Energy optimization in the brewing industry: Case study of East African breweries limited Nairobi

Mutua James and B. K. Kariuki

Abstract—Most brewing companies nowadays are working towards increased productivity, competitiveness and profitability. A great draw back to the realization of this ambition is the escalating cost of energy resources. Besides, energy is getting scarce as its availability is drastically reducing with the ever increasing demand resulting from growing industrialization. The primary sources of energy for the industry are fuel oil and electricity. Liquefied petroleum gas (LPG) and diesel also form the secondary energy resources utilized by the companies. A small percentage reduction in these energy consumptions, and thus the cost, will allow for significant reduction in the cost of production per unit volume of the factory. This will in turn lead to even more competitive pricing.
This paper will identify all the energy saving opportunities (ESOs) in the brewing industry and suggest the best energy management practices that would lead to optimization of energy consumption. Further, target setting, benchmarking, monitoring and evaluation of energy utilization will be presented. An implementation plan for the identified ESOs will eventually be suggested.

Keywords—Energy optimization, energy management practices, energy saving opportunities, target setting.

I. INTRODUCTION

ENergy management is an astute and effective use of energy to maximize profits and enhances chances of competitive positions. Effective management of energy consuming systems can lead to significant saving in energy and cost of energy and extended equipment life. From inception, energy management is an ongoing process that is integrated with routine plant operations or building maintenance, occupancy or mechanical equipment [1]. This helps in optimizing energy usage. Energy management comprises of four main steps; Energy data analysis which entails reviewing utility & fuel energy bills on a monthly and annual basis and comparing them to a previous reference year. Energy audit is a complete assessment of the manufacturing facility and its energy use patterns. Here, utility bills are reviewed to determine actual energy use of selected equipment. Carrying out energy audit provides the necessary information for designing an implementation program. A set of energy saving measures with individual simple pay back periods are developed from the energy audit. The list is usually divided into no-cost housekeeping measures, low-cost maintenance and upgrading and major retrofit projects involving considerable capital expenditure [2].
Implementation of the recommended saving measures identified in the energy audit and eventually monitoring and target setting facilitates the use of information on energy consumption as a basis for controlling and managing consumption downward [3].

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II. OVERVIEW

East African Breweries Limited (EABL) spends a sum of Ksh. 1.05 Billion on average per annum, on its primary energy resources alone. This sum comprises Ksh. 425 million, on 500,000 GJ of fuel oil energy and Ksh. 625 million on 167,000 GJ of electricity [4].
EABL has a clear statement of the organizations policy about energy efficiency, waste levels and the length to which the company is willing to go to promote efficiency and reduce waste. In light of this, the company has of late installed modern equipment in the process heating line with more heat recovery options. This way, the company was able to save up to 20% of its energy expenses. Moreover, the company has taken a leading initiative on environmental conservation program, with energy conservation as the road-map. A number of energy saving systems has been established in the facility to conserve energy and ensure efficient energy use. They include; The facility is metered on both high rate and low rate electricity tariff, changing from hard start to variable speed drives for heavy electric prime movers, boiler efficiency tests and flue gas analysis are frequently performed on running boilers, the facility has installed capacitor banks on most heavy prime movers to ensure a higher power factor and thus mitigate power factor surcharges and continuous evaluation of performance of the energy consuming systems with a view of ascertaining their efficiency and to optimize plant operations.
However, EABL has not undertaken a proper energy audit of its facility before, except for an electricity evaluation conducted in the year 1990 among others energy evaluation exercises. Thus as part of the energy management and conservation initiative, a proper energy audit of the facility was deemed necessary.

III. METHODOLY

To effectively analyze energy consumption in the facility, three modes of data acquisition were adopted, these included;

- Historical data collection
- Walk through audit
- Actual data collection

A. Historical audit

A three year historical audit was conducted, with 2005 / 2006 as the reference year. Comprehensive enumeration of the historical data led to: Establishment of Energy use pattern for the facility, determination and plotting of Energy use indices(EUI) and determination of the relative consumptions for the major Energy resources namely Electricity and Fuel Oil.

B. Walk through audit

An understanding of HOW, WHEN and WHERE the energy resources are utilized at EABL with view of spotting potential Energy Saving Opportunities was conducted. This also formed reference point for monitoring progress. The major Energy Saving Opportunities identified were recorded and analyzed.

C. Actual data collection

For a duration of 3 months actual data readings from electricity, steam and water metering points were taken. further, diesel, petrol, fuel oil consumption and liquified petroleum gas usage were too recorded. This formed the basis for calculating site energy balance and a reference point for maximizing on available energy resources and eradication of any possible inefficiencies in the plant.

IV. RESULTS AND DISCUSSION

The eight most conspicuous energy saving opportunities identified were;

A. Energy saving opportunities

- Biogas Collection & utilization
  During the time of the study, the gas was being freely flared into the atmosphere. An average of 800 m^3 / day was flared. This is a strategy to dispose industrial waste (waste water) in environment friendly states (CO_2 & HO_2). With correct and controlled reactor temperature of 38^{o}C), pH and micro organic level, the reactor yielded 7200 m^3/day of the biogas. However this gas collection & utilization had a huge potential saving in heat & electric energy requirements of the facility.
- Condensate recovery around site
  Condensate recovery from a number of areas on site is poor, majorly because the condensate return system is inefficient & lacks proper sequencing. Hence such condensate channeled to the drain. This was evident in the oil heater, line3, line 4 & keg line. Improved condensate recovery would bring savings in fuel, water & chemical costs.
- Softener Make-up water & Heavy furnace oil(HFO) Preheating
  Currently the HFO & make-up water is preheated using steam direct from the boiler. A saving in fuel cost can realized if alternative heat sources are adopted for this heating, e.g., waste heat from marsh kettles or enhancement of the flared biogas.
- Boiler Economizer
  At the time of this study, boiler 2 (under commissioning), was the only boiler fitted with an economizer. Boilers 1, 3 & 4 had no economizers, & the flue gas released had huge energy levels. In practice, an economizer guarantees a saving of up to 9% energy input.
- Fused Fluorescence Light fixtures
  Fused fluorescence light fixtures consume some energy when powered. According to SADC Industrial Energy Management Project, such fixtures consume at least 15% of the rated power. A physical count of both functioning and fused fluorescence light fixtures (58W) was undertaken on site. It was found that an average of 27% of such installed fixtures was fused. Immediate savings at zero cost would be realized with removal of such fused fixtures. To prevent premature extinction of the functioning tubes, the fused tubes are replaced with dummy tubes.
- Halogen Security Light System
  250W halogen lamps were in use for security lighting within the plant. However, these were switched from designated control points. Such a strategy is only as reliable as the operator. A sum of 31 of these fixtures (over the tank farm & condensers) was observed to be on at least twice a week. Installation of photo controls (photo cells) on the security light system would bring immediate saving at low cost, by eliminating the unutilized utility operating hours.
- Cooling tower ID fans
  The plant had two large & one stand alone cooling towers all running on duty. Each of the large has 2 off 11 kW twin ID fans and the stand alone has single 11 kW ID fan. The cooling load on the cooling towers varied significantly at different times of the day and at different weather conditions, due to effects of natural convection. Installing variable speed drives (VSDs) would provide speed stepping at different cooling loads & thus reduce electrical energy input significantly. The VSDs would also eliminate cases of the fans running at low loading factors which result in very low motor efficiencies.
- V-Block and Temporary Frigg NH_3 Compressors
  The NH_3 compressors operated with a load of 1140 kW. The V-block plant had been in operation for over 50 years & the low efficiencies outweigh its synchronizing ability (power factor correction) far much. Recommissioning the plant with 2 off 500kW screw compressors & VSD primary glycol pumps would significantly reduce the energy input.

B. Site electricity balance

Electricity formed the main source of energy used by the facility. A the refrigiration plant lead the pack in terms of consumption as shown in Fig.1

C. Site steam balance

Steam formed the major form of energy used in drying of yeast, heating the brewing kettles and sterilizing beer bottles before packaging. The energy balance for the same was done and recorded in TableI

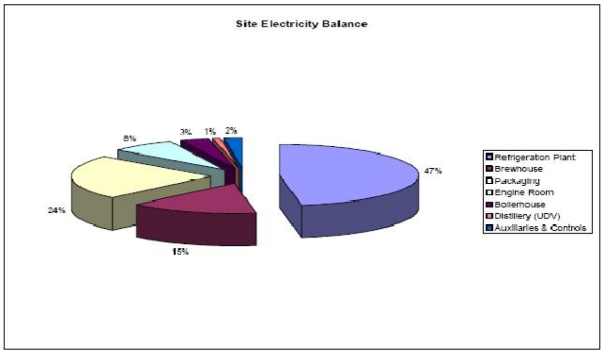

Fig. 1. Site electricity balance

TABLE I
SITE STEAM BALANCE

Area / Consumer	Units	Meter Reading		3 Months Consumption (92 Days)	Conversion factor	Nominal Consumption (kg/hr)	Derived Consumption (kg/hr)
		1/10/2008	1/1/2009				
Yeast Drier	Tonnes	55817.70	60174.20	4356.50	1	1973.05	2849.96
New Brew House	Tonnes	150443.00	153428.00	2985.00	1	1351.90	1952.74
Old Brew House	Tonnes	84843.00	102537.00	17694.00	1	8013.59	11575.15
Pack Line 3	Tonnes	36745.00	36745.00	0.00	1	0.00	0.00
Pack Line 4	Tonnes	79873.70	87922.20	8048.50	1	3645.15	5265.21
CPA	Tonnes	7632.00	8502.70	870.70	1	394.34	569.60
Total	**Tonnes**			**33954.70**		**15378.03**	**22212.65**

D. Savings analysis in the identified ESOs

The possible saving that could be attained after implementation of the identifies opportunities were summarized in TableII

TABLE II
SUMMARY OF ENERGY SAVING OPPORTUNITIES (ESOS)

Description	Energy Saving Opportunities	Operating Cost (Ksh)	Saving (Ksh)	Implementation Cost (Ksh)	SPB (yrs)
Maintenance Practice	Check & Align Belt Drives on NH3 Condensers FD Fans	230,412,655	9,216,506	0	0
	Control Noise and vibration on NH3 Condensers FD Fans	230,412,655	4,608,253	0	0
	Remove Fused Fluorescence Light fixtures	4,981,249	278,573	0	0
Low Cost Projects	Enhance Condensate Recovery around Site	12,124,153	10,216,620	2,900,000	0.28
	Preheat Softener Makeup water & HFO Using Waste Heat	9,330,356	9,330,356	3,000,000	0.32
	Install photo-control on Halogen Lamp Security Light System	566, 161	125,814	45,000	0.35
	Fit Boiler Economizers	427,251,528	27,814,811	9,750,000	0.35
	Fit Water Softener Unit on Condenser Water Feed	230,412,655	4,608,253	2,600,000	0.56
	Install VSD on Feed Pumps to pH Correction Tank	2,670,705	1,303,304	780,000	0.60
Retrofit Projects	Install Air Compressor Control (sequencer)	19,133,237	4,089,103	2,600,000	0.64
	Install VSD on Boiler FD Fans	8,981,764	3,465,838	2,600,000	0.75
	Install VSD on Effluent Upflow Pumps	2,670,705	1,303,304	1,040,000	0.80
	Install Biogas Collection & Utilization Plant	427,292,160	77,439,574	68,500,000	0.88
	Install VSD on CTL 6 Distribution Pumps	2,089,085	806,126	780,000	0.97
	Install VSD on Cooling Tower ID Fans	4,243,454	2,070,805	3,000,000	1.45
	Install VSD on Pasteurizer Supply Pumps	1,141,875	440,621	650,000	1.48
	Install VSD on Bottle washer Supply Pumps	1,141,875	440,621	650,000	1.48
	Replace V-Block & Temporary Frigg NH3 Compressors with Screw set plant	134,944,992	26,988,999	(40,000,000)	1.48

E. Target setting , benchmarking and monitoring

For the facility to operate at a profit, a target of electricity had to be set, both internally and in comparison with the world targets. From the electrical energy consumptions the average specific energy was 0.03615 GJ/HL. Compared with the world target of 0.036GJ/HL, EABL is almost attaining the world specific energy for brewing [5]. With implementation of the recommended measures, the facility will attain this ratio in electrical energy consumption and possibly set a new world record of electrical energy ratio for brewing. Graphically, the actual, target and optimum ratios of electrical energy in GJ/HL for the period of June-December 2008 are depicted in the Fig.2.

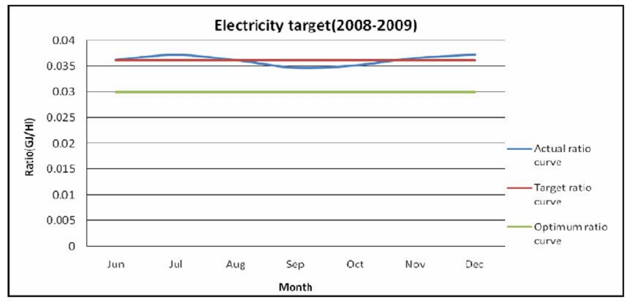

Fig. 2. Actual, Target & Optimum electrical energy ratio for Jun-Dec 2008

A target for fuel oil consumption was set with reference to the world ratios as can be seen in Fig.3. From the plot of fuel oil energy ratios against time in Months, the actual fuel oil energy ratio largely deviates from the target ratio. This is an indication of how fuel oil energy consumption fluctuates depending on product demand. With observation of recommended energy saving measures, however, such form of instabilities can be minimized.

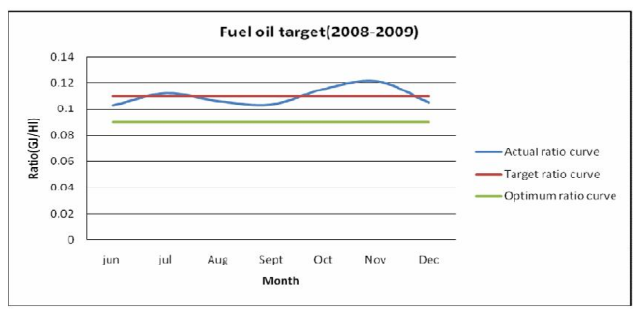

Fig. 3. Actual, Target & Optimum ratios for fuel oil energy

V. IMPLEMENTATION PLAN

A four years implementation plan for the ESOs was developed. The plan incorporated the facilitys future plans, implementation costs of the ESO measures and their individual payback periods. Major funding of the implementation costs is anticipated from the savings generated from the no cost maintenance practices. However, the facility was expected to inject Ksh. 6,534,226 of the total implementation cost of Ksh. 138,895,000 (4.7%), according to the implementation plan. This is summarized in Fig.4

Fig. 4. Four year implementation plan

Energy Saving opportunities (ESOs)	Implementation Year			
	1	2	3	4
1. Check & Align Belt Drives on NH_3 Condensers FD Fans 2. Control Noise and vibration on NH_3 Condensers FD Fans 3. Remove Fused Fluorescence Light fixtures	Ksh. 0			
1. Enhance Condensate Recovery around Site 2. Preheat Softener Makeup water & HFO Using Waste Heat 3. Install photo-control on Halogen Lamp Security Light System 4. Fit Boiler Economizers		Ksh. 3,707,168		
1. Fit Water Softener Unit on Condenser Water Feed 2. Install VSD on Feed Pumps to pH Correction Tank 3. Install Air Compressor Control (sequencer) 4. Install VSD on Boiler FD Fans 5. Install VSD on Effluent Upflow Pumps 6. Install Biogas Collection & Utilization Plant			Ksh. 2,827,058	
1. Install VSD on CTL 6 Distribution Pumps 2. Install VSD on Cooling Tower ID Fans 3. Install VSD on Pasteurizer Supply Pumps 4. Install VSD on Bottle washer Supply Pumps				Ksh. 0

A. *Recommendations*

It was recommended that a stable and flexible energy policy be established. This policy should be based on the facilitys objective to reduce energy consumption indices. Training of the staff and entire site of energy conservation awareness should also be undertaken.

Further establishment of an energy management office under the utilities department was deemed necessary. The bearer of this office should be the energy manager who should be remunerated from the human resource budget of the company for the initial 6 months of employment, after which, he be paid from the savings generated, according to commission and terms agreed upon with company management.

VI. Conclusion

The need for a clear statement on energy policy, a functional Energy Management System (EMS), and an energy office (with energy manager) under the utilities department, was emphasized. These were identified as fundamental tools to effectively manage and optimize the energy resources and thus save on under utilized energy consumption and the corresponding energy expenses. Energy saving opportunities (ESOs) for the facility were also identified and quantified. These amounted to Ksh. 184,547,481 per annum.

Acknowledgment

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