ENERGY ASSESSMENT OF BETA GLASS PLANT

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ABSTRACT

This paper describes the plant-wide energy assessment carried out at Beta-Glass factory. After the initial tour of the plant, relevant data were collected for the period of June 2005 to May 2006. Using these data, the performance parameters of the plant were calculated. The work showed that the specific energy consumption of the plant was 10.09GJ per ton of glass. Compared with world industry average of 4.8GJ per ton of glass (Phubalan, 2007), the plant specific energy consumption is high, meaning there is still much room for improvement. Result from the study showed that of the total energy (475988 GJ) consumed in the plant over the one year period, natural gas accounted for 94.7%, diesel 3.8% and electricity 1.5%. This shows that the glass company depend heavily on natural gas. In the audit work, it was also established that about 52.55% of the total energy input into the plant and about 84.52% of the total energy input into the manufacturing process, is consumed in the furnace. Thus the furnace is the most energy intensive unit in the plant and also holds the greatest energy saving potential in the plant.

Keywords: Energy assessment, Efficiency, Energy consumption, Glass industry, Specific energy consumption

1.0 INTRODUCTION

The cost of fuel has risen remarkably in recent years . In most energy intensive sectors, the energy cost takes up substantial share in the overall cost structure of the operation (Phubalan, 2007). Producing glass is an energy intensive process. Effective use of energy is therefore necessary to cut down energy cost to ensure that glass manufacturers remain competitive (Glass Best Practices, OIT, 2002).

In addition to saving money, energy efficiency or conservation is also an essential step being currently taken toward overcoming the mounting problems of world-wide environmental pollution and global warming (UNIDO and MITI, 1993).

Apart from the more obvious improvements in the house keeping aspects of factory practice, most effective savings are usually made in the high energy consuming areas.

Thus, it is imperative that detailed energy audit should focus on specific systems and major equipment like steam system, compressed air system, heat generators(i.e furnaces, boilers), heat recovery system, air-conditioning system e.t.c, (Gottschulk,1996).

Energy audit as a tool for energy management is a systematic study or survey to identify how energy is being used in a building or plant and identifies energy saving opportunities.

An energy audit or assessment provides essential information on how much, where and how energy in the form of electricity, gas, fuel oil or steam is used within a factory or building during a fixed period. This will indicate the performance at the overall plant or process level. The energy manager can therefore compare these performances against past and future levels for a proper energy management.

This research work was carried out in the glass factory to achieve the following objective:

- To determine the forms of energy used.
- To examine historical energy use and cost data.
- To identify areas of high energy consumption by carefully examining historical energy use and cost data.
- To relate energy consumption to production (i.e specific energy consumption).
- To determine where the most significant energy saving potentials are possible.

2.0 LITERATURE REVIEW

Manufacturers across the world are struggling with volatile energy costs. While many industrial decision-makers anticipate a solution in the form of lower energy prices, others are investigating the merits of efficient practices that reduce unnecessary energy consumption. An energy assessment (often referred to as an audit) is the key to identifying energy-saving opportunities (Christopher, 2006).

Pusat Tenaga Malaysia (PTM), which is the executing agency for the Malaysian Industrial Energy Efficiency Improvement Project (MIEEIP), conducted energy audits at twenty four factories from eight energy intensive sectors namely: Food, iron and steel, glass, rubber, cement, ceramics, paper and wood (Hishamudin, 2001). The results, which are presented in Table 1 reveal the typical base line energy usage per each sub-sector. Technical solutions proposed in the energy audit show massive potential for energy saving in every sub-sector with an average of almost ten percent of the energy usage. The results are bound to create a positive impact on the industries as well as the national economy and the environment. By saving energy, industries can reduce the emission of green house gases (GHG) into the atmosphere.

According to data made available by the standing Committee of the European Glass Factory, (CPIV, 2000), average specific energy consumption in the European industry decreased from about 22.5 GJ per ton of melted glass in 1960 to 9.0 GJ per ton of melted glass in 2000 while the specific CO_2 emission decreased from1800 kg per tonne of glass in 1960 to 7.5 kg of CO_2 per tonne of glass in 2000.

K. Phubalan (2007) noted in a report of energy audit work carried out by PTM at JG containers, Klang, Malaysia, that the specific energy consumption of 8.0 GJ per ton of melted glass recorded in JG containers is very high compared to average of 5.0 GJ per ton of melted glass in Europe. He also noted that specific energy consumption should meet below 4.8 GJ per ton of melted glass to reach world industry best Energy Efficiency (EE) standard.

In another energy audit work carried out by Clarke and Wilson (1993), study was made on the energy required for the production of food cans. The overall energy requirement for making a product is the gross energy requirement (GER) while the energy used within the factory walls is the process energy requirement (PER). These are expressed as energy requirement per unit of product and are expressed in terms of gigajoules per ton of product. The PER was estimated as 2.65 GJ/ton and the GER is 53.1 GJ/ton of product.

Aiyedun and Ologunye (2001), in an energy work with Cadbury Nigeria Plc, noted that for many industries, the cost of energy consumed is a major factor in the operating cost and must be closely monitored and reduced to a possible minimum in order to improve profitability and competitiveness.

In their work, data was collected for a five-year period (1994-1998) and various energy performance parameters were used in analyzing the data. The normalized performance indicator (NPI) value calculated for the five year period gave an average value of 1.16GJ/m^2. This was rated as "fair" for the factory, meaning that significant savings/ improvement in energy usage is still achievable. The average cost of energy input per ton of product was estimated as N4960/ton. The highest value of N6090/ton in 1995 was attributed to wastage and lack of cost consciousness. The average energy productivity or specific energy consumption (energy requirement per ton of product) was estimated as 24.7GJ/ton of bottle.

3.0 DATA COLLECTION AND ANALYSIS

The energy used in the plant comes from three main sources; electricity which is the most refined source, natural gas and diesel fuel. Natural gas used in the plant is consumed basically in the furnace, fore hearth and gas turbine while the diesel fuel is used for running two standby generators in the plant.

One year data (from June 2005-May 2006) was collected for a plant-wide energy assessment. Data collected included:

- Fuel consumption and cost
- Electricity consumption and cost
- Production output

3.1 Fuel Consumption

The natural gas used in the plant is metered in standard cubic feet (SCF) while the diesel fuel is metered in litres. The monthly quantity of natural gas used was converted to m^3 and that of diesel was converted to kg. The various conversions were carried out as follows:

For natural gas,

1 SCF = 0.0283 m^3

In January for example, 32,889 SCF = 32889 x 0.02832 m^3 = 931 m^3

For diesel fuel, Mass of fuel is obtained using the expression:

Mass (kg) = volume (litres) x specific gravity of fuel

For diesel fuel, specific gravity is given as 0.898

In January for example, mass (kg) = 62,013 x 0.898 = 55688 kg

Table 2 shows the monthly natural gas and diesel consumption in the plant during the one year period of the audit.

3.2 Electricity Consumption

Electricity used in the plant is obtained from three different sources namely: Gas turbine and diesel generating units, both situated in the plant and PHCN. Based on electricity billing data collected from Beta Glass, the annual electricity consumption in the plant for the one year period was 18,457,097 kWh. Out of this total quantity of electricity used in the plant, the gas turbine unit generated 15,556000 kWh, the diesel generators 907,654 kWh and about 1,993,443 kWh was bought from PHCN.

Table 3 shows a summary of the monthly electricity consumption in the plant.

3.3 Energy Consumption/Production Output

Energy is supplied to the plant externally via three sources: natural gas, diesel, and electricity from PHCN. Table 4 gives a summary of the monthly energy consumption via the three energy sources and the monthly production output.

Table 5 shows the annual energy consumption and cost for the three energy sources in the plant. These distribute into the total energy consumption and cost. For an annual production output of 43,703 metric tons of glass, 475988GJ (11376 x 10^6 kcal) of energy was delivered to the plant. This was delivered at a total cost of about N224 million.

3.4 Energy Performance Result of Plant

Two major energy performance indicators used in glass factories were used in evaluating the plant based on data collected during the one year period. They are as follows:

Specific energy consumption (GJ/ton)

This is the total energy consumed per unit of production (ton or kg), given by:

$$e = \frac{E}{m} \quad (1)$$

where e is the specific energy consumption, E is total energy consumed, and m is the total production output.

The total production output in this case represents the total ton of packed glass and not of melted glass.

Specific energy cost (N/ton)

This is the cost of energy required to produce a unit ton of packed glass, given by:

$$C_e = \frac{C_E}{m} \quad (2)$$

where $C_e$the specific energy cost and C_E is the total energy cost.

Table 6 gives a summary of the energy performance result of the plant. For the plant, the specific energy consumption for the specified period is 10.89GJ/ton (2602772kcal) per ton of packed glass and the specific energy cost is ₦5343 per ton of packed glass (₦5.343 per kg of packed glass).

Thus to produce 1 ton of glass in Beta Glass (Delta plant), about 10.89GJ of energy is required at cost of ₦5.343.

3.5 Distribution of Energy Consumption

One of the major objectives of this research is to identify areas of high-energy consumption in the plants by analyzing the historical energy consumption in the plants via analyzing the historical energy consumption data. This will enable the energy auditor to know areas in the plant, where the most significant energy saving potentials are possible through improved energy efficiency.

In an attempt to achieve this objective, data for the energy consumption (in the form of electricity, natural gas and diesel) in each section of the glass bottle manufacturing process as well as the necessary utilities were carefully gleaned.

Table 7 shows the distribution of the energy consumption in the various units of the plant.

Some audits give the distribution of the energy consumption for only the production process but this audit has been made to cover the entire plant having observed that some of the utilities also consume considerable amount of power.

In analyzing the data, each process and unit of the plant was made to grasp the specific fuel consumption or specific electricity consumption as the case may be. The specific energy consumption was estimated based on an average of 120 ton of glass produced per day from one furnace.

4.0 RESULTS AND DISCUSSION

4.1 Observations

Based on the result and findings of the energy assessment carried out in the Beta glass factory, the following were observed:

- The total energy consumed in the entire plant over the one year period is 475988 GJ. Out of this total, natural gas accounted for 94.7%, diesel 3.8% and electricity 1.5%. This shows that the company depends more heavily on natural gas.

- The total cost of energy in the plant over the one year period was N223.5 million, of which natural gas accounted for 77.8%, diesel 12.8% and electricity 9.4%

- The furnace is the most energy intensive unit in the plant. It consumed about 52.55% of the total energy input into the plant and about 84.52% of the total energy input into the manufacturing process. Thus, the furnace holds the greatest energy saving potential in the plant.

4.2 Efficiency of Glass Production

The plant specific energy consumption was estimated as 10.89 GJ. As far back as 1960, glass plants operated with specific energy consumption of 22.50 GJ/ ton glass.

Presently, in some glass factories around the world, specific energy consumption are as low as 4.8 GJ/ton glass. Thus there is still much room to further reduce the specific energy consumption of the Beta glass factory.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

A study of energy use in the Beta glass factory was carried out to assess the energy use pattern and efficiency of energy use.

Based on the findings of the energy assessment, the following conclusions can be drawn:

- Natural gas fuel was the predominant energy source employed for the production process in the factory.

- The specific energy consumption calculated for the plant showed an average result, meaning there is still vast room for further improvement.

- The furnace is the most energy intensive unit in the plant and also holds the greatest energy saving potential in the plant.

5.2 Recommendations

1. Further work should be carried out on the glass melting furnace to quantitatively determine its energy efficiency.

2. More glass industries in the country should be included in future work to give a better average of the energy situation in the glass industry in Nigeria.

3. Mathematical modeling of the energy use data based on recommendation 2 should be given attention.

Month	QUANTITY(NATURAL GAS)		QUANTITY (DIESEL)	
	X 1000 SCF	X 1000 Nm^3	Litres	Kg
Jun.-05	32,820	931	62,013	55,688
Jul.-05	35,820	1014	39,798	35,739
Aug. -05	36,701	1039	66,640	59,843
Sept.-05	35,449	1004	92,590	83,146

Table 1: Malaysian Industrial Energy Efficiency Improvement Project Audit (2001)

Industrial sub-sector	Typical base line energy usage per sub-sector	Potential energy saving percentage to energy usage	Potential energy savings per sub-sector	Total potential CO_2 reduction
	Toe/yr	%	Toe/yr	Ton/yr
Food	172,275	9.3	16,095	53,1562
Iron and steel	521,964	5.9	30,805	102,689
Rubber	281,820	10.1	28,420	94,739
Cement	101,490	8.0	8,127	27,092
Ceramic	39,079	8.8	3,442	11,473
Glass	124,354	2.6	3,295	10,983
Paper	93,682	6.5	6,063	20,210
Wood	3,872,921	23.0	890,812	2,969,488
Total	5,207,585	9.3	987,059	3,290,326

toe= ton of oil equivalent (conversion factor, I toe = 41.84 GJ)

Table 2: Monthly natural gas/diesel consumption

Oct.-05	36,766	1041	12,081	55,749
Nov.-05	32,468	919	14,242	12,789
Dec.-05	32,560	922	14,155	12,711
Jan.-05	35,318	1009	12,796	11,491
Feb.-06	31,862	902	25,211	22,639
Mar.-06	32,194	912	17,371	15,599
Apr.-06	39,459	1117	18,157	16,305
May.-06	45,720	1295	14,149	12,706
Total	427,206	12,105	439,203	394,405

Table 3: Monthly electricity consumption (kWh)

MONTH	TURBINE Electricity (kWh)	NEPA Electricity (kWh)	GENERATOR Electricity (kWh)
Jun.-05	1101000	171458	138268
Jul.-05	1244000	142697	83586
Aug.-05	1348000	188953	161385
Sept.-05	1386000	154599	255539
Oct.-05	1312000	113398	140580
Nov.-05	1243000	122450	3300
Dec.-05	1243000	55100	2631
Jan.-05	1367000	157350	16716
Feb.-06	1281000	161069	57877
Mar.-06	1385000	221850	19461
Apr.-06	1331000	179336	6970
May.-06	1315000	325183	21341
Total	15556000	1993443	907654

Table 4: Energy consumption/production output

Month	Natural Gas GJ	Diesel GJ	Electricity (NEPA) GJ	Total GJ	Production Output (metric Ton)
Jun.-05	34661	2562	617	37840	3112
Jul.-05	37751	1644	514	39909	3849
Aug.-05	38682	2753	680	42115	4059
Sept.-05	37379	3825	557	41761	3823
Oct.-05	38756	2564	408	41728	4212
Nov.-05	34214	588	441	35243	2929
Dec.-05	34326	585	198	35109	2776
Jan.-05	37565	529	566	38660	3900
Feb.-06	33581	1041	580	35202	3784
Mar.-06	33954	718	799	35471	3583
Apr.-06	41586	750	646	42982	3495
May.-06	48213	584	1171	49968	4181
Total	450668	18143	7177	475988	43,703

Table 5: Energy consumption and cost

Energy source	Annual quantity	Heating value	Price per unit	Cost $x10^6$₦	% cost	Energy consumpt. common basis (GJ)	% Energy	Energy cost Per common Unit(₦/GJ)
Natural Gas	12,105000 m^3 (4270600 SCF)	37.23 MJ/m^3	₦407 per 1000SCF	173.9	77.8	450668	94.7	385.9
Ago diesel	394405 kg (439203 litres)	46.00 MJ/kg	₦65 per litre	28.5	12.8	18143	3.8	1570.9
Electricity (PHCN)	1993443 kWh	3.60MJ/kWh	₦10.57 per kWh	21.1	9.4	7177	1.5	2939.9
Total				223.5	100	475988	100	

Table 6: Energy efficiency performance result

Total energy consumed	475988 GJ
Total energy cost	₦233.5 x 10^6
Total production	43703 tons
Specific energy consumption	10.89 GJ
Energy cost per metric ton of packed glass	₦ 5343/ton glass

Table 7: Distribution of energy consumption

End-use category	Natural gas MJ/day	Electricity MJ/day	Ago diesel MJ/day	Total(MJ/d)	(MJ/d.ton)	% Process	% Plant
A PROCESS							
Batch plant		5213		5213	43.44	0.55	0.35
Cullet crushing plant		1297		1297	10.81	0.14	0.09
Cullet washing plant		3418		3418	28.48	0.36	0.23
Quarry plant		3845		3845	32.04	0.41	0.25
Furnace	741744	51978		793722	66144.35	84.52	52.55
Fore heart/lehr	86676	19569		106244	885.37	11.31	7.03
Forming machines		22075		22075	183.96	2.35	1.46
Printing/packaging		3301		3301	27.51	0.35	0.22
Total					7825.96	100.00	
B. UTILITY							
Lighting		7297		7297	60.81		0.48
Compressed air system		80362		80362	669.68		5.32
Water treatment/pumps		9021		9021	75.18		0.60
Estate/ Admin. Block		17334		17334	144.45		1.15
Power generator(Turbine)	405710	1728		407438	3395.32		26.98
Diesel generators			49706	49706	414.22		3.29
Total	1234130	226438	49706	1510273	12585.62	99.00	100.00