

# AN ENERGY AUDIT IN A TEA MANUFACTURING INDUSTRY AT NORTH BENGAL, INDIA

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## Abstract

Growing concerns about rising energy bills due to high energy consumption and its adverse environmental impacts vis-à-vis stringent environment protection act (EPA) has forced many industries to carry out energy audit. The energy audit helps identify the opportunities to reduce energy bills keeping production amount and quality same or, even better and thereby, conserve environment. In the present paper focus is given on energy audit plan for a medium scale tea manufacturing industry having its own garden located at Jalpaiguri area of North Bengal, which is the northern part of West Bengal, India. By executing the audit, amount of energy usage by the machineries and production processes are determined and analyzed. Finally some suitable recommendations are suggested to bring down overall energy use.

**Keywords:** Energy Audit; Energy Management; Tea Manufacturing Industry

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## 1. INTRODUCTION

The essence of energy audit following Energy Conservation Act (EC Act)-2001 [1][2] is to monitor and analysis of the energy use in any industry or, organization and thereafter, submission of exhaustive report highlighting opportunities to improve energy efficiency and cut down energy consumption along with cost benefit calculations and action plan to achieve the purpose of energy usage reduction and environment protection.

The need of proper energy management vis-à-vis energy audit is becoming a must for any moderate to high energy consuming industry including tea manufacturing factory due to ever increasing energy cost and stringent environment protection law. Proper implementation of energy audit helps cut short energy bill and improve working environment by arresting smoke, dust, steam, hot air leakages etc. through suitable methodologies without affecting and, in fact, sometimes improving amount and quality of production.

India is the largest tea producing country in the world. India has acquired an exalted status on the global tea map. India produces all types of tea i.e., CTC (crush, tear and curl) tea, Orthodox tea, green tea and organic tea. Out of the above, CTC and orthodox are the most common.

In this present paper thorough energy audit is carried out for a medium size tea garden (total area 940 hectares) factory located at Jalpaiguri area of North Bengal, India and various energy conservation methodologies are proposed through this audit which if implemented will definitely reduce energy bills and conserve environment.

## 2. WORKING PROCEDURE OF ENERGY AUDIT

Energy audit identifies energy usage at every energy-cost-centre i.e., in all machineries, processes and others which consumes energy in one form or, other and analyze them in order to find out procedures to cut short the energy cost.

Depending on the type of industry/organization and the depth of energy audit need, in terms of cost reduction and other aspects, the energy audit may be classified as Preliminary, Targeted and Detailed audits. [2][3][4]. Detailed energy audit is the most comprehensive audit which includes three phases viz. pre-audit, audit and post-audit phases. In this present study the energy audit carried out is a detailed audit.

## 3. PROGRESS OF DETAILED ENERGY AUDIT WORK

### 3.1 The 1st Phase I.E. Pre-Audit Phase

In this phase initially the whole tea manufacturing factory is inspected for understanding the production machineries and processes, ratings of machines and possible area of energy wastages are noted. A discussion with factory manager and operation staff is organized to take stock of the overall situation and to explain them the purpose of energy audit and its advantages and their co-operation is sought. [2,4]

### 3.1.1 Factory Details

Table 1: Details about Tea Manufacturing Factory

<b>Name</b>	<b>Jalpaiguri Tea Garden (not original name)</b>
<b>Power Sources</b>	i) Grid Power Supply (WBSEDCL) ii) Own Generation (used when Grid power is not available)
<b>Heat Generating Source</b>	Coal(used in Coal Firedfurnace to heat up air)
<b>Overall Production in a Year</b>	1350000 kg(approx.) of CTC tea
<b>Factory working Time</b>	18 hours in a day

### 3.1.2 Factory Layout:

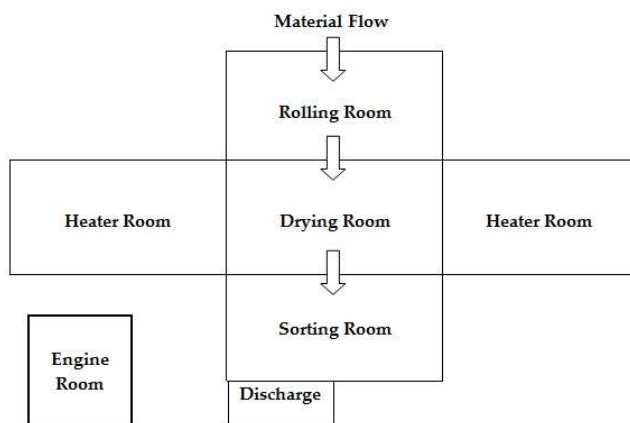


Figure 1: Factory Layout

### 3.1.3 Tea Manufacturing Process Study:

All the processes involved in tea production system are meticulously observed and following is a description of the processes:

**Tea Handling:** The Plucker pluck the green leaves from the garden. There is a special technique of plucking which is followed by the pluckers.



Figure 2: Tea Plucking

**Withering :** Withering is one of the most important stage of tea manufacturing. In the withering process removal of moisture from the green leaves are carried out. Green leaves are kept approximately for 12 to 14 hours as per requirement on the Trough, which is a metal net. Axial flow fans are used at one end to blow air beneath the trough and the air comes out through the green leaves and thus removes moisture from the leaves.



Figure 3: Withering

**CTC (Crush, Tear & Curl) process:** This CTC process is done by the C.T.C Machine. In C.T.C. machine the three processes namely, crush, tear & curl, on the tea leaves are done by using suitable high and low speed rollers. The green leaves after being withered is sent to the Feeder with the monorail and fall down in the Rotor Vane at the rate of 500kg/hour. This is the first part of the C.T.C. Machine. After that green leaves are passed through belt conveyors and in the conveyors itself there are sets of rollers having different speeds at different locations of the conveyor belt which finally carry out the remaining CTC operations.

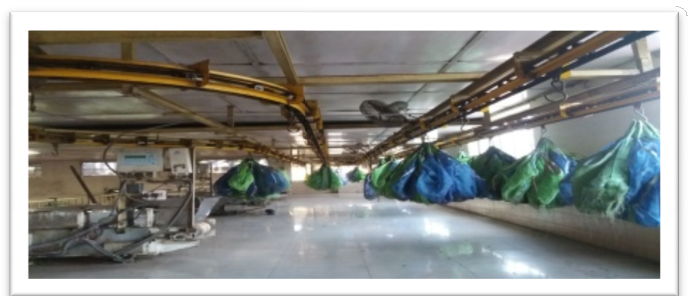


Figure 4: Tea Handling by Monorail

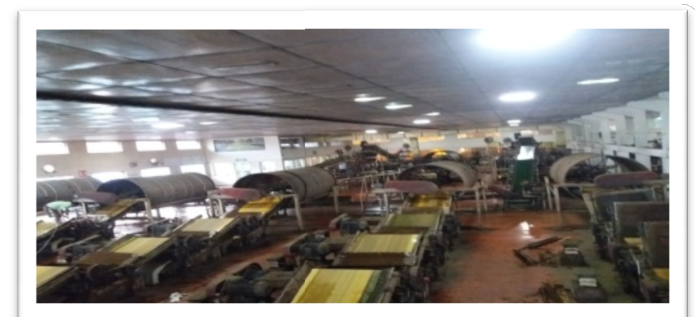


Figure 5: CTC Machine

**Fermentation :** After processing in CTC machine tea materials are sent to CFM (Continuous Fermenting Machine) which is basically a belt conveyor. Fermentation is an important stage of Black tea manufacturing. During fermentation a large number of dissimilar chemical reactions take place by using polyphenol and oxidation with atmospheric oxygen. In this process the chlorophyll in the tea leaf is enzymatically broken down, and its tannins are released or transformed. At the end of fermenting, the tea materials pass through a special kind of spiral type device located on the conveyor itself, called 'santoor', which makes the tea materials in a desired small round shape conventionally named as "gooli". Bigger "goolis" are sent to a mini C.T.C. for reprocessing .



**Figure 6:** Fermentation Process in CFM

**Drying:** In this process tea materials are dried up after fermentation. In the present factory, hot air from coal fired air heater dry up the tea materials in three numbers of Vibro Fluid Bed Dryers (VFBD). This VFBD comprises of heater shell and accessories supported by suitable ducting, hot air blower, temperature controller and feed system. After the drying process all the tea materials pass through conveyor to the Weight Measuring Unit.



**Figure 7:** Vibro Fluid Bed Dryer (VFBD)

**Weight Measuring Unit:** A Dryer Mouth Batch Weighting Machine is used to measure the tea grains weight. This weight is compared with the weight of green tea leaves measured just before the C.T.C. machine. From this comparison, the quality of 'drying' which, in turn, indicates the quality of produced tea is ascertained.



**Figure 8:** Batch Weighting Machine

**Sorting:** After the tea is measured in the above weighting machine, it is sent to big storage Hoppers, two in numbers. At the end part of the each hopper, there are six numbers of Vibro Screens having different sizes of mesh, starting from the biggest size mesh screen at the top. These screens vibrate and segregate tea materials based on its grain size into six different categories or, grades. The market price of tea varies from grade to grade.



**Figure 9:** Vibro Screen Sorter

**After Sorting :** Graded teas fall into small hoopers and pass through Vibro Slow Speed Fibre Extractor machine which extracts fibre, flaky and unwanted debris from the graded tea.



**Figure 10:** Vibro Slow Speed Fiber Extractor

**Packaging and Delivery:** After separating all different graded or, quality tea, packaging is done in plastic/paper bags and despatched from the factory.

### 3.2 Audit Phase- II

During audit phase II the following observations and analysis are completed.



Figure 11: i) Tea Storing ii) Packaging

Table 2 Analysis of Tea Production

Month	Green leaf Quantity (kg)		Tea quantity (kg)		Ratio (Tea/Green Leaf)	
	2014	2015	2014	2015	2014	2015
January	21079	12094	5100	2830	0.242	0.234
February	63635	97218	14290	22870	0.224	0.235
March	595393	451118	134408	103556	0.225	0.229
April	338964	516770	85444	124659	0.252	0.241
May	743822	1031868	170944	235052	0.229	0.227
June	1467553	1427472	321064	308657	0.218	0.216
July	1713719	1314227	368964	287160	0.215	0.218
August	1626001	1395765	350266	302853	0.215	0.216
September	1639666	1478685	354500	318362	0.216	0.215
October	1545789	1663999	343195	372895	0.222	0.224
November	1343319	1297715	305562	299950	0.227	0.231
December	847454	461256	228989	153650	0.270	0.333

Table 3: Summary of Annual Electrical Energy Consumption

Month	Grid Supply Electrical Energy (KWh) Consumption		Diesel Engine Generated Electrical Energy (KWh) Consumption		Total Electrical Energy (KWh) Consumption	
	2014	2015	2014	2015	2014	2015
January	2928	1331	64	40	2992	1371
February	3422	5704	144	768	3566	6472
March	54187	46857	400	1800	54587	48657
April	35743	46002	3312	5520	39055	51522
May	79928	96019	8872	25016	88800	121035
June	202859	190281	20736	33552	223595	223833
July	296489	160344	9808	27232	306297	187576
August	319830	182955	11064	17280	330894	200235
September	225111	199709	9632	6416	234743	206125
October	231675	281079	4144	11672	235819	292751
November	137482	190372	2416	5272	139898	195644
December	158836	73509	2896	3128	161732	76637

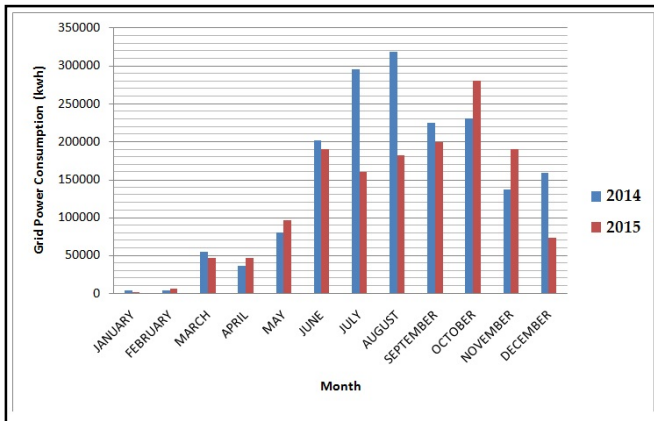


Figure 12: Month wise Grid Power Consumption(KWh)

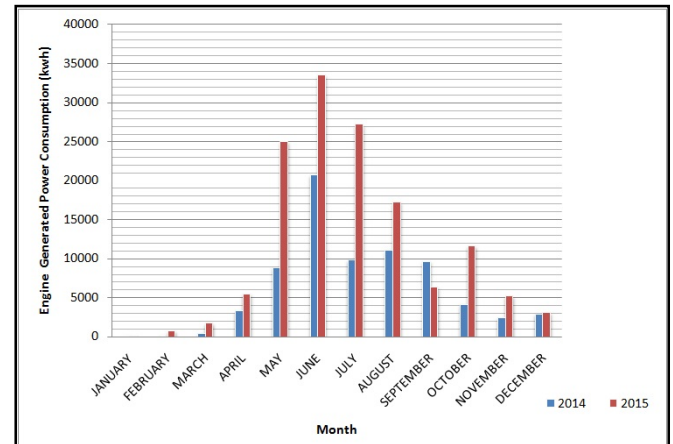


Figure 13: Month wise Engine Generated Electrical Power Consumption (KWh)

Table 4: Tea Production wise Energy Consumption Analysis

Month	Tea quantity (kg)		Total Electrical Energy Consumption in KWh		Electrical Energy Consumption per kg of tea (kwh/kg)	
	Year					
	2014	2015	2014	2015	2014	2015
January	5100	2830	2992	1371	0.5866	0.4844
February	14290	22870	3566	6472	0.2495	0.2829
March	134408	103556	54587	48657	0.4061	0.4698
April	85444	124659	39055	51522	0.4570	0.4133
May	170944	235052	88800	121035	0.5194	0.5149
June	321064	308657	223595	223833	0.6964	0.7251
July	368964	287160	306297	187576	0.8301	0.6532
August	350266	302853	330894	200235	0.9446	0.6611
September	354500	318362	234743	206125	0.6621	0.6474
October	343195	372895	235819	292751	0.6871	0.7850
November	305562	299950	139898	195644	0.4578	0.6522
December	228989	153650	161732	76637	0.7062	0.4987

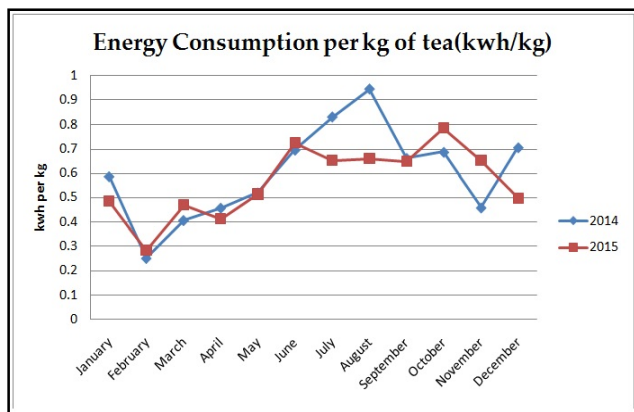


Figure 14: Rate of Electrical Energy Consumption per unit Tea Production (KWh/kg)

Table 5: Overall Yearly Data

	2014	2015
<b>Total Tea Production (kg)</b>	2682726	2532494
<b>Total Electrical Power Consumption (KWh)</b>	1821978	1611858
<b>Total Coal Consumption in furnace to heat up air (kg)</b>	2339582	2103746

#### 4. POST-AUDIT :

##### 4.1 Audit Phase–III : Proposals To Reduce Energy Consumption In Tea Production Processes

Present manufacturing processes for tea production in the Tea factory are meticulously observed and following are the possible improvement proposals for different processes to reduce energy cost and also for better operation of the plant.

**Table 6:** Process Withering

Present Practice/ problem related to present technology	Solution for Technology Gap/problem related to present practice
In the factory the withering fans run continuously during withering process and intermittent running of fans is not practiced.	Intermittent withering instead of continuous withering as practiced by some of the gardens without loss in withering time and quality of product.
Present factory like most of other factories are having aluminum/steel fan blades in withering fans.	Use of energy efficient FRP(fiber reinforced plastics) blades.
Air leakage was observed from dampers and side windows.	Arresting air leakage can save up to 10-15% of total flow volume produced by fans which is otherwise wasted as leakage.

**Table 7:** Process: CTC (Cutting, Twisting and Curling)

Present Practice/problem related to present technology	Solution for Technology Gap/problem related to present practice
There are eight conveyer-banks, known as CTC banks. During off peak season C.T.C. machines are lightly loaded but still most of the banks of CTCs are operated due to typical arrangements of the banks.	Energy cost will be reduced by duly modified arrangement, use of single CTC cutter, known as rotor-vane, during off peak season can be practiced with a single conveyer-bank to distribute the shred leaves equally to only required nos. of CTC banks.
Most of the CTC motors are under loaded as the rating of the motors seem to be on the higher size considering production volume	Proper sizing of CTC motors.( may be a single motor, along with a back-up machine, having higher rating instead of three motors can be tried)

**Table 8:** Process Fermentation

Present Practice/problem related to present technology	Solution for Technology Gap/problem related to present practice
In CFM (continuous fermentation machine) air leakage was observed from unloaded banks.	Stopping air leakage in CFM by dampers and use of VFD through sensors.
Air humidifier in case of floor fermentation is operated continuously without any regulator.	Regulating the humidifier as per the requirement in floor fermentation.
Undesired bigger size ball formation up to 5-6% of the total made tea is observed at drier mouth. These balls are sent back to a mini C.T.C machine and reprocessed again resulting in loss of energy and manpower in reprocessing.	Use of ball breaker after fermentation to reduce ball formation.

**Table 9:** Process Drying

Present Practice/problem related to present technology	Solution for Technology Gap/problem related to present practice
Hot air leakage is observed from hot air carrying ducts at isolating dampers and joints and insulation of hot air ducts are not proper.	Stopping hot air leakage by proper sealing of dampers and providing proper insulation to ducts to reduce energy loss.
Hot air exhaust from drier (at 80-90 deg C) is vented out. Potential of heat recovery of low grade heat not explored.	Employment of proper mechanism for re-circulation of exhaust hot air for pre-heating inlet air. Also use of exhaust air for hot water generation can be explored.
Excess air in coal fired air heater is not regulated. High percentage of excess air results in lower performance of heaters.	Use of proper quantity of air required for tea drying process by Automatic air-flow controller (AAFC) will reduce coalcost.
Regular cleaning of tubes and ducts in coal fired air heaters are not done, thick formation of carbon layer observed.	Regular cleaning of tubes and ducts to improve heat transfer efficiency and thereby reduction in coal consumption.
Flue gas directly vented out through chimney without any heat recovery in coal fired furnace.	Preheating the coal furnace inlet air by outgoing flue gas.

#### 5. CONCLUSION

Successful implementation of energy audit reveals a number of opportunities to reduce energy cost, enhance effectiveness and quality in production and preserve environment degradation. In this present work, complete energy audit is carried out for a medium sized tea manufacturing factory located at Jalpaiguri, West Bengal. At first the purposes, methodology and types of energy audits are described. To carry out the energy audit starting from the complete walk-through visit, detail understanding of all the tea production processes including study of all the machines involved in the processes and their energy consumption patterns and overall arrangement of the machines, conveyor systems, ducting etc. are done and noted. Electricity and coal consumption for the years 2014 and 2015 along with tea production volume are collected and analyzed along with cost involvement. Possible avenues to reduce energy cost in the production system and for other areas like air loss etc. are proposed in detail. It is expected that once these recommendation are successfully implemented, energy cost in tea production will be reduced by substantial amount, which not only make the company more competitive in the market but also reduce environment pollution.

## 6. REFERENCE

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## BIOGRAPHIES



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