs$

Benin Electricity Distribution Company (BEDC) charges ₦40.67 per kwh for Commercial C3 category under which the business centers fall. (Http://bedcpower.com/new-electricity-tariff-and-customer-classification/), (Http://bedcpower.com/wp-content/uploads/2015/08/CONSULTATION_PAPER_FOR_TARIFF_REVIEW_August_0415.pdf) The calculation of the daily energy cost (C_D) as well as the annual energy cost (C_A) for both conventional and energy saving technologies using the following;

$$C_D = E_D \times R \quad \text{--------------} \quad \text{(iii)}$$

$$C_A = E_A \times R \quad \text{--------------} \quad \text{(iv)}$$

$C_D = Daily\ Energy\ Cost\ (₦)$

$C_A = Annual\ Energy\ Cost\ (₦)$

$E_D = Daily\ Energy\ Consumption\ (kWh)$

$E_A = Annual\ Energy\ Consumption\ (kWh)$

$R = Rate\ of\ Energy\ Charge\ (₦/kWh)$

$R = ₦40.67\ per\ kWh$

Results and Discussion

Tables 3 and 4 show the daily and annual energy conserved respectively when some devices and equipment were replaced with energy saving equivalents. The total daily energy conserved is 1058.196 kWh while the total annual energy conserved is 386241.54 kWh. This huge amount of energy conserved can be put to use in other areas that either have inadequate or no electricity at all. The power is therefore managed at the demand side to cater for deficiencies without necessarily increasing the generation of power.

Table 3: Daily energy conserved

Business Centers	Daily Conventional Consum.(kWh)	Daily Energy Saving Consum. (kWh)	Daily Energy Conserved (kWh)
A	760.464	562.74	197.724
B	585.792	421.776	164.016
C	664.704	498.528	166.176
D	991.692	723.936	267.756
E	905.268	642.744	262.524
Total	3907.92	2849.724	1058.196

Table 4: Annual Energy Conserved

Business Centers	Annual Conventional Consumption (kWh)	Annual Energy Saving Consumption (kWh)	Annual Energy Conserved (kWh)
A	277569.36	205400.1	72169.26
B	213814.08	153948.24	59865.84
C	242616.96	181962.72	60654.24
D	361967.58	264236.64	97730.94
E	330422.82	234601.56	95821.26
TOTAL	1426390.8	1040149.26	386241.54

Table 5: Annual conventional cost

Business Centers	Power Demand (kW)	Annual Energy Consumption (kWh)	Annual Energy Cost (₦)
A	63.372	277569.36	11288745.87
B	48.816	213814.08	8695818.63
C	55.392	242616.96	9867231.76
D	82.641	361967.58	14721221.48
E	75.439	330422.82	13438296.09
Total	325.66	1426390.8	58011313.84

Table 6: Annual energy saving cost

Business Centers	Power Demand (kW)	Annual Energy Consumption (kWh)	Annual Energy Cost (₦)
A	46.895	205400.10	8353622.07
B	35.148	153948.24	6261074.92
C	41.544	181962.72	7400423.82
D	60.328	264236.64	10746504.15
E	53.562	234601.56	9541245.45
Total	237.477	1040149.26	42302870.40

Table 7: Annual Cost Comparison and Savings

Business Centers	Conventional Annual Cost (₦)	Energy Saving Annual Cost (₦)	Annual Energy Cost Savings (₦)
A	11288745.87	8353622.07	2935123.80
B	8695818.634	6261074.92	2434743.71
C	9867231.763	7400423.82	2466807.94
D	14721221.48	10746504.15	3974717.33
E	13438296.09	9541245.45	3897050.64
Total	58011313.84	42302870.40	15708443.43

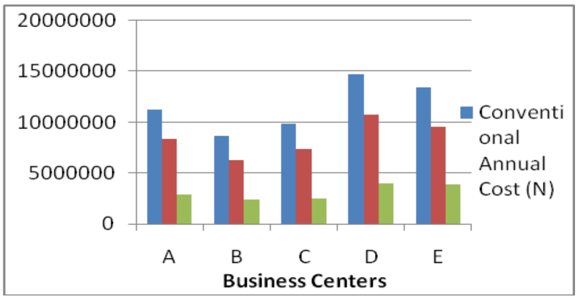

Chart 3: Annual Cost Comparison and Savings

Table 5 shows the conventional business centers annual energy consumption and cost while Table 6 shows the Energy Saving Business Centers annual consumption and cost, from the two tables it is evident that a higher amount of money was spent on the conventional as opposed to the energy saving technology. This excess amount of money is available to be put into other productive ventures. The annual total energy conserved of 386241.51 kWh translated to the saving ₦15,708,443.43 annually.

The cost comparison of conventional and energy saving business centers per annum is presented in Table 7 and Chart 3 which shows that business center A saved 26%, business center B saved 28%, business center C saved 25%, business center D saved 27% and business center E saved 29%. An overall average annual savings of 27% was recorded using energy savings equipments and devices as against the conventional ones.

Conclusion and Recommendation

It is very certain that there is tremendous savings in terms of power as well as cost when energy saving equipment and devices were used in the five business centers. This implies that if consumers diligently follow the energy saving pattern, a lot of energy could be conserved which would automatically translate into cost savings for the consumer. The energy conserved means that there will be more available power to serve other upcoming business centers and the likes since they all have the same source as a result of being supplied by the same transformer.

Considering the large amount of energy conserved as well as the huge amount of money saved by employing energy saving devices and equipments, it is therefore recommended that consumers should be well educated on the economic importance and the high performance of an efficient demand side management. This will reduce loss and at the same time increase the power available for consumers as a whole.

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