

# ENERGY AUDIT FOR A STEAM PLANT (CASE STUDY PYRETHRUM FACTORY IN NAKURU, KENYA)

**Ndugi D.S.**

Department of Energy & Industrial Engineering, Egerton University,  
P.O Box 536  
Egerton

**Ndiema C.K.W.,**

**Omwando T.,  
Osore, E. A.**

Department of Mechanical & Industrial Engineering, Masinde Muliro University of Science and Technology

**Yegon, E.**

Department of Mechanical & Mechatronics Engineering, Multimedia University of Kenya,  
P.O Box 15653-00503  
Nairobi

## ABSTRACT

Abstract: Energy conservation is an essential step towards overcoming the mounting problems of global energy crisis and related environmental issues. Energy Management is considered the key to effective energy conservation. Present study is dealing with developing an "Energy Management System", and implementing it in a real situation. A program was established as a continues improvement cycle. It started with formation of an energy management team, data collection, monitoring reports and audits. Hence the performance of a process plant can be improved by monitoring, analysis and adjustment of the appropriate plant operating parameters and in some cases, plant modifications. This involves studies of plant energy distribution and the corresponding losses associated with the various uses of energy, the scope and duration of a study may vary depending on the complexity of a plant and various operational requirements and constraints. Energy auditing has been established as useful tool for identifying energy wastage and opportunities for energy saving in a process industry. Heat recovery system is recommended for installation by retrofitting into existing plant in addition to other good housekeeping measures. Pyrethrum processing can be made profitable if energy losses are minimized. From the energy audit, it is possible for plant managers to differentiate the immediate energy saving potentials from those requiring either some investments or further studies. This paper outlines the methodology and the scope for carrying out an energy audit with the main objective of improving the overall plant energy efficiency. The procedure included plant familiarization, data collection and parameter measurement, analysis of energy consumption and losses in the various sections of a steam plant and recommendation for remedial measures

## Keywords:

**Pyrethrum, steam plant, energy audit, heat recovery, energy conservation.**

## 1. INTRODUCTION

The last decade has seen a near exponential increase in energy consumption in all the sectors of Kenya's economy. The increase demand for the petroleum products in transport industry has resulted in increased price of this energy source. According to

statistic, energy remain a primary input in most production processes and accounts for about 20-30% of production cost and in some cases up to 70% out of this about 10 to 30% is wasted as heat in the 2004, energy management measures were initiated by the Kenya government in collaboration with Kenya association of manufacturers to facilitate improvement in energy utilization [1]

In general the driving force towards energy conservation is the prospect of saving money. In the long term, saving energy reduces environmental pollution and retards the depletion of non-renewable energy resources. Towards this end, processing industries are encouraged to promote energy efficiency practices. Improvement of the current operating practices and the use of efficient technologies and equipment can help achieve energy saving objectives in the process industries. By virtue of diverse range of processes and process conditions, the industrial sector is the prime target for energy conservation. Identification of the energy saving opportunities in any process plant can be facilitated by undertaking an energy audit [2].

An energy audit is essentially an energy survey aimed at identifying and screening the scope and feasibility of improving the efficiency of a process plant. It is usually focused on the improvement of utility systems and utility equipment such as boilers, steam distribution systems, compressors, dryers and chillers [3]. To perform energy balancing for such equipment, data can be obtained from empirical measurements, thermodynamics tables and well-established correlations in literature. At the end of the energy audit, conservation measures are instated or recommended. These measures can be classified as short-term, medium-term and long-term measures according to the estimated payback period for the investment [4].

### 1.1 Energy Audit

An energy audit is a technique for identifying energy losses, quantifying them, estimating conservation potential, evolving technological options for conservation and evaluating the economics for the measure suggested.

- Assists industries in reducing their energy consumption.
- To promote energy-efficient technology through training programs and workshops.

- To promote transfer of energy- efficient and environment- sound technology to the industrial sectors in the context of climate change [5].

Based on [6] the energy audit process starts with an examination of the historical and descriptive energy data for the facility. Specific data that should be gathered in this preliminary phase includes descriptive information about the facility such as a plant layout, and a list of each piece of equipment that significantly affects the energy consumption. Before the audit begins, the auditor must know what special measurement tools will be needed. A briefing on safety procedures is also a wise precaution. During the implementation of the management program, two types of audits were conducted in the plant: internal and external audits.

## 2. METHODOLOGY

### 2.1 Plant Familiarization

Discussions with the plant management were held to establish the general background of the company and understand the overall process operations. Among other issues of interest were the plant's level of commitment and the extent to which the plant management is willing to invest. This was followed by a tour around the plant to familiarize with the processes and process equipment. During the tour, major energy consuming sections and areas having potential for improvement were identified.

### 2.2 Obtaining Relevant Plant Data

Before carrying out the conservation study, energy utilization and process operation data that are essential for the study were requested from the plant management. Some important information required included:

- Monthly energy consumption profile
- Equipment list by sections.
- Individual equipment and overall plant production rate.
- Individual process equipment specifications.
- Energy consumption for the overall plant and individual process equipment
- Periods of operation and annual plant and equipment operating hours.
- Fuel, type, characteristics and composition

### 2.3 Energy Audit Technique

The energy audit evaluates the efficiency of all process equipments/systems that use energy. The energy auditor starts at the utility meters, locating all energy sources coming into a facility. The auditor then identifies energy streams for each fuel, quantifies those energy streams into discrete functions, evaluates the efficiency of each of those functions and identifies energy and cost saving opportunities. The types of energy audit are walk through audit, total system audit, boilers/steam generations plant, steam system audit and specific energy consumption [7,8]

### 2.4 Determination of Energy Losses

After identifying the major energy consuming sections as the focal point of the study, a more detailed analysis of energy consumption and losses,(energy balance for the relevant sections of the plant) were performed. In order to carry out energy balance, process parameters such as steam flow rate, flue gas and fuel compositions, pressure, temperature and other boiler characteristics were measured. The list of the commonly used equipment for this study are shown in Table 1

Table1: Equipment for Energy Auditing

Parameter	Purpose	Description
Flow rate	Heat recovery potential	Flow meters
Temperature	Heat recovery potential	Thermocouples
Pressure	System optimization	Gauge manometers
Flue gas	Heat recovery potential	Flue gas analyzer
Smoke	Combustion improvement	Smoke tester
Water conductivity	Blow down recovery	Electronic meter

## 3. RESULTS AND DISCUSSIONS

### 3.1 Boiler characteristics

Fuel burnt in the boilers was mainly saw dust whose energy content as determined by the standard laboratory experiment was 16.3MJ/Kg an instantaneous boiler analysis was carried out by taking a sample of the flue gas from the boiler stack using an electronic flue gas analyzer. The measurement recorded by the flue gas analyzer included oxygen (O<sub>2</sub>) content carbon dioxide,(CO<sub>2</sub>)content and flue gas temperature. The overall boiler characteristic by measurement and calculation are presented in table 2

Table 2: Boiler characteristics

Fire rate	low
Capacity	14.5ton/hr
Steam pressure	6bars
Air temperature	21°C
Flue gas temperature	195°C
O <sub>2</sub> in flue gas	7.0%
CO <sub>2</sub> in flue gas	22ppm
Smoke test index	7
Sensible heat loss in flue gas	15.8%
Latent heat loss in flue gas	1.5%
Wall losses by conduction	6.9%
Thermal efficiency	75.8%

The amount of oxygen and carbon dioxide present in the flue gas indicate that the combustion process is just satisfactory. Furthermore the smoke test index corn firms that there is a large proportion of soot. The apparent inefficient performance can be address by modifying boiler burners. It has been shown that

retrofitting an existing boiler and adopting improved operation practices can result in significant energy conservation. The predisposing factor to poor performance of the boiler system is the use of saw dust as fuel whose combustion cannot be effectively controlled energy distribution in the boiler unit illustrated figure 1

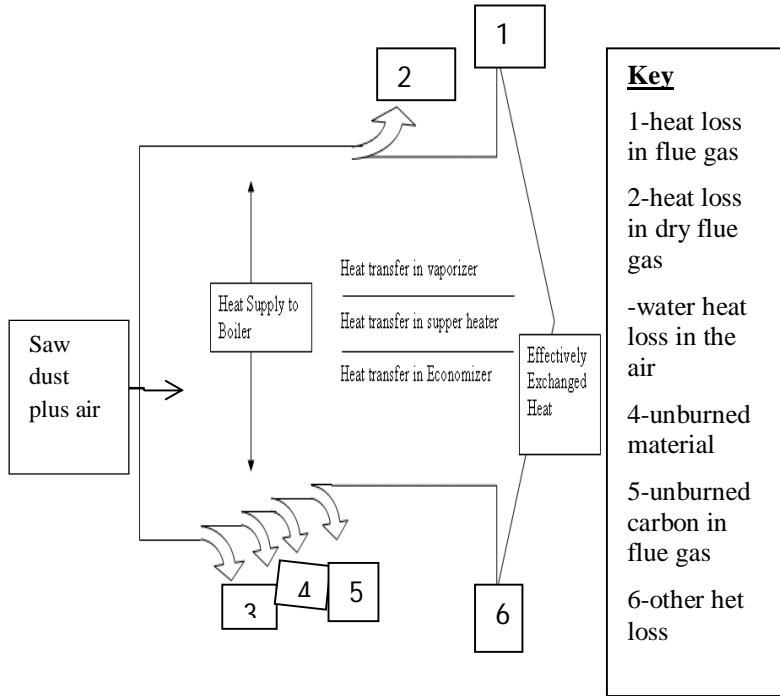
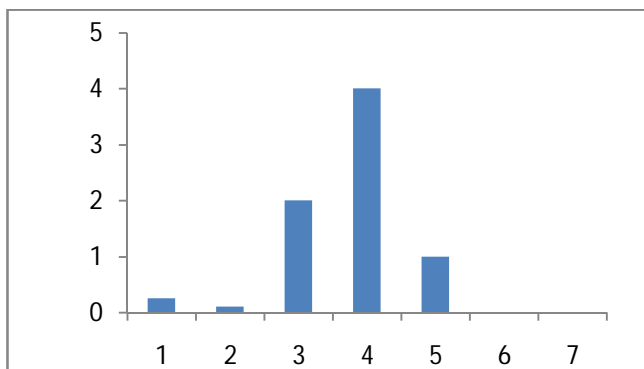


Figure 1: Energy distribution in the boiler unit

### 3.2 Steam Distribution System

The system under consideration include the piping and fittings such as steam trap, flanges and glove valves which serve as pressure reducing valves. The audit revealed that some steam pipes did not have insulation due to wear while steam leakages occurred in fittings. Calculated energy losses in the steam distribution system are presented in figure2.



**Key:** 1-uninsulated pipe; 2-insulated pipe; 3-steam trap; 4-flanges; 5-glove valves

Figure 2: Energy losses in steam distribution system

The histogram in figure 2 shows the trend of the steam energy loss in different fittings in the steam distribution line

### 3.3 Opportunities for Energy Saving

A careful analysis of the process and from the obtained data shows that there is a scope for heat recovery. Most of the changes required to address losses in steam generation and distribution call for change of attitude and operating practices. Routine and housekeeping is essential for energy conservation.

Some of the mandatory housekeeping measures include sealing of steam leakages and rehabilitation of the pipe insulation system.

A practical and cost-effective heat recovery, requires that steam selected must have the following characteristics

- Large heat capacity flow rate
- Reasonably high temperature (above 100.c)
- Feasible by plant layout
- Does not affect the process and product quality
- Does not involve any major modifications on the process

A common source of wastage in process plants is rapid cooling of product streams by externally supplied cold media (e.g. cooling water). The streams being cooled may be used to preheat feed streams or some other streams that are externally heated (e.g. by steam). The pairs of streams chosen for heat exchange should be conveniently located from one another for heat integration to be physically and economically viable. Energy savings from recovery of process heat can easily be determined from the information on the quantity and quality of the steam being cooled. The designed heat recovery system known as heat exchanger can be installed by retrofitting into the existing plant 1, 2, 3.

### 4. CONCLUSIONS

Energy planning and management is vitally important as an investment input for profitable industrial operations. For a factory whose products have international market value attached such as the productions of pyrethrum, energy consumption is a major factor of production hence conservational efforts are mandatory. It is important to that any energy planning strategy should focus on minimizing energy wastage as well as motivating technological innovations.

Energy auditing is a useful tool for instituting energy conservation measures in any industrial plant. From the study, the following constraints were discernible:

- Insufficient emphasis given to energy management by industries
- Energy consumption and efficiency, and their role in the profitability of a company are not fully appreciated.
- Lack of appropriate equipment for measurement and data collection
- Inadequate energy audit awareness among management and operating staff
- Lack of motivation for energy conservation

## REFERENCES

- [1] Ali H. Energy-Efficiency Improvement Opportunities for the Textile Industry. China Energy Group, Energy Analysis Department, 2010.
- [2] Ibrahim, H. (2006) Energy audit. A tool for Energy Management by Facts. Module 6, Journal of Energy Management, Gov. au, Ireland.
- [3] Manan, Z.A. (2003) Identifying Energy Saving Opportunities in a process plant through preliminary Energy Audit, *Jurnal Teknologi*, 38(A), University Teknologi, m Malaysia
- [4] Melvin, M. and Chiogioji, H. (1979) Industrial Energy conservation, Mercel Dekker, Inc., USA
- [5] Kennedy WJ, Wayne CT, Barney LC. Guide to energy management. 4 th edition. The Fairmont Press, 2003.
- [6] Nagaraj AR. Energy Management in Textile Industry, 2012.
- [7] Vikram S, Bharat D, Sudarshan G. Energy Audit Report AFCO, EGYPT. Central Technical Cell. Alexandria, Egypt, 2012.
- [8] Worrell E; Blinde P; Neelis M; Blomen E; Masanet E. Energy-efficiency Improvement and Cost Saving Opportunities for the U.S. Iron and Steel Industry. An Energystart Guide for Energy and Plant Managers, 2010.
- [9] Wakaba, J. (2004) Energy Conservation in Small and Medium Enterprises in Kenya, Government, A report, Government Press Nairobi.