Industrial Energy Management Opportunities in Nigeria: A Case Study of Energy Audit of VIK Industries Nigeria, Ltd.

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ABSTRACT

In this paper, the analysis of the energy audit of VIK INDUSTRIES NIGERIA, Ltd., has been carried out. A walk-through energy audit of VIK Industries Nigeria, Ltd. was undertaken to identify core areas of energy waste in the company by human and machinery factors, create awareness on energy saving among staff, and sensitize the company of the energy saving potentials in the company in addition to adopting more energy efficient technologies for operation.

The results showed that molds and motor drives accounted for 75.49% of the energy consumed by VIK Industries Nigeria, Ltd., and they are inductive resulting in reactive power of 126.19KVAR per day. This is improved by using capacitor banks or other power factor correcting mechanisms such as ElectroFlow to reduce the KVAR losses. Cooling consumed 16.30% of total energy; this can be reduced by buying of soft-starting A/Cs and better electrical housekeeping. Lighting and Office equipment consumed the least with 7.43% and 0.75%, respectively.

The energy audit identified areas where energy was used or wasted; opportunities to reduce energy usage, formulated prioritized recommendations for implementing process improvements to save energy.

(Keywords: energy audit, efficiency, VIK industries)

INTRODUCTION

The term energy audit is commonly used to describe a broad spectrum of energy studies ranging from a quick walkthrough of a facility to identify major problem areas to a comprehensive analysis of the implications of alternative energy efficiency measures sufficient to satisfy the financial criteria of sophisticated investors (Akpama, et al., 2009).

Energy is the backbone of development in any economy. It functions as a factor of production, livelihood and development. The evidence all over the world has shown a positive association between per capita income and per capita energy consumption (Sarkar, 2002). Efficiency of energy utilization in Nigeria is low. There are significant opportunities of increasing energy efficiency and conservation measures in all the end-use sectors such as, domestic, industrial, commercial, transport, and agriculture.

The industry sector plays a significant role in global energy consumption (Avami, 2007). Industrial users of energy are normally businesses for whom energy efficiency might be important for economic reasons. A process that uses less energy, may cost less money to run, and therefore has the potential to make larger profits for the business. However, care has to be taken when analyzing or promoting energy efficiency via purely economic considerations. A very efficient process may be used to replace other more expensive business resources, like labor or capital, leading to economic benefit but increased total energy use by an industry due to a greater production level, which is not desirable from a sustainability point of view (Brookes 2004).

VIK Industries premises consist of one storey building housing the offices and a separate structure for the production line and store. The storey building housing the administrative offices has offices with light controls, air-conditioners, fans and office equipment, while the factory production line has injection molding and blow molding machines with the electric motors and compressors.

VIK Industries working days are Monday to Saturday from 8am to 5pm throughout the year except for holidays and when there is need for overtime to meet demand.

The sources of electricity are PHCN and two standby generators of 725 and 1000 KVA respectively. The structures are properly earthed with good and functional switchgear system. The company has no energy saving policy and plan, and this is the first energy audit being conducted in the company.

METHODOLOGY

Inspection, calculations, analyses, and assumptions are the major audit techniques used along with one questionnaire administered to the operation manager of the company while the second questionnaire was filled during the on-the-spot inspection of the production to lookout for poor electrical housekeeping, poor operation, equipment misuse, energy control mechanism, maintenance, etc. The questionnaires are:

i. Electrical Equipment Data Questionnaire
ii. Industrial Equipment Energy Audit Form

Condition of the Facility and Equipment

The electrical injection molding and blow molding machines, electric motors, refrigerators, and air compressors are responsible for most of the energy consumed. The areas of energy waste due to condition of equipment were:

i. Noisy belts,
ii. Water and oil leakage at the production line,
iii. Some of the A/C units are poorly installed and exchangers,
iv. Most doors are not firmly shut leading to air escape,
v. In most offices, a switch controls between three to four lighting points,
vi. Housing keeping of electrical equipment by the staff is average.

Data Collection

The Electrical Equipment Data Questionnaire was administered, filled and returned, while the Industrial Equipment Energy Audit Form was filled during the walk-through inspection of the production line, oral interaction with production staff and visit to some selected offices at random.

Assumptions

VIK Industries has 9 hours as the production working hours apart from overtime to meet demands during peak period. In computing the daily wattage consumption (KWh) of each item, 26 working days were used per month to cover for overtime while the following operating hours were assumed: A/C – 10 hours; lighting fittings – 11 hours; computer sets – 4 hours, injection molding and blow molding machines, fans, electric motors and compressors – 9 hours; laptop – 8 hours; fridge – 24 hours; laser jet printer –2 hour; desk jet printer – 3hours.

It is important to remember that results are dependent on the quality of input data provided, and can only act as an approximation.

RESULTS AND DISCUSSIONS

The results of the “Electrical Equipment Data Questionnaire” is presented in Table 1 below with assumption that total working days are 24 days per month.

The grand total of the monthly electricity demand of VIK Industries is 49,529.22 KWh while the reactive power per month is 3,280.97 KVAR.

DISCUSSION

The Major Sources of Power Consumption

The results in the following tables show that molds and motor drives accounts for 75.49% of the energy consumed by VIK Industries Nigeria, Ltd., and they are inductive resulting in reactive power of 126.19KVAR per day. This can be improved by using capacitor banks or other power factor correcting mechanisms such as ElectroFlow to reduce the KVAR losses. Cooling is the second largest consumer of energy in the factory with 16.30%, this can be reduced by buying of soft-starting A/Cs and better electrical housekeeping. Lighting and Office equipment consumed the least with 7.43% and 0.75%, respectively.

Table 1: Results of Electrical Equipment Data Questionnaire.

ITEM	4Ft FL	Bulb	A/C	Fan	CRT	CPU	L-top	Comp	E/Kettle	Desk J	Laser J	Fridge	Motors	IM	BM	H/ Lamp
Units	182	28	26	11	5	5	3	1	1	2	1	4	-	3	2	12
Rating (Watts)	40	60	1,120	60	200	100	40	26250	2,000	100	650	150	51,000	30,000	22,000	400
Total Consumption	7280	1680	29120	660	1000	500	120	26250	2,000	200	650	600	51,00	90,000	44,000	4,800
Kilowatts (KW)	7.28	1.68	29.12	0.66	1.00	0.50	0.12	26.25	2.00	0.20	0.65	0.60	51.00	90.00	44.00	4.80
Power Factor			0.85	0.85									0.84			
KVAR Losses			4.37	0.099									8.16			
Hour Operation/Day	10	10	10	9	8	8	5	0.5	2	2	2	24	10	10	10	11
KVAR-Hr Per Day			43.7	0.891									81.6			
KW-Hour/Day	72.8	16.8	291.20	5.94	8.00	4.00	0.60	13.13	4.0	0.40	1.30	14.40	81.60	900.00	440.00	52.80
Total KW-Hr/Day	1,904.97															
Total KW-Hr/Month (26 working Days/)	49,529.22															
KVAR-Hr Losses Per Day	126.19															
KVAR-Hr Losses Per Month	3,280.97															

Table 2: Percentage of Power Consumption by Sector in VIK Industries.

N/S	Item	Total Nos. in use	Wattage rate	Total KW-Hr	KWh per Month	%
1	Lighting					
	FL Tube 4ft.	182	40	72.80	1892.8	3.82
	Bulbs	28	20	16.80	436.8	0.88
	H/Lamp	12	400	52.80	1352.0	2.73
					3681.6	7.43
2	Cooling and Fans					
	A/C	26	1,120	291.20	7571.2	15.23
	Refrigeration	4	150	14.40	374.4	0.76
	Fans	11	60	5.94	154.44	0.31
					8100.04	16.3
3	Molds and Motor drives					
	Electric Kettle	1	2,000	4.0	104.0	0.21
	Blow Mold	2	22,000	440.00	11,440.0	23.09
	Injection Mold	3	30,000	900.00	23,400.0	47.22
	Induction Motor	-	51,000	81.60	2,121.6	4.28
	Air compressor	1	26,250	13.13	341.38	0.69
					37,406.98	75.49
4	Office Equipment					
	CRT Monitor	5	200	8.00	208.0	0.42
	CPU	5	100	4.00	104.0	0.21
	LaserJet Printer	1	650	1.30	33.8	0.07
	DeskJet Printer	2	100	0.40	10.4	0.02
	Laptop	3	40	0.60	15.6	0.03
					371.8	0.75

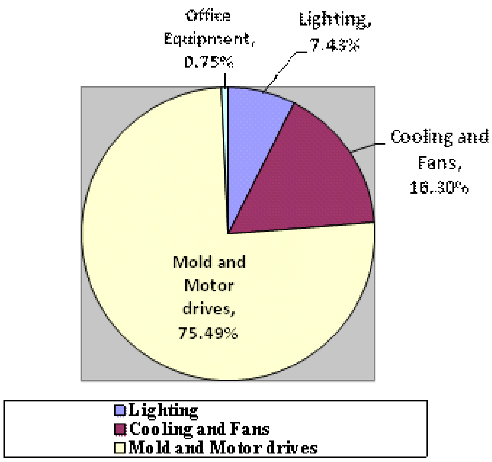

Figure 1: Pie Chart of Power Consumption by sectors of VIK Industries

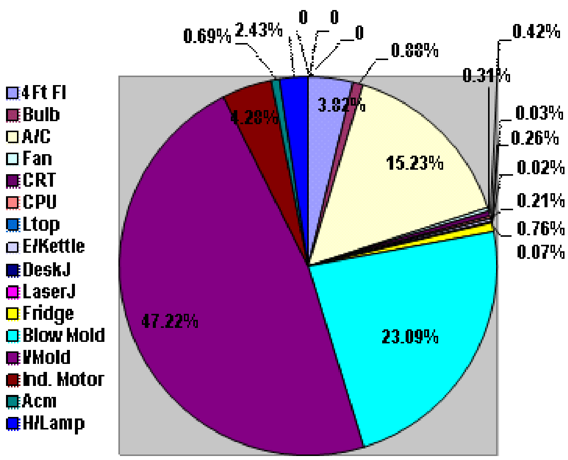

Figure 2: Pie Chart of Power Consumption by items in VIK Industries.

THE FACTORY

The average energy consumption of VIK industries was computed to be 22,260 KWh per for the year 2009. The value of the average monthly electricity demand consumption is slightly higher that the computed value of the energy audit.

Baseline Electricity Consumption (BCE)

BCE = $((DC_{jan} + \ldots + DC_{sept})/9\text{months}) \times 12\text{months}$ = 26,360 KWh

Where, DC_{jan}= Demand Consumption for January Month, DC_{sept} = Demand Consumption for September month.

Average Monthly Electricity Bill (AMEB)

AMEB= $((EB_{jan} + \ldots + EB_{sept})/9) \times 12$= N351,875.48
Where, EB_{jan} and EB_{sept} – Electricity Bill for January and September, respectively.

Identified Energy Management Opportunities

Below is a computation of energy consumed by lighting points, the cost of current consumption and, where appropriate, the potential savings.

Retrofit of 4-feet fluorescent and incandescent lamps with CFLs

Calculation of Estimated Energy Savings per annum (CEES), KWh.

CEES = ((wattage of fluorescent lamp – wattage of CFL) x Total Nos. of Retrofits + (wattage of incandescent lamp – wattage of CFL)) x Total Nos. of Retrofits x Nos. Operating hours per annum = 28,348.32KWh.

Calculation of Cost Saving per annum (CS), ₦
CS = CEES x Charge per KWh = **₦301,342.64**

Calculation of Implementation cost, ₦

- Nos. of fluorescent and incandescent lambs to be retrofitted = 210 points
- cost of 210 CFLs @ ₦500 per unit = ₦105,000.00
- cost of 210 lamp holders @ ₦100 per unit = ₦21,000.00
- Cost of 12 CFL of 120 watts @ ₦4,000 per unit = ₦48,000
- Workmanship = ₦20,000.00
- Contingency = ₦5,000.00
- Total = ₦199,000.00

Therefore, the Pay Back Period is (Cost of Implementation/Cost Saving) = 8 months.

Change of CRT monitors to Flat Panel Screen Monitors

Using the data in Table 1, the number of computers with CRT is as follows:

- 5 Nos. of CRT monitors in use
- 5 Nos of CPU in use
- Each CRT monitor operates at 200W
- Each CPU operates at 100W
- A Laptop operates at 40W

Calculation of Annual Power Saving in KWh

- Power consumption by 5 Nos. CRT monitors = Quantity x Wattage x Operating hours = 5 pieces x 200 x 8 hours per day x 26 days per month x 12 months per year = 2496 KWh

- Power consumption by 5 Nos. CPUs = Quantity x Wattage x Operating hours = 1248 KWh

- Power consumption of 5 Laptops = 460.8KWh

- Annual Power Saving in KWh = CRT monitors and CPU Power consumption – Laptop Power consumption = 3283.2 KWh

- Cost Savings = Annual Power Saving x Charge per KWh = **₦34,900.42**

Calculation of Implementation Cost, ₦

- Purchase of 5 pieces of Laptops @ ₦105,000.00 = ₦525,000.00

Calculation of Payback period (PBP) in years

- PBP = (Implementation cost/Cost Savings) =15 years

Though the payback period is high but for future purchase and replacement, Laptops can be targeted to replace the Desktop computers. In addition, the old Desktops can be auction to reduce the payback period for replacement.

Computation of Power Factor Compensation

Most of the loads connected to electrical supply in VIK Industries that consume 75.49% of the energy are inductive in nature. Therefore, in order to meet the magnetic component of the load, additional reactive power is drawn from the power supply, which is normally represented as kVAr.

Assuming Power Factor (PF) of 0.97 for all the inductive equipment after correction, then the energy saved can be calculated from Table 1 as
= 159.59KWh

Cost saving per annum = 49,791.768 KWh

Energy Saving Per Annum
The total saving per annum will be = 49,791.77KWh

The Cost Saving per annum @ ₦10.63 is = ₦529, 286.49

Cost of Implementation and Payback Period
The cost of using ElectroFlow for power factor correction is N3, 400,000

The cost recovery = (cost of using power factor correction mechanism/ cost saving per annum) = 6.4 years.

The compensation will improve system efficiency; improve longevity of drives in addition allowing more load to be added to the system without changing switchgears and cables.

ENERGY SAVING THROUGH GOOD HOUSEKEEPING AND PROPER OPERATION

One of the aims of the walk-through audit is to identify bad practices, inefficient equipment and poor energy habit in order to save power consume.

Electrical Drives

Some energy can be saved by:

i. The some of the motors were observed to be noisy because they have been rewound more than twice. Those motors cab be replaced.

ii. Some of the motors were dirty, dusty and poorly ventilated and energy can be saved if they are properly ventilated to reduce energy loss to heating.

Refrigerators and Air Conditioners

Serving of the air condition and refrigeration equipment was observed to be only on average, therefore some of them are already dirty and dissipating much heat. And the organization has no minimum temperature setting for air conditioner and refrigerators so that staff can use it for regulating their temperatures.

Energy can be saved by VIK Industries if:

i. The heat exchangers are regularly cleaned for easy heat transfer.

ii. They are not placed in direct access to sunlight or heat dissipating objects.

iii. Cooling temperatures are set for the entire company to avoid wastage.

iv. Doors should be fitted with springs to allow for self-control to trap cold air.

Lighting Points

During the walk-through, it was observed some of the lighting points were on even though the sunlight was bright enough to provide illumination. Energy consume through lighting can be reduce by:

i. Providing electronic control to conserve day-time power waste for lighting. Energy conservation of the order of 10% can be achieved by making arrangement to switch off lights automatically when not required.

ii. Proper choice of lighting: Choose the Right Light.

Heaters Plants and Dryers

The heaters were observed to be losing heat because they are not properly lagged and the dryer is regularly clean.

In order to save some energy, there is a need to:

i. Lagged heaters will reduce heat lost to the environment.

ii. Dryer should be regularly cleaned

CONSTRAINTS AND RECOMMENDATIONS

Constraints

1. VIK Industries was not prepared to give the one year PHCN monthly bill for the purpose of this audit.

2. Since the audit is a walk-Through audit, power audit equipment were not used for measurement, rather values were approximations.

RECOMMENDATIONS

Based on the discussion and data from the audit report, the following can be recommended as measures to conserve energy:

1. Capacitor banks should be used to correct the power factor in order to free the reactive power.

2. Retrofit of all the 4-feet fluorescent and incandescent lamps with Compact Fluorescent Lamps CFLs.

3. Put spring mechanism on the door of rooms with A/Cs for unmanned closing of the doors.

4. Increase awareness among the staff on how to conserve energy when using A/C, computer monitor and CPU.

5. Energy saving policy should be developed and implemented with a staff designated to supervise the timeline.

CONCLUSION

The walk through energy audit of VIK industries has been completed with areas of energy usage/waste identified. From the audit, it was observed that molds and motors were largely responsible for most of the energy consumed in the factory followed by cooling and lighting respectively. Hence the recommendations given above as possible measures to effectively conserve and manage available energy.

A meaningful energy efficiency and conservation program depends on the determination of the end-users to implement recommendations and opportunities identified by energy audits.

Energy audit is not the solution, but a prelude to effective energy efficiency and conservation programs.

APPENDIX A

Abbreviations

A/C	Air Conditioner(s)
CFL	Compact Fluorescent Lamp
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DestJ	Desk Jet "Printer"
KWh	Kilowatt hour
LaserJ	Laser jet "Printer"
N/A	Not available
PHCN	Power Holding Company of Nigeria
InD	Infrared Heater
RH	Resistance Heater
FL	Fluorescent

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