MANUAL ON ENERGY CONSERVATION MEASURES IN TEA CLUSTER JORHAT

ENERGY IS LIFE
BEE
CONSERVE IT

PCRA

Bureau of Energy Efficiency (BEE)

(Ministry of Power, Government of India)

Prepared by :

Petroleum Conservation Research Association (PCRA)

(Under ministry of Petroleum and Natural gas)

(Government of India)

ACKNOWLEDGMENT

Indian Tea Industry mainly consists of the units in SME sector and contributes greatly to Indian GDP. The tea sector is very Energy intensive as well, and hence draws focus whenever Energy Efficiency Improvement in Industries is considered. The very basic scale of production of these units makes them prone to inefficiencies in Energy as well as other resource utilization. Improving operating efficiency is going to be the key to survival and this intervention by Bureau of Energy Efficiency (BEE) is a welcome step.

The sincere help and support extended by the various tea associations like ABITA (Assam branch of Indian Tea Association), TAI (Tea Association of India), ATPA(Assam Tea Planters Association), NETA (North east tea Association) etc deserves accolades for facilitating the study. We express our sincere thanks to Shri Abijit Sharma, Secretary ABITA, Shri J Barua, Secretary TAI, Shri D. Bora, Secretary ATPA, Mr. Dipak Kumar Dowerah Secretary NETA and other team members for all the help and support extended during the study. We also put on record the contributions of the TRA (Tea Research Association), Toklai- Jorhat for their valuable suggestions and cooperation, M/s Bonti Consultancy Services, Guwahati for their support in carrying out the study.

PCRA has been supporting units in SME sector continuously and has succeeded in triggering efforts for Energy Conservation in these Industries. However, the Jorhat Tea cluster Job has gravitated the efforts of PCRA more intensely to the cluster. The initiative matches well with our Corporate Mission and provides us opportunity to deliver on the subjects included directly or indirectly in our Corporate Vision as well.

PCRA expresses its sincere thanks to Bureau of Energy Efficiency (BEE) for associating Petroleum Conservation Research Association in its prestigious Pan-India intervention in the SME Clusters aimed at improving performance of these clusters on Energy Consumption through proposed hard interventions.

We thank the following persons from BEE for their valuable support and guidance in the entire process of study and report preparation.

Dr. Ajay Mathur, DG BEE,

Smt. Abha Shukla, Secretary BEE,

Shri J. Sood, Energy Economist, BEE

Shri. Pawan Tiwari, Advisor BEE

PCRA would further be working in the cluster for ensuring that the initiatives of BEE does bear fruit and the projects identified in this study actually get implemented. An impact analysis can also be considered at a definite interval to assess how much has been the Energy Saving triggered by this intervention. During onsite study, sufficient awareness about the project was created and the entrepreneurs were motivated to adopt the project.

It is observed that the project would succeed in its aim of improving energy efficiency in the complete cluster and the study as well as the intervention in Jorhat tea cluster would set bench mark for success in the Energy Efficiency in SME sector under cluster model.

K.L.Bhutia

Team Leader, Jorhat Tea Cluster

PCRA Coordinatior-N.E

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DISCLAIMER

The information given in this manual is based on the data collected form the tea factories that were studied during the project. For preparing the manual every care has been taken to evaluate the data correctly, but the possibility of inadvertent error cannot be ruled out. BEE/ PCRA reserves the right to rectify such errors later on.

Since, the study was carried out at Jorhat Tea Cluster, so the information given in this manual does not necessarily reflect the Indian Tea Industry as whole.

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Executive Summary

Jorhat tea Cluster has very rightly been chosen under BEE SME program as the units here are traditionally very old which have not really progressed in pace with the technological advancements. The Cluster Manual has been prepared to present the overview of the cluster in terms of its features, growth potential, and drivers for growth in past and future prospects. The cluster manual presents an account of present technology and the technological interventions required to improve the Energy Performance of the cluster.

The Cluster Manual also tries to identify the projects required to be undertaken for improving the Energy Intensity of the cluster and analyze them financially so as to trigger adoption in the cluster.

The section on list of energy conservation opportunities and technology gap assessment in its complete perspective has been discussed and a complete techno economics of implementing the proposed technology has also been worked out. Sections also deal in availability of service providers in the cluster and also various barriers to implementation of the projects.

A summary of the techno economics of the proposed technology has been provided in section 5.1.3. The Cluster Manual has been prepared in such a way that it discusses Energy Saving Projects in entirety including cost benefit analysis and it can be adopted readily in any of the units.

Energy conservation opportunities in Jorhat tea cluster:

After conducting detailed audit of the tea estates following saving opportunity were observed for reducing the energy consumption and energy cost to great extent. The table depicting process wise recommendation is appended below:

Table : 1a

Process	Energy saving opportunity	Payback
Withering	Stopping hot air leakage and insulation of hot air ducts.	No cost
	Intermittent withering instead of continuous withering	
	Use of one 70 w MH lamp in trough instead of tube lights.	Low cost
	Blocking Air Leakage in withering troughs	
	Suction of withering fans to be tapered to increase the efficiency of the fan (Fig-2).	Long term
	Use of energy efficient motors for withering	
	Use of energy efficient fan blades (FRP blades)	
	VFD drive for air flow control instead of damper control	
CTC (cutting twisting and curling)	Use of single rotor vane during off peak season	No cost
	Proper sizing of CTC motors (most of the motors were grossly under loaded).	Long term
	Use of synthetic flat belts instead of v-belts.	
Fermentation	Stopping air leakage in case of CFM (Continuous fermentation machine), use of VFD.	Short term
	Regulating the humidifier as per the requirement in floor fermentation.	Low cost
	Use of ball breaker after fermentation to reduce ball formation	

Process	Energy saving opportunity	Payback
Drying (NG fired)	Shaft Mounted ID Fan as opposed to Belt Driven Fan.	Short term
	Monitoring and ensuring bluish flame from the burner.	
	Use of energy efficient burners	Long term
	Use of VFD for hot air ID fan	
	Automatic temperature regulator.	
	Use of heat pump for re-circulation of exhaust hot air for preheating inlet air.	
Drying (coal fired)	Excess air control in coal heaters	Short term
	Monitoring of Drier output moisture content of made tea.	
	Improve heat transfer efficiency by cleaning tubes and ducts.	
	Use of VFD for hot air ID fan	Long term
	Preheating the heater inlet air by flue gas economiser.	
	Use of AFRC (air fuel ratio controller in coal heaters).	
Sorting	Discontinuing with use of incandescent bulbs for heating the rollers of sorting tray.	No cost
	Proper maintenance of fibrous sheet in sorting roller to create static charge for sorting fibre from made tea.	
General recommendation	Proper loading of transformers	No cost
	Monitoring of DG performance	
	Scope for reduction in contract demand	
	Separate servo transformer for lighting	Low cost
	Bio-mass gasification to meet thermal energy requirement	Long Term
	Improvement of power factor by APFC	
	Insttalation of wind-solar hybrid power generation	

ENERGY IS LIFE B E E CONSERVE IT

1. About BEE SME Program :

Worldwide the Micro, Small and Medium Enterprises (MSMEs) have been accepted as engines of economic growth to promote and accelerate equitable development. The major advantage of this sector is its enormous employment potential at significantly low capital involvement. This can be established from the simple fact that the MSMEs constitute over 90% of total enterprises in most economies and are credited with generating the highest rates of employment growth and also account for a major share of industrial production and exports. In Indian context, MSMEs play a pivotal role in the overall industrial economy. In recent years the sector has consistently registered higher growth rate as compared to the overall industrial sector. With its agility and dynamism, the sector has shown admirable innovativeness and adaptability to survive the recent economic downturn and recession.

As per available statistics (the 4th Census of MSME Sector), this sector employs an estimated 59.7 million persons spread over 26.1 million enterprises. It is estimated that in terms of value, MSMEs have a 40% share in total industrial output at a huge volume of producing over 8,000 value-added products. At the same time, MSMEs contribute nearly 35% share in Direct Export and 45% share in the Overall Export from the country. SMEs exist in almost all-major sectors in the Indian industry such as Food Processing, Agricultural Inputs, Chemicals & Pharmaceuticals, Electrical & Electronics, Medical & Surgical Equipment, Textiles and Garments, Gems and Jewellery, Leather and Leather Goods, Meat Products, Bioengineering, Sports goods, tea, Plastics Products, Computer Software etc.

However, despite the significant contributions made to towards various aspects of the nation's socio-economic scenario, this sector too faces several critical issues that require immediate attention. One such factor that falls in the ambit of this publication is the prevalence of age old technologies across the sectors and inherent inefficiencies associated with resource utilization, including, energy. The National Mission for Enhanced Energy Efficiency in Industry under the National Action Plan for Climate Change (released by Government of India on June 30, 2008) has emphasized the need for improving Energy Efficiency (EE) in the manufacturing sector. A number of sector-specific studies have also unanimously confirmed that energy intensity in the industry can be reduced with the widespread adoption of proven and commercially available technologies, which will improve EE and produce global benefits from reduced Green House Gasses (GHGs) emissions.

As a result of increasing awareness towards efficient usage of energy and other resources, there has been a visible reduction in energy intensity in comprehensive Indian industrial sector. However, focusing the observation on the MSME sector reveals that the energy intensity per unit of production is much higher than that of the organized large scale sector. Since energy cost is significant contributor to the overall production cost of SMEs due to high and rising energy costs in current scenarios, it is required to increase the Energy Efficiency (EE) levels in order to ensure the sustenance of SMEs. One of the ways to reduce the inefficiencies is by replacing the conventional/old/obsolete technology with feasible and adaptable energy efficient technologies. This would not only contribute towards reduction in production cost, but would also improve the quality and productivity of MSME products. However, while knowing the way out, there are still numerous barriers (as listed below) and market failures that have prevented widespread adoption of new energy efficient technologies.

Key barriers in promotion and adoption of EE technologies in Indian SME sector:

- Lack of awareness and capability on the part of SMEs to take up energy conservation activities
- Lack of scientific approach on monitoring and verification of performance assessment of installed equipments and utilities.
- Non availability of benchmark data for various equipments/process
- Low credibility of the service providers such as equipment suppliers and their technologies
- The SME owners are more concerned on production and quality rather than energy efficiency and conservation
- The key technical personnel employed in the SME units are based on their past experience in similar industries rather than technically qualified personnel and hence, they are not aware of the latest technologies or measures which improve energy efficiency
- Lower priority to invest in improving efficiency than in expansion (this may be due to lack of knowledge on cost benefit)

Majority of SMEs are typically run by entrepreneurs and are leanly staffed with trained technical and managerial persons to deploy and capture energy efficiency practice to reduce manufacturing cost and increase competitive edge. Therefore, it will be useful to build energy efficiency awareness in the SMEs by funding/subsidizing need based studies in large number units in the SMEs and giving energy conservation recommendations including short term energy conservation opportunities, retrofit/replacement options and technology up-gradation opportunities.

In this context, the Bureau of Energy Efficiency (BEE) has laid adequate emphasis on the SME sector as presented in the Working Group on Power for 11th Five-Year Plan (2007-2012)-Sub-Group 5. Consequently, the Bureau has initiated the Energy Efficiency Improvement program in 25 SME clusters in India.

1.1 Program Objectives

The BEE SME Program is aimed to improve Energy Efficiency in SME sector by technological interventions in the various clusters of India. The EE in SMEs is intended to be enhanced by helping these industries in the 25 energy intensive SME clusters of India by:

- Technology interventions
- Sustaining the steps for successful implementation of EE measures and projects in clusters
- Capacity building for improved financial planning for SME entrepreneurs.

The program also aims at creating a platform for :

- Dissemination of the best practices and the best available technologies available in the market for energy efficiency and conservation,
- To create awareness in the clusters, and
- To demonstration the new technology interventions/ projects to stimulate adoption of similar technology/projects in the clusters.

The BEE SME program has been designed in such a way so as to address the specific needs of the industries in the SME sector for EE improvement and to overcome the common barriers in way of implementation of EE technologies in cluster through knowledge sharing, capacity building and development of innovative financing mechanisms. Major activities in the BEE SME program are listed below:

- Energy use and technology studies
- Capacity building of stake holders in cluster for building EE projects
- Implementation of energy efficiency measures
- Facilitation of Innovative financing mechanisms for implementation of energy efficiency projects

The brief objective of each of these activities is presented below:

➲ *Energy use and technology studies*

An in-depth assessment of the various production processes, energy consumption pattern, technology employed and possible energy conservation potential and operational practices in cluster by means of conducting detailed energy audits and technological gap assessment studies in a cluster is presented herewith. The energy audit study includes analysis of the overall energy consumption pattern, study of production process, identification of energy intensive steps/sub-processes and associated technology gap assessment for the individual units. The study also focuses on identifying the Best Operating Practices and the EE measures already implemented in the units.

➲ *Capacity building of stakeholders*

The aim of this activity is capacity building of the enrolled LSPs to equip them with the capability to carry on the implementation of the EE technology projects in cluster on a sustainable basis. The needs of the LSPs will be identified as a preparatory exercise to this activity, as to what they expect from the BEE Program in terms of technical and managerial capacity building.

Implementation of EE measures

To implement the EE and technology up-gradation projects in the clusters, technology specific Detailed Project Reports (DPRs) for five different technologies for three scales of operation will be prepared. The DPRs will primarily address the following:

- Comparison of existing technology with feasible and available EE technology
- Energy, economic, environmental & social benefits of proposed technology as compared to conventional technology
- Details of technology and service providers of proposed technology
- Availability of proposed technology in local market
- Action plan for implementation of identified energy conservation measures
- Detailed financial feasibility analysis of proposed technology

Facilitation of innovative financing mechanisms

Research and develop innovative and effective financing mechanisms for easy financing of EE measures in the SME units in the cluster. The easy financing involves following three aspects:

- Ease in financing procedure
- Availability of finance on comparatively easy terms and relaxed interest rates
- Compatibility and availing various other Central/ State Governments' incentive schemes like CLCSS, TUFF

1.2 Expected Project outcome

Expected project outcome of BEE SME program in clusters are:

Energy Use and Technology Analysis

The outcome of the activity will include identification of the EE measures, potential of renewable energy usage, fuel switching, feasibility analysis of various options, and cost benefit analysis of various energy conservation measures including evaluation of financial returns in form of payback period, IRR and cash flows. The cost liability of each measure, including the capital and operational cost will also be indicated.

The identified EE measures will be categorized as per the following types:

- Simple housekeeping measures/ low cost measures
- Capital-intensive technologies requiring major investment.

The sources of technology for each of the suitable low cost and high cost measures, including international suppliers as well as local service providers (LSPs)/ technology suppliers, in required numbers shall be identified. It is envisaged to create a knowledge bank of detailed company profile and CVs of key personnel of these technology sources. The knowledge bank will also include the capability statements of each of these sources.

The EE measures identified in the energy audit study will be prioritized as per their energy saving potential and financial feasibility. The inventorization survey would establish details like the cluster location, details of units, production capacity, technologies employed, product range, energy conservation potential along with possible identified EE measures and respective technology suppliers.

The specific outcomes of this activity will be as follows:

- Determination of energy usage and energy consumption pattern
- Identification of EE measures for the units in cluster
- Development and preparation of case studies for already implemented EE measures and Best Operating Practices in the units
- Evaluation of technical & financial feasibility of EE measures in terms of payback period, IRR and cash flows.
- Enlisting of Local Service Providers(LSPs) for capacity building & training including creation of knowledge bank of such technology suppliers

- Capacity building modules for LSPs
- Development and preparation of cluster manuals consisting of cluster details and EE measures identified in cluster.

Implementation of EE measures

The aim of this activity is development and finalization of bankable DPRs for each of the EE projects, which would presented before the SME units for facilitation of institutional financing for undertaking the EE projects in their respective units.

The activity will ensure that there is close match between the proposed EE projects and the specific expertise of the Local Service Providers (LSPs). These DPRs will be prepared for EE, renewable energy, fuel switching and other possible proposed measures during course of previous activities. Each DPR will include the technology assessment, financial assessment, economic assessment and sustainability assessment of the EE project for which it has been developed. The technology assessment will include the details of the design of equipment/ technology along with the calculation of energy savings. The design details of the technology for EE project will include detailed engineering drawing for the most commonly prevalent operational scale, required civil and structural work, system modification and included instrumentation and various line diagrams. The LSPs will be required to report the progress of the implementation of each such project to BEE PMC. Such implementation activities can be undertaken by the LSPs either solely or as a group of several LSPs.

Capacity Building of LSP's and Bankers

The outcome of this activity would be training and capacity building of LSPs so as to equip them with necessary capacity to undertake the implementation of proposed EE projects as per the DPRs. Various training programs, training modules and literature are proposed to be used for the said activity. However, first it is important to ascertain the needs of the LSPs engaged, as in what they expect from the program in terms of technical and managerial capacity building. Another outcome of this activity will be enhanced capacity of banking officers in the lead banks in the cluster for technological and financial feasibility analysis of EE projects that are proposed by the SME units in the cluster. This activity is intended to help bankers in understanding the importance of financing energy efficiency projects, type and size of projects and ways and means to tap huge potential in this area. Different financing models would be explained through the case studies to expose the bankers on the financial viability of energy efficiency projects and how it would expand their own business in today's competitive environment.

- ***Concluding workshop***

The outcome of this activity will be the assessment of the impact of the project as well as development of a roadmap for future activities. The workshop will be conducted for the representatives of the local industrial units, industry associations, LSPs and other stakeholders so that the experiences gained during the course of project activities including implementation activities of EE project can be shared. All the stakeholders in the project will share their experience relating to projects undertaken by them as per their respective roles. Effort from industrial units as well as LSPs to quantify energy savings thus achieved would be encouraged. This would lead to development of a roadmap for implementing similar programs in other clusters with greater efficiency and reach.

1.3 Identified clusters under the program & target cluster for implementation

25 most energy intensive MSME clusters across different end use sectors have been identified to implement the BEE SME program for EE improvement. The details of industrial sector and identified cluster are provided in Table 2 below:

Table 1b: ***List of clusters identified for BEE SME Program***

S. No.	Cluster Name	Location
1.	Oil Milling	Alwar; Rajasthan
2.	Machine Tools	Bangalore; Karnataka
3.	Ice Making	Bhimavaram; Andhra Pradesh
4.	Brass	Bhubaneswar; Orissa
5.	Sea food processing	Kochi, Kerala
6.	Refractories	East &West Godavari, Andhra Pradesh
7.	Rice Milling	Ganjam, Orissa
8.	Dairy	Gujarat
9.	Galvanizing	Howrah, West Bengal
10.	Brass& Aluminum	Jagadhari, Haryana
11.	Limestone	Jodhpur, Rajasthan
12.	Tea processing	Jorhat, Assam
13.	Foundry	Batala, Jalandhar & Ludhiana, Punjab
14.	Paper	Muzzafarnagar, Uttar Pradesh
15.	Sponge iron	Orissa
16.	Chemicals& Dyes	Vapi, Gujarat
17.	Brick	Varanasi, Uttar Pradesh
18.	Rice Milling	Vellore, Tamil Nadu
19.	Chemical	Ahmedabad, Gujarat
20.	Brass	Jamnagar, Gujarat
21.	Textile	Pali, Rajasthan
22.	Textile	Surat, Gujarat
23.	Tiles	Morbi, Gujarat
24.	Textile	Solapur, Maharashtra
25.	Rice Milling	Warangal, Andhra Pradesh

As a part of BEE SME program, one of cluster identified was the Jorhat, Tea cluster. It was proposed to carry out energy use and technology audit studies in 30 units in the Jorhat, Tea cluster covering all types and sizes of the industries to understand/give valuable insight into the process of developing energy efficiency solutions relevant to the SME industries in the Jorhat, Tea cluster

1.4 Cluster

Jorhat Tea cluster, located in Upper Assam comprises of the Tea Estates located in the erstwhile-undivided Jorhat District of Assam. After the division of the Jorhat District into Jorhat District and Golaghat District, presently the Tea Estates of this cluster is spread over the districts of Jorhat and Golaghat. The type of tea produced in this Tea Cluster is primarily BLACK TEA. The black tea that is being produced in this tea cluster are of CTC (Cut, Tear, and Curl) and Orthodox type.

A glance at the background of the tea gardens in Jorhat Tea Cluster reveals that almost all the tea gardens with in – house factories were established in the pre – independence era and these Tea Estates were managed by either as family business acquired through inheritance or by group companies like Amalgamated Plantations (P) Ltd, Williamson and Magor, etc. In case of the first case the adaptability for new technology is low, whereas in case of Tea estates managed by group companies it is seen that the adaptability for new technology is high as these are managed from outside Assam, mainly from the metros. Also these tea estates have the willingness for technological innovation.

The Bought Leaf Tea factories (BLTF) and the tea gardens without in – house factories were established in the post independence era, mainly after the late '80s. And first generation entrepreneurs mainly start these tea establishments and the adaptability for proven new technology is high but these establishments are not interested to experiment with technological innovation mainly due to financial constraints.

As the BEE SME cluster development program is meant for enhancing the energy efficiency in tea manufacturing process, so for this purpose the tea gardens, which are not having in – house factories, were not considered during the study. The Tea processing units that were being taken up during this study are the Tea Estates with in – house tea factories, both managed as family run business as well as managed by group companies and BLTF (bought leaf tea factory), which are managed by first generation entrepreneurs. This is done with the objective of arriving at a holistic conclusion, as the managerial approach is different for these three differently managed tea-processing units.

Executing Agency

BEE has appointed PCRA (Petroleum Conservation Research Association) as the executing agency for the project. Executing agencies has a major role in executing the project that includes carrying out Energy Audit and report preparation, preparation of cluster manual, DPR preparation of the identified projects, organizing information decimation workshop etc.

Moreover, PCRA will assist BEE in the capacity building of banks and LSP's, implementation of energy efficiency projects and concluding workshop for service providers.

2 CLUSTER SCENERIO :

2.1 Overview of Jorhat Tea Cluster

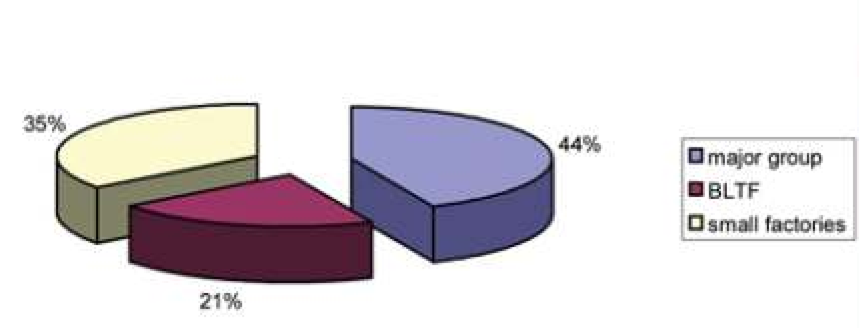
In Assam, tea is grown both in the Brahmaputra and Barak plains, Assam produces 51% of the tea produced in India and about 1/6th of the tea produced in the world. There is a tea auction center in Guwahati and it is the world's second largest in terms of total tea auctioned .

Tea industry has contributed substantially to the economy of Assam, about 17 percent of the workers of Assam are engaged in the tea industry

Tea cluster in Assam are mainly divided into three zones viz, Jorhat zone, Tezpur zone and Tinsukia zone . For the BEE-SME program Jorhat zone has been chosen for the energy efficiency study .

In Jorhat cluster there are about 150 tea factories in and around Jorhat, Golaghat and some part of Sibsagar also. In this cluster there are factories which belong to established groups like APPL, Williamson Magor, Jaishree Tea etc and also there are small factories run by entrepreneurs and some of these are factories bought leaf tea factories (BLTF).

Fig-2a : Overview of tea factories in Jorhat cluster

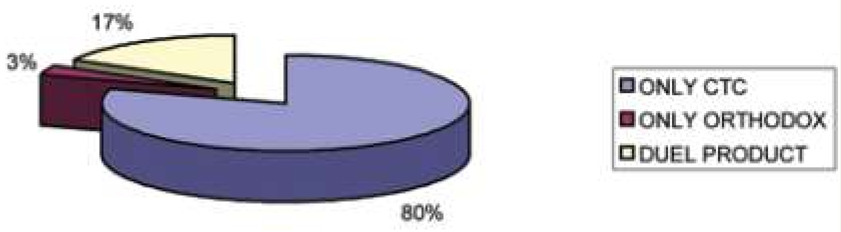


2.1.1 Product Manufactures

The product manufactured in the cluster is mostly CTC tea or black tea with some factories manufacturing duel product orthodox tea and CTC as per the demand of the market and very few factories manufacturing exclusively orthodox tea. It is noticed that manufacturing of CTC is less energy intensive then orthodox and CTC is mostly produced in bulk.

The pai chart (fig-1b) shows in percentage the type of product manufactured in the cluster :

Fig 2b: Type of product manufactured by differnent factories



2.1.2 Classification of units

The tea factories of this SME cluster can be classified in three broad categories based on;

- **Plantation Type**:

Tea factories classified on this type are divided into two types, the first category is the tea factories having their own plantation, whereas the second category of tea factories are those which do not have their own plantation and depend on the green tea leaves bought from gardens not having their own factory. But as this study is concentrated on the energy usage in the tea factories so for the purpose of the study this classification is not considered.

- **Type of product**:

Tea factories based on this type can again divided into two types – tea factories mostly concentrating on orthodox tea and others concentrating on CTC tea. But as switching over between this two type is not a cumbersome process so this classification of the tea factories is not much relevant. Also as the energy consumption pattern in both these two types is similar so from energy point of view this classification does not hold much ground.

- **Production Capacity**:

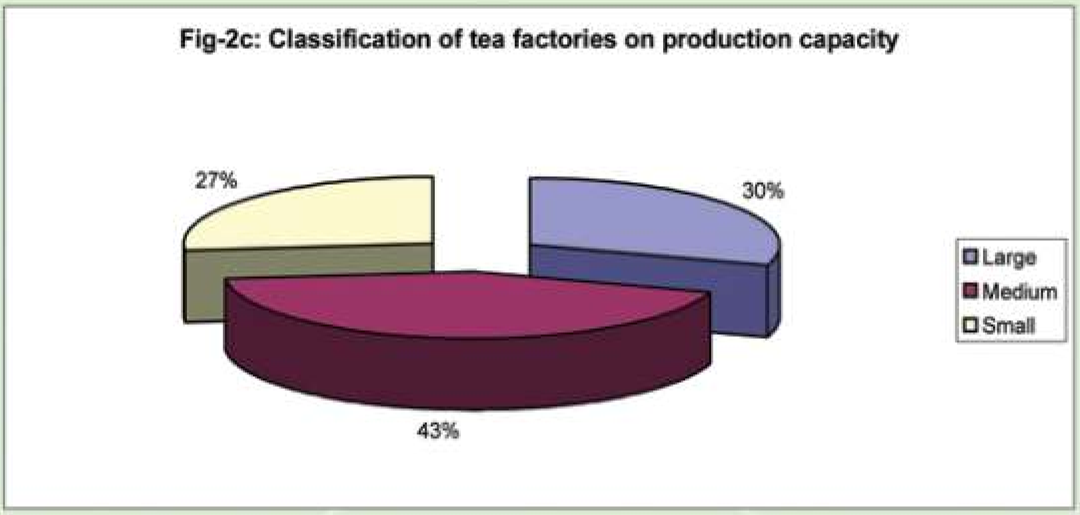
This classification is of relevance for the purpose of this study as it is seen that the energy intensity, i.e., energy required per kg of made tea varies considerably with capacity. For the purpose of this study the tea factories are divided into three sub – groups based on production capacity. The tea factories producing less than 5 lakhs kgs of made tea per year are classified as small tea factories. The term of medium tea factories is used for tea factories producing between 5 to 15 lakhs kgs of made tea per year. And the tea factories having a production capacity of more than 15 lakhs kgs of made tea per year are classified as large tea factories.

For the purpose of this study the tea factories are classified based on the third category, i.e., based on production capacity of the tea factories.

2.1.3 Production capacity detail

In Jorhat cluster all three type of factories (small, medium and large) are existing . Combined production capacity of the cluster can be estimated as 100 million kgs of made tea . Almost 95 % of the total tea produced in the cluster is CTC type and only 5% is orthodox type . Fig 1c shows the no. of factories in each categories in percentage.

Since the raw material for Tea i,e green leaves availability are seasonal hence the daily production capacity of a particular factories varies widely . In a factory producing 10 lakhs kgs of made tea annually can produce up to 10000 kgs in a day during peak season and it may be producing only 1000 kgs in a day during off peak season.



2.1.4 Raw material

Raw material used is in the cluster are the fresh leaves from the garden preferably two leaves and the bud. Most of the factories have their own gardens to feed their factories but the if the leaves are not sufficient then the factories are purchasing the leaves from small growers. There are factories in cluster who are solely dependent on purchased leaves and do not have their own gardens, these factories are called bought leaf tea factories or BLTF. Tea being a plantation industry, the production of raw material is seasonal and depends on the prevailing climatic condition. In Jorhat Tea Cluster, peak season starts from the beginning of the spring, i.e., from the month of March – April and it lasts till the end of Autumn, i.e., October – November. The winter season, i.e., from the month of December to February, is a lean season for the tea factories of Jorhat Tea cluster, during this period the gardens go for pruning of tea bushes and the production of fresh leaves is stalled and so the production. Tea factories are not operational during the lean season for which the repair, maintenance as well as modification work (if any) are done in this period of the year. During the peak season, the tea factories operates even round the clock to process the tea leaves plucked from the gardens as the green tea leaves cannot be stored.

2.2 Current Policies and Initiatives of local bodies

Tea board:

The Tea Board is currently implementing a subsidy scheme under QUPDS (**Quality up gradation and product diversification scheme)** for factory modernization that is scheduled to be in operation in its current phase. Most of the energy efficient equipment recommended by the project is eligible for 25% subsidy under the scheme. The project would also seek the services of a financial consultant who would additionally recommend to the Tea Board non-financial incentives for adoption of renewable energy and energy conservation practices. The project would then dialogue with Tea Board to adopt the recommended incentives.

Duration of the Scheme:

The duration of the scheme is five years during the 11th plan period (i.e.2007-12). However, the receipt of applications for subsidy would be closed either on 31st October 2011 or at an earlier date in the event of the exhaustion of the approved outlay for the Scheme whichever is earlier.

However, in the event of non- exhaustion of the sanctioned allocation, the duration would be extended until 31 March 2012.

Associations :

Following are the list of associations active in the cluster are :

ABITA- Assam branch of Indian tea Association

TAI- Tea Association of India

ATPA- Assam tea planters Association

NETA- North East Tea Association

These Associations are working for both welfare and legal issues of the gardens. They all have a mission for reducing the cost of tea production and awareness on energy conservation, implementation of energy efficient technology in the tea factories are in their agenda.

2.3 Energy Situation in the Cluster:

The tea factories in the Jorhat tea cluster uses electricity from grid to meet their electrical energy requirement. For the purpose of meeting the thermal energy requirement the tea factories uses either coal or Natural gas. The detailed energy status of this cluster is as below;

2.3.1 Electrical Energy:

All the tea factories utilize electricity from the ASEB (Assam State Electricity Board) grid to meet the electrical energy requirement. Although grid power is available but power cut is very frequent and grid availability on an average is only 70 %. Hence the gardens have to rely on in – house generating sets (DG) running mostly on HSD. The average per unit cost of electricity for gardens is ₹ 5/- and ₹ 11/- for grid and self generation (DG Set) respectively. Therefore, the cost of per unit (kWh) of electrical energy on an average for the cluster works out to be:

Table 2a: Unit cost of electricity

PER UNIT COST OF ELECTRICAL ENERGY	
GRID AVAIBILITY	70%
DG POWER	30%
AVERAGE UNIT COST OF GRID	₹ 5.5/UNIT
AVERAGE UNIT COST OF DG	₹ 12/UNIT
TOTAL UNIT COST	5.5* 0.7 + 12* 0.3 = **₹ 7.45 /kWh**

The unit cost of electricity for the cluster is ₹ 7.45/ kWh which is quite high therefore, the cluster has been very keen to reduce the electricity consumption by reducing the SEC (specific energy consumption) per kg of made tea .

Table 2b : Tariff Structure :

S no.	Tariff Structure at HT connection for units at Jorhat Cluster:	
1	Supply Authority	Assam State Electricity Board (ASEB)
2	Supply Voltage	33 kV / LT depending upon load
3	Contract Demand (CD)	Upto 1200 KVA
4	Fixed charges	@₹ 230 per kVA of (75% of CD)
5	Energy Charges	₹4.0/ kWh for E1
		₹ 5.6 /kWh for E2
		₹3.75 /kWh for E3
6	Electricity Duty	₹ 0.10 / kWh
7	Overdrawal penalty	3 times / kVA
8	Meter Rent	₹ 800
9	Transformer rent	₹ 1978
10	Power Factor Rebate/Penalty:	
	0.85 ≥ PF > 0.95 0.95>1 = 0.85 <0.85	Rebate @ 1% Rebate @ 2% no incentive, no penalty penalty @ 1% for every step of 0.01

2.3.2 Thermal Energy :

To meet the thermal energy requirement for drying and withering, the factories in cluster mainly use coal, Natural Gas, HSD, Tea Drying oil or FO (Furnace oil).

Coal: The coal required by these tea factories is bought from the coal fields located in upper Assam; the coal supplied to cluster has a calorific value of 4500 kcal on an average . The average price of coal that is supplied to these tea factories is Rs. 4.50 per kg of coal, the availability of the coal is not a problem for the cluster but quality is an issue since most of the supplier of the coal does not give any certificate of quality and calorific value of the coal. And also the coal available comes from different coalfields, therefore, the uniformity of size and calorific value of coal differs every time new load of comes. Due to this region it is difficult to maintain a standard operating practice of coal use in the factories.

NG (natural gas) : Some of the factories in the cluster have the availability of Natural Gas and some factories have recently switched over to NG, as NG as a fuel is clean and requires less logistics and also the supply is quite reliable . The main supplier of Natural Gas to cluster is Assam Gas Company Ltd and some of the tea factories gets the Natural Gas from GAIL. The cost of natural Gas at present is ₹. 8.30/ scum.

HSD (Diesel) : HSD is mostly used in factories for captive power generation as the grid supply is quite unreliable in the cluster. Average Cost per kW by captive generation is quite high (₹ 12/kW) as compared to grid to generate power as (₹ 5/kW). HSD is also used by some factories for hot air generation in withering . Prevailing cost of HSD at present is ₹ 38/lit .

TD oil (FO) : TD oil (Tea drying oil) or FO is normally used in the cluster by some factories for hot air generation for withering . But due to high cost of fuel oil nowadays factories are switching over to coal or NG. Prevailing cost of TD oil at present is ₹ 40/lit.

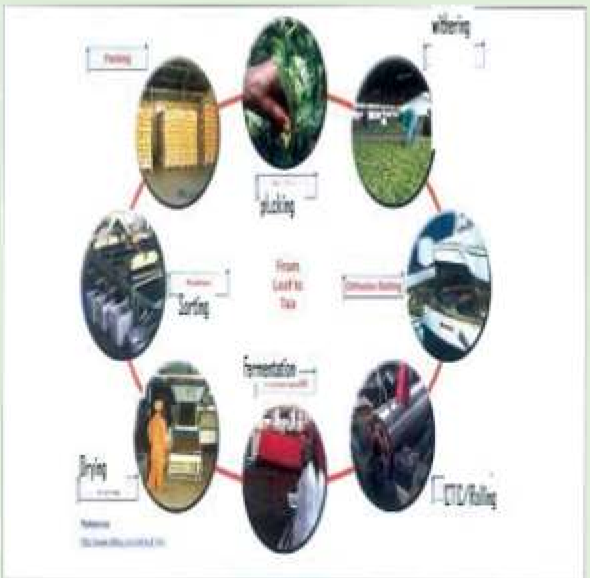
Table: 2c-

Average Cost of thermal energy	
Coal	₹. 4.5/KG
NG (natural gas)	₹. 8.30/ scum.
HSD (Diesel)	₹ 38/lit
TD oil (FO)	₹ 40/lit.

2.4 Manufacturing Process Overview

2.4.1. Process Technology

The tea factories in the Jorhat Tea Cluster mainly produce CTC and orthodox type of tea. The tea processing technology is as given below;



Raw material used is fresh leaves from the garden. Green tea leaves harvested from the tea gardens are brought to the factory by trucks / trailers. They are evenly spread on troughs in 2 to 3 lofts at different elevations and allowed to wither. Green tea leaves contain about 80% moisture and 15-20% of it is removed during withering. It is brittle and if it were not withered it would be mashed into a pulp during further operation. Withering also makes the leaves flaccid. Conveyors carry the withered leaves to the rolling units where the leaf cells are ruptured, releasing enzymes and a twist or a curl given to the leaves to initiate fermentation. The tea leaves are fed into a crushing tearing and curling machine. Here the leaf breakage is more severe, exposing more surface area to the atmosphere. Quicker and more intensive fermentation is achieved. They are then lead into fermenting rooms / drums rotated at slow speed and allowed to ferment in an artificially created humid atmosphere. During fermentation tea leaves change color, the organic acids and other undesirable materials get oxidized and yield the type of liquor having the desired color, taste and flavor. The moisture content in the leaves at this stage is 60-65%.

The process of tea manufacturing involves following steps :

Withering

Withering is principally a drying process to remove the surface moisture and partially the internal moisture of the freshly harvested green leaves. In addition, withering is done to get the correct physical condition, which will allow the leaves to be rolled without breaking. Also, the withering promotes dissipation of heat generated during continuous respiration (chemical changes). There are two major types of withering, open or natural withering, and artificial or trough withering.

Usually, the green leaves from the tea estates are brought to the factory in the afternoons and are spread thinly on banks of troughs (tats). The troughs are made of metal wire meshes with wooden support on which tealeaves are spread and the air is blown from the bottom so that the air passes through green leaves.

Fig-2b: Withering fans

The air is the exhaust from the heater, which is located at ground level whereas troughs are located in an upper floor. Withering is done at 20–25°C depending on the climatic conditions. For best withering, a wet and dry bulb temperature difference of 4°C is maintained. During withering, the moisture content of the green leaves is reduced to 55% (wb) (hard withering) for Orthodox tea production and 70% (wb) (light withering) for CTC tea production. Depending on the weather and the condition of the leaf, withering takes about 6 hours for light withering and about 12-18 hours for hard withering. In withering, more air is blown at the initial stage and on an average the air flow rate should be reduced to two-thirds of its initial value. Once proper withering is achieved, the airflow is continued to prevent the spoiling of withered leaves.

CTC (Cutting twisting curling)

In CTC tea production, a rotor vane is used to shred (pre-condition) the withered leaves. During shredding, the juices come out from the tealeaves. To avoid the loss of juices, a reconditioned (RC powder) is added, which is made up of the pulverized fly-off (leafy grade) from the dryer or fiber removed from the grading operation. CTC machines cut, tear, and curl the preconditioned tealeaves, and hence light withering is necessary. The RC powder and shredded leaves are well mixed and crushed by double action rollers. The CTC machines can burst leaf cells so severely that in some cases the withering stage is not so much important. A large amount of heat is generated due to the friction, and a large quantity of water is evaporated during this process. The moisture content is reduced to 55% from 70%. Depending on the tea grade, 3–4 banks of CTC machines are arranged in a row and the flow of material from one CTC machine to another is by belt.

At this stage the withered leaf cells are ruptured, releasing enzymes and a twist or a curl given to the leaves to initiate fermentation.

Rolling

The process of rolling is practiced by the gardens that are producing orthodox tea. The chemical compounds of the tealeaves are released to initiate oxidation in the fermentation process. Rolling twist the leaf, and at the same time, breaks the leaf structure(cells) to release the juices (catechism and enzymes) for oxidation . A compressed drum/roller twist the withered leaves on a continuous circular motion. A rolling machine size varies from 150-325 kg of leaf per hour. The roller has minimum cutting action and more compressed rolling action. The compression of the roller depends on the type of withering. Low-pressure rollers are suitable for under –withered and high-pressure rollers for over withered leaves. Normally, light rolling at the initial stage and heavier rolling at the later stage of the rolling operation are done. This stage is a mechanically intensive operation that consumes considerable electrical energy and rolling machine has a rated capacity of about 11-15 kW.

Fermentation

As an indicator, the fermented tea leaves become reddish brown. Once the required fermentation is achieved, the fermented leaves should be dried (fired) to arrest further fermentation. Fermentation process gives the different characteristics of the tea brew, normally, shorter/light fermentation gives more flavored and aroma rich tea while longer/deeper fermentation gives color and liquor. Some manufacturers fire the 'dhool' immediately after rolling without fermentation. However, some oxidation takes place during the rolling operation. The natural (Orthodox) fermentation process does not require any energy unless humidifiers are used. In drum fermentation or continuous fermentation, electrical energy is consumed to rotate the drum and to run the blowers. During the fermentation process, CO_2 is produced.

(Fig 2d : Floor fermentation)

Drying or Firing

The fermented tea particles are dried or fired to arrest the fermentation and also to reduce the moisture to about 3%. Clean and odorless hot air is passed through the fermented tea particles in dryers.

Temperature of the hot air varies between 90–160°C depending on the type of dryer. Drying or firing is a thermal energy intensive operation that also consumes electrical energy to drive blowers and dryers.

Drying is a critical process that decides the final product quality of black tea. Two types of dryers are used in the tea industry:

Endless Chain Pressure (ECP) dryer or Fluidized Bed Drier (FBD). In the ECP dryer, tea particles are spread over continuously moving chain-type trays through which hot air flows. The trays move from top to bottom while the hot air is blown from the bottom. The temperature of hot air is about 90°C. The ECP dyer has an advantage to dry both leafy grades and powdered grades. In the FBD, tea particles are pneumatically fluidized by hot air at 140–160°C. Since the tea particles should have a minimum moisture content to get fluidized, it is more suitable for CTC (powdered grades) tea drying. Uniform drying is ensured in FBD and a better quality tea could be produced. This is also a more energy efficient method compared to ECP dryers with less mechanical controls. Moreover, FBD is available at a higher rated capacity of

(Fig-2e : Drying process)

2.4.2. Process Flow Diagram

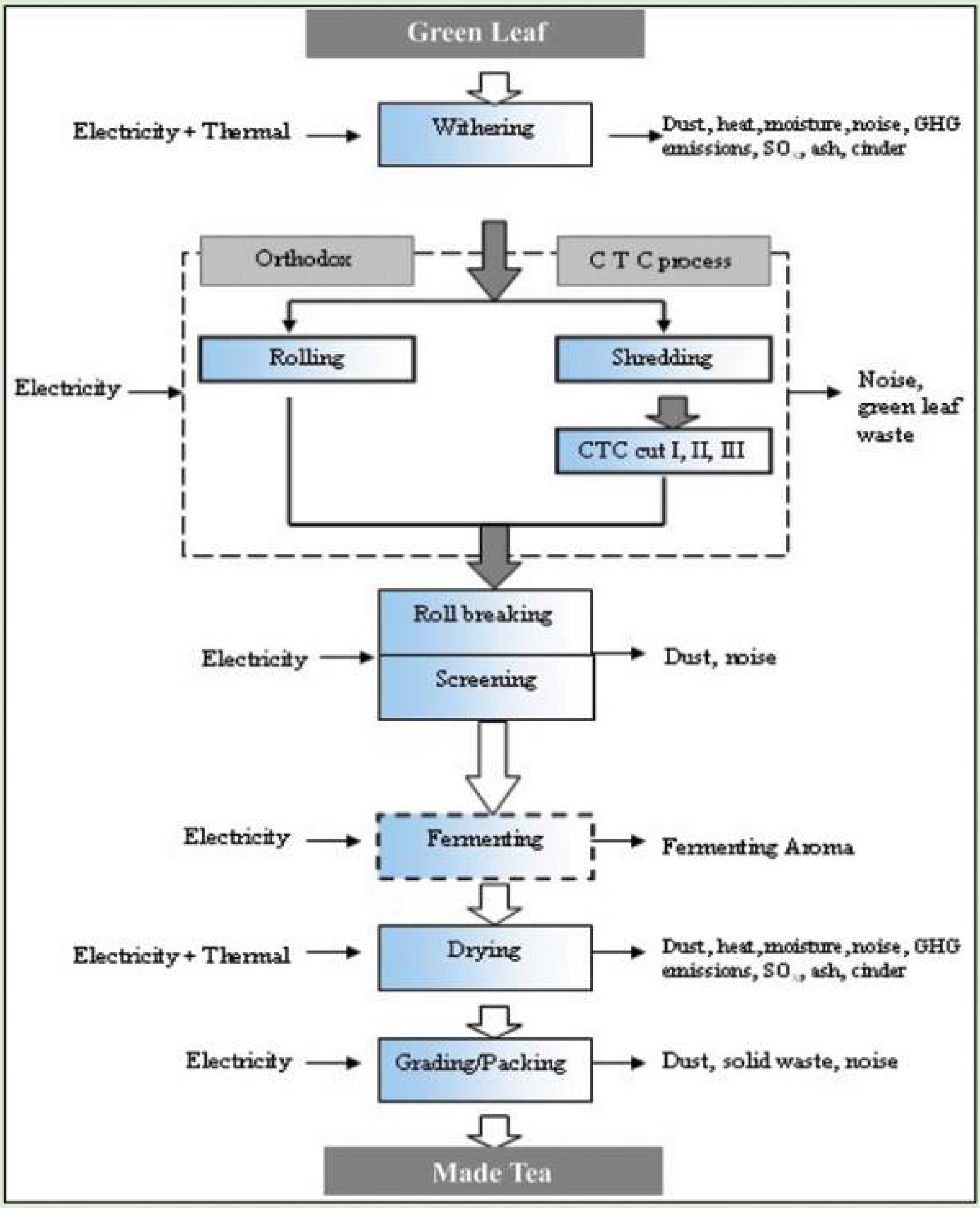


Fig- 2e: Process flow diagram

2.5 Energy Problems and Barriers in Technology Up gradation:

2.5.1. Energy Availability:

- The electrical energy requirement is fulfilled from grid power. But the power supplied from the grid is erratic for which the tea factories have their own in – house Generation (mostly DG sets). But there are not much intervention for utilization of renewable source of energy like solar and biomass for meeting the electrical and thermal energy requirement.
- Some of the factories in the cluster receives NG supply through piped gas, there lies a possibility of generating power through gas gen-sets which will bring down the energy cost for gardens substantially. Presently break even price for NG for power generation vis a vis grid and DG set combine is ₹ 18/scum which is much lower then present prevailing price of NG at ₹ 8.3/scum . But due to policy decision of state government and oil companies cluster is not able to avail the advantage.

2.5.2. Technological Barriers:

- Due to absence of any scientifically designed operator training program, the operation and maintenance protocols for optimum utilization of thermal energy equipment are not followed.
- Though the thermal energy requirement is highest during the drying process of tea and the acceptability for fuel efficient air heater is expected to have a high acceptability, yet there is lack of technological intervention in this regard.
- Majority of the unit's entrepreneurs in Jorhat tea cluster do not have any in depth technical expertise and knowledge on energy efficiency, and are dependent on local technology suppliers or service companies, who normally also rely on established and commonly used technology. The lack of technical know-how has made it difficult for the factory owners to identify the most effective technical measures.
- Most of units in Jorhat tea cluster have been established several years ago when energy efficiency was not important issue for the operation of a plant. They are operating with outdated technology and low-end technologies.
- As majority of the entrepreneurs in cluster are not aware of the energy losses in the plant, there may be a strong feeling that the energy efficiency

initiatives in manufacturing facility can have a cascading effect of failure in critical production areas directly or indirectly connected if the intended performance of the replaced / retrofitted equipment falls below design values.

- There is a strong feeling in the tea factories entrepreneurs that, energy efficiency initiatives are difficult and they do not wish to take the risks such as business interruption due to production loss vis-à-vis the drive to save energy. These can however be overcome by motivating them to attend the awareness programs and use the detailed report on the benefits of the measures identified and cost benefit analysis. Further, sourcing of expertise on maintenance service provider or training by the equipment supplier will definitely overcome the barriers.

2.5.3. Financial Barriers:

- The cost of new technology is high. There is inadequate data on return on investments from energy saving alone. This creates barriers to financial decision making for acquisition of new technology.
- Banks, although willing to lend to the sector are unable to take decisions about lending in the absence of information about techno economic feasibility of energy saving equipment.

2.5.4. Manpower Barrier:

- Skilled workers are locally available to run the machines available in Jorhat cluster. However, there is hardly any innovation regarding energy usage by the workers in these enterprises and the production process remains traditional. This is one of the lacunae of the Jorhat Tea cluster.
- Specialized training with local service providers for better operation and maintenance of equipments; importance of the energy and its use will create awareness among workforce. These programs should be organized with equipment suppliers.

3. Energy Audit and Technology assessment :

3.1 Methodology Adopted:

The Methodology adopted for achieving the desired objectives viz: Assessment of the Current operational status and Energy savings included the following:

Pre-audit discussions at site with the concerned officials/supervisors to collect data/ information on the operations and Load Distribution. The data was analyzed to arrive at a base line energy consumption pattern.

Measurements and monitoring with the help of appropriate instruments including continuous and/ or time-lapse recording, as appropriate and visual observations were made to identify the energy usage pattern and losses in the system.

Computation and in-depth analysis of the collected data, including utilization of computerized analysis and other techniques a appropriate to draw inferences and to evolve suitable energy. Conservation plans for improvements/ reduction in specific energy consumption.

3.1.1 Energy Use And Technology Study

3.1.1.1 Pre Audit Activities:

The pre – audit phase consisted of activities primarily dedicated towards creation of awareness about achieving energy efficiency in general and about the objective of this project in particular. The pre – audit activities consisted of the following activities;

- Networking with the various tea organization, viz., Indian Tea Association, Tea Association of India, Assam Branch of Indian Tea Association, Assam Tea Planters Association
- Networking with Tocklai Tea Research Center, which is the pioneer institution for carrying out research on tea.
- Networking with Tea Board of India.
- Organizing seminar at Jorhat to disseminate information about the project

3.1.1.2 Preliminary Audit Phase:

During this phase preliminary audits were carried out in the tea factories to understand the prevailing practice of tea processing. Also the objective of this phase was to prepare a database regarding the energy requirement per kg of made tea and to evaluate the best practice being adopted by the tea factories. The activities that comprised of in this phase are;

- Selection of a total of 30 tea factories for carrying out preliminary audit. The selection of the tea factories was such that half of the tea factories that were studied utilizes coal for the thermal energy requirement and the rest that were studied utilizes Natural Gas for meeting the thermal energy requirement.
- The tea factories that were owned by the group companies adopt the latest technology, as these companies are cash rich. For this reason, during the study tea factories owned by the group companies were taken up to evaluate the best practice related energy efficiency being adopted in this cluster and also to make a comparison regarding the acceptability of energy efficient technology amongst the tea factories of the cluster.
- Data regarding the consumption of energy were taken from the tea factories during this phase to evaluate the average energy consumption per kg of made tea. The other objective for the collection of this data is to define the baseline scenario regarding energy consumption in this cluster.
- During this phase the potentiality of energy savings that can be achieved through adoption of new energy efficient technology were studied.
- The personals working in the tea factories were counseled regarding the importance of energy saving was done during this phase, so that awareness is created in the grassroots level, as involvement of grassroots level is very much important for achieving energy efficiency.

3.1.1.3 Detailed Energy Study:

After the completion of the preliminary energy study, the detailed energy study was carried out in a total of 9 tea factories. The activities that comprised of in this phase are;

- A detailed study of the energy consumption by the various processes of tea making was studied.
- During this detailed study recommendations regarding the adoption of energy efficient practices that can be adopted were prepared.
- The detailed data to be required during preparation of the DPR for new energy efficient technologies identified were collected during this phase.

3.1.2 Technology Gap Assessment

1. Technology Gap Assessment was done for the total of 30 tea factories within the cluster that were being studied and its process wise assessment are appended below:

Table-3a : *Process wise technology gap assessment:*

Process	Present practice/equipments	Technological gap Assessment
Withering	Hot air leakage observed in ducts from isolating dampers and joints and insulation of hot air ducts not proper	Stopping hot air leakage by proper sealing of dampers and providing proper insulation to ducts to reduce radiation loss.
	Most of the factories are continuously running the fans during withering and not practicing intermittent running of fans .	Intermittent withering instead of continuous withering as practiced by some of the gardens without loss in withering time and quality of product
	Air leakage was observed from dampers and side windows (in enclosed trough) .	Arresting air leakage can save up to 15-20% of total CFM produced by fans which is otherwise wasted as leakage.
	Most of the factories are having axial flow withering fans without cone and tapered inlet.	Suction of axial flow fans for withering can be tapered, and cone can be provided to increase the efficiency of the fan (Fig-2) .
	Air leakage from other fan during single fan operation as other fan is working as exhaust.	Opposite damper position during single fan operation to arrest the leakage (up to 15% of total CFM produced is leaked from other fan during single fan operation)
	Presently most of the factories are having aluminum/steel fan blades in withering fans	Use of energy efficient FRP (fiber reinforced plastics) blades.
	Flow control of withering fans done by damper control method.	Damper control increases system resistance to the fan, which reduces the fan efficiency . VFD (Variable frequency drive) for flow control can be thought of .

Process	Present practice/equipments	Technological gap Assessment
CTC (cutting twisting and curling)	During off peak season CTC machines are lightly loaded but all banks of CTC's are operated	Use of single rotor vane during off peak season can be practiced with a conveyer to distribute the shred leaves equally to both bank of CTC
	Most of the CTC motors under loaded as the rating of the motors are designed as per the worst case situation.	Proper sizing of CTC motors. (Note: Single motor with higher rating instead of three motors can be tried).
Fermentation	In case of CFM(continuous fermentation machines) air leak was observed from unloaded banks .	Stopping air leakage in CFM by dampers and use of VFD through pressure sensors.
	Air humidifier in case of floor fermentation are operated continuously without any regulator .	Regulating the humidifier as per the requirement in floor fermentation.
	Ball formation up to 5-10% of the total made tea is observed at drier mouth. These balls are reprocessed from CTC resulting in loss of energy and manpower in reprocessing.	Use of ball breaker after fermentation to reduce ball formation
Drying	In NG fired direct fired burners in driers the flames of the burners were yellowish in most of the cases, this means improper burning of NG and loss in burner efficiency.	Monitoring and ensuring bluish flame from the burner. Use of energy efficient burners.
	Driers requires hot air at controlled temperature(130 deg C) and pressure . The control of hot air flow is through dampers .	Keeping the dampers fully open and controlling the flow through VFD results in substantial reduction in electrical energy consumed by ID fan.
	Temperature control of drier is done manually	Automatic temperature regulator.
	Hot air exhaust from drier (at 80-90 deg C) is vented out. Potential of heat recovery of low grade heat not explored .	1) Use of heat pump for re-circulation of exhaust hot air for preheating inlet air. 2) Use of exhaust air for hot water generation can be explored.
	Excess air in coal fired heaters are not regulated. High percentage of excess air were recorded in most of the factories resulting in lower efficiency of heaters .	Excess air control in coal heaters up to standard limit. Use of AAFRC (Automatic air fuel ratio controller) resulted in saving up to 18% coal by some factories.
	Regular cleaning of tubes and ducts in coal heaters not done thick formation of carbon layer observed.	Regular cleaning of tubes and ducts to improve heat transfer efficiency.
	Flue gas directly vented out through without heat recovery in coal heaters	Preheating the heater inlet air by flue gas economizer.

Process	Present practice/equipments	Technological gap Assessment
Sorting	Some factories are using incandescent bulbs (60 W) for heating the rollers of sorting tray to generate static charge for picking fiber from made tea.	Discontinuing with use of incandescent bulbs. Proper maintenance of fibrous sheet in sorting roller to create static charge for sorting fiber from made tea.
General recommendation	T-8 and T-12 type of Tube lights with magnetic choke are used extensively in factories	Use of T-5 tube lights with electronic chokes saves up to 40 % of energy in lighting. Also T-5 tubes has better lumens and longer life .
	DG sets performance monitoring is usually not done.	DG sets performance like kWh per liter, lube consumption, DG cooling system, kVA loading etc are to be done on regular basis to know the health of the DG sets.
	Contract demand of the factories is usually much higher then the maximum demand recorded.	Scope for reduction in contract demand should be explored and also unwanted connected load can be reduced to bring down the contract demand.
	Available voltage level varies considerably in the factories with voltage as low as 360 V and as high as 440 V .	Use of AVR (Automatic voltage regulator) to supply voltage at constant level of 415 Volts. Separate servo transformer for lighting load
	Average Power factor observed in the factories were in the range of 0.85 to 0.95.	Improvement of power factor by APFC.
Renewable energy	All gardens have potential for bio-mass utilization as gardens are spread in vast area of land	Bio-mass gasification to meet thermal energy requirement and power generation can be explored
	Waste wind from withering trough is not being utilized	Installation of wind-solar hybrid power generation system

3.2 Energy use and Technology study

3.2.1 Manufacturing Process Study:

The first order of business in tea industry is to manufacture acceptable tea. Failure to meet standards may have severe repercussions, such as loss of throughput and even market position. Off-specification made tea must be rerun, blended with superior product, sold at a lower price, used for other purposes or discarded. These are costly alternatives, including discarding in accordance with pollution abatement procedures.

Quality through drying

Drying of tea is a manufacturing necessity to give quality to the brew as well as to remove moisture, arrest fermentation, reduce volume and increase in shelf life . Drying plays an important role in the development of liquoring characters of the made tea .

Drying process is closely connected to some other processes including proper internal biochemical or microbiological changes which take place simultaneously to ensure the characteristic quality features of the made tea like color, smell, taste, consistence and shape. During drying, some degradation process may also occur simultaneously which endanger the quality of the dried product and, therefore, it should be prevented.

Drying :

Drying is done in two stages

1) Withering

2) Drying after fermentation

Withering

Here the main objective is to reduce the moisture content of leaf to concentrate the juices and to bring the physical condition to a rubbery state in which it will stand twisting without braking up into flakes. There are two types of withering namely physical and chemical withering.

The length of drying time, inlet temperature, drying speed and thickness of spread of leaf influence the equality and valuation of the made tea, which affect the chemical part of drying. For teas, which shrunk during drying, drying with controlled humidity offers the best solution.

Objective of Physical Withering:

1. For the subsequent stages of manufacture, tealeaf is conditioned physically and biochemically.
2. 10-15% moisture is removed from the plucked leaf for reconstituted tea manufacture and 15-20% for no reconstituted tea manufacture.
3. The leaf is conditioned from turgid stage to flaccid stage, which facilitates better rolling.

Changes occurring during chemical withering

1. The level of organic acids, which are responsible for flavor increases.
2. Caffeine content, which is responsible for cup character of black tea, increases .
3. The levels of soluble proteins, free amino acids and simple sugar increases.
4. The level of amino acid increases as a result of break down of proteins by the enzyme peptidases, which is responsible for the for the formation of aroma of made tea

While withering the tea leaves :

1. The hot air temperature should not exceed 35 Deg C.
2. The loft should always be warmed up before spreading of wet leaves.
3. Surface moisture from wet leaves should be removed as quickly as possible to prevent bacterial contamination.
4. Hot air should not be used to force wither in later stage.
5. Variable fan speed is preferred, spreading of we leaves should always start from the side of bulking chamber.
6. Leaves may be spread near bulking chamber.
7. To ensure minimum damage and good uniformity in the weight-to-volume ratio, handling and spreading of tealeaves in the withering

troughs should be done carefully.

Drying of fermented tea

To terminate the biochemical changes and to remove moisture to have better keeping quality are the two objectives of drying .During drying, the coppery red color of fermented leaf turns to black and fermentation is arrested . The moisture content in the fermented dhool and the made tea are 55-60% and 2.5-3% respectively.

Rate of Moisture removal in drier:

The optimum rate of moisture removal from the fermented leaf during drying is between 3.2-3.5% per minute.

If the exhaust temperature is high, the rate of loss of moisture is very rapid and a hard crust is formed at the surface . When the rate of moisture is very rapid and a hard crust is formed at the surface. When the rate of moisture removal is above optimum and the core moisture is not removed properly tea gets case hardened .

If the moisture removal is below optimum, tea gets under fired. Then the enzyme is not deactivated and post fermentation will continue. At low exhaust temperature in dryer, fermenting will continue for a longer period . This is termed as stewing (Krishi Vigyan Kendra; 2000) .

Hence, drying is a delicate operation in which the rate of loss should be regulated so that stewing and case hardening cannot take place .

Temperature of moisture loss during Drying

Temperatures of the leaf and moisture loss in all the four zones of a fluidized bed Dryer (FBD) play major roles on the quality of tea. 50% of the feeding moisture is removed in the first zone. The leaf temperature at the end of the first zone should be maintained at 40 deg C to 50 deg C. This will help the enzymes to get deactivated, which is necessary to achieve theaflavins (TF) and thearubigins (TR) at the correct ratio. To have a better brightness and color of the liquor, the TF:TR ratio should be 1:10 to1:12 (krishi vigyan Kendra;2000). The enzyme is not deactivated when the temperature of dhool is less then the optimum. Hence post fermentation continues and causes stewing.

30% of the feeding moisture is removed at the second zone of the zone of the FBD at the end of the second zone, the dhool temperature should be maintained at 70 deg C.

The remaining 17%of the feeding moisture is removed at the third zone. Then the leaf temperature should reach 70-80 deg C.

In FBD, till the tea reaches 25-30% moisture level, the course of drying is called constant rate of drying period. In this, the tea, if uniformly fluidized, will remain at wet bulb temperature of air contacted irrespective of heat input. The drying course when the moisture drops from 25% to 2.5%comes under falling rate period.

Here the moisture removal rate accompanies temperature rise of tea particles. This range decides ultimately the drying time and final tea quality.

Moisture removed during drying operations

The extent of loss of moisture is determined by the method of manufacture of tea.

The moisture content in fresh green leaf is of the order of 75-80%. Moisture removed during withering and drying for typical tea manufacturing methods along with the quantity of green leaf withering and the made tea obtained from dryer are given in table 1.This is based on taking moisture content of 80% on fresh green leaf, 58%in withered leaf and 2.8% in the made tea.

Table-3b : *Moisture removed during withering and drying:*

	Orthodox	CTC
Weight of green leaf(kg)	100	100
Weight of moisture removed in wither(KG)	44	30
Weight of moisture removed in dryer(KG)	33	47
Weight of made tea (KG)	23	23

Energy consumption in drying operations

Drying process is energy intensive, consuming both thermal and electrical energy. Withering and drying are the two unit operations, which consume the maximum amount of energy.

Value of the specific amount of energy consumed for drying is very important in practice, having a direct effect on the cost of the operation and, thus, on the market price of the dried tea.

The average specific electrical energy consumption (SEEC) and specific thermal energy consumption (STEC) for three ea factories manufacturing tea by different methods are given in the table . Energy consumption also depends on the type and age of the equipments as well as their capacity utilization and production of the made tea .

Relationship between made tea quality and the energy consumed per kg of made tea

If the tea is over dried to avoid accidentally exceeding moisture specification, excessive energy is consumed. The second cost liability is that the additionally dried tea must replace the moisture that would be sold, if the specifications were met exactly. The third liability stems from the fact that most facilities are energy-rate limited. Thus higher energy to product ratios result in lower production rates . The greatest opportunity in cost reduction lies in controlling quality of made tea closer to specifications .

By comparing the present made tea moisture Mp against specification Ms as a function of feed moisture Mf, energy savings for a dryer can be estimated. If E* = minimum energy consistent with meeting quality specifications exactly and E= energy actually expanded, the general moisture –energy relationship for a dryer is given by $E^*/E<(Mf-Ms)/(Mf-Mp)$.

As the moisture Mp in the made tea increases, the dryer efficiency also increases. Hence, E^*/E will always be less that the value calculated strictly by energy balance.

In the tea dryer, if the fermented dhool containing moisture content of 55% is over-dried to made tea with 0.5% moisture where as the specification required is only 3% moisture in made tea, we have Mp=0.5, Ms=3, Mf=55. Then $E^*/E = e<0.95$. Thus by controlling at specification, more than 5% of energy saving can be obtained. Also the weight of made tea produced increases by 2.5% equivalent to the excess moisture removed in the dryer. This result in increase in revenue.

Mf	Mp									
	0.5		1.0		1.5		2.0		2.5	
	e	S	e	S	e	S	e	S	e	S
55	0.950	5.0	0.960	4.0	0.970	3.0	0.980	2.0	0.990	1.0
60	0.958	4.2	0.966	3.4	0.974	2.6	0.983	1.7	0.991	0.9

e= (Mf-Ms)/(Mf-Mp) where E*/E<e

S= Minimum % of energy saving that can be attained if tea is manufactured exactly meeting the specifications

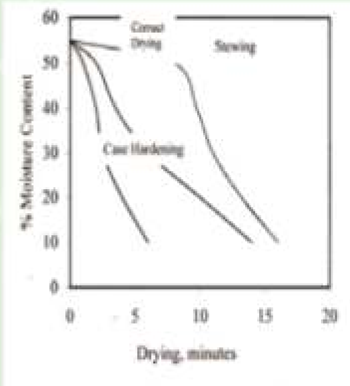


Fig 1. Drying Characteristic Curve

Generally, the excellent quality of dried made tea is the most important requirement and can be considered on the highest hierarchy level. To ensure the god quality, requirements related to some preconditions of the drying process should be satisfied. The requirement of the reasonable energy consumption of the dryer should be considered. Total energy consumption related to net mass of evaporated water is important and well-known characteristics having influence on the cost of made tea and, then, the economy of the manufacturing technology.

Optimizing energy consumption by adopting proper drying techniques and by using energy-efficient motors results in good quality tea, which is going to be the beverage of the 21st century.

3.2.2 Energy Consumption Profile

The tea factories of Jorhat tea cluster generally uses grid power and HSD for meeting the electrical energy requirement. And for thermal energy requirement, they use either NG (natural gas) or coal for drying and withering. Apart from these some tea factories also uses FO (Furnace oil) and HSD (diesel) for withering.

The average energy consumption profile of the different energy sources expressed in terms of equivalent G Cal required per kg of made tea produced by the tea factories using coal as source of thermal energy is depicted in Figure –3a , whereas the average energy consumption profile of the tea factories using Natural gas as the source of thermal energy requirement is depicted in Figure –3b.

Fig-3a: Average energy consumption of tea factories using coal in G cal.

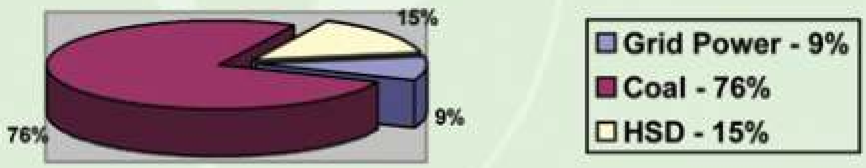
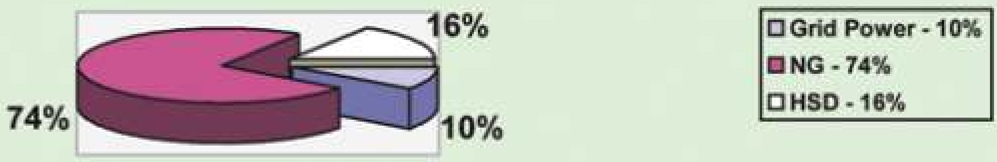
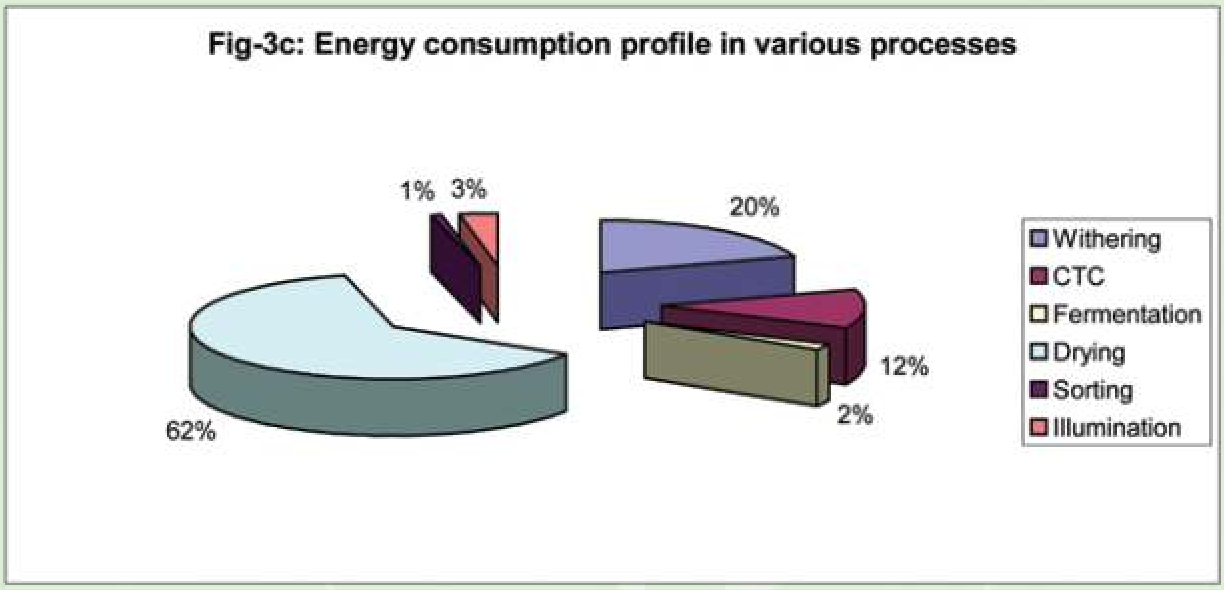


Fig-3b : Average energy consumption of tea factories using NG in Gcal



Energy consumption profile of various processes:

Typical case of total Energy consumed in Giga calorie by different processes in percentage by tea processing factories are depicted in the fig below:



1. The main equipment used and the energy requirements in different sections of the tea factory are given in the table and graphic below:

Table-3c: *main equipment used and the energy requirements*

Section	Main equipment	Form of energy
Withering	Motors, blowers, fans	Electrical energy and thermal energy
Rolling and cutting unit	Rolling machines, motors	Electrical energy
CTC units	Motors, CTC machines comprising rotor vanes, rollers pair etc	Electrical energy
Fermentation unit	Motors, humidifier, fans	Electrical energy
Drying unit	Air heaters, dryers, ID fans, chimneys etc	Thermal and electrical energy

2. Energy consumption profile of individual units of different production capacities using coal and NG in the cluster is depicted below:

Table 3d: ***Annual Energy consumption in different production capacities of cluster using coal:***

Parameter	Unit	Up to 5 lakhs kg of made tea	Between 5-15 lakhs kg of made tea	Above 15 lakhs kg
Annual electrical energy consumption	kWh /annum	221197.4	688252.8	862896.8
Annual electrical energy consumption	MCal/ annum	190,230	591,897	742,091
Annual coal consumption	tpa	390.64	1107.21	1457.63
Annual HSD consumption	KL	27.66	88.69	136.43
Total thermal energy consumption	MCal /annum	2,034,504	5,869,315	7,923,604
Annual production capacity	tpa	450	1000	1900
Total annual energy consumption in one unit of different capacity	MCal	2,224,734	6,461,213	8,665,696
Total annual energy consumption in one unit of different capacity	kloe	222.5	646.1	866.6

Table 3 e : *Annual Energy consumption in different capacities of cluster using NG:*

Parameter	Unit	Up to 5 lakhs kg of made tea	Between 5-15 lakhs kg of made tea	Above 15 lakhs kg
Annual electrical energy consumption	kWh /annum	234896.8	656332.6	805998.7
Annual electrical energy consumption	MCal/ annum	202,011	564,446	693,159
Annual NG consumption	scum/annum	216602	431594.8	629896.2
Annual HSD consumption	KL	30	92	145
Total thermal energy consumption	MCal /annum	2,379,379	5,063,310	7,497,004
Annual production capacity	tpa	480	960	2100
Total annual energy consumption in one unit of different capacity	MCal	2,581,390	5,627,756	8,190,163
Total annual energy consumption in one unit of different capacity	kloe	258.1	562.8	819.0

Total energy consumption in "kloe" is more or less similar with similar production capacity in a unit where Natural Gas or Coal are used as fuel.

3.2.3 Energy Efficiency Study:

Energy Performance in Existing Situation

The energy performance of any industry depends on the scale of production. As this same principle is also applicable to Tea Industry, so for the purpose of evaluating the energy performance, the economics of production is taken into consideration. Thus keeping this into consideration, the tea factories within the Jorhat Tea Cluster is broadly divided into two groups and the energy performance of each group is evaluated separately so that an analysis about the role of economics of production on the energy cost for tea processing can be done.

In this context it is noteworthy that bifurcation of tea factories is specific to this project only and there is no official notification by any authorized bodies in this regard.

The energy performances of these three groups of tea factories are tabulated as below;

Table 3f *:The energy performance (avg.) of three group of tea factories of the cluster are tabulated as below;*

Type of Tea Factory	Grid power, kWh/ kg of made tea	Kgs of coal/ kg of made tea	Liters of HSD/ kg of made tea	Liters of FO/ kg of made tea	Scum of NG/ kg of made tea
Large Tea Factories	0.55	0.72	0.07	0.04	0.32
Medium Tea Factories	0.65	0.82	0.08	0.05	0.39
Small Tea Factories	0.85	1.02	0.09	0.07	0.51

From the above table it is being clearly reflected that scale of production is vital in achieving energy efficiency in tea processing in the present scenario. Gird power which substantiates the majority of the electrical energy requirement is 18% more in case of small tea factories as compared to medium tea factories.

Whereas coal and Natural Gas which substantiates the majority of the thermal energy requirement is 24% and 31% respectively more in case of small tea factories as compared to medium tea factories. Thus the opportunity of attaining energy efficiency is more in case of small tea factories as compared with medium tea factories.

Considering the calorific value of coal as 4500 kcal per kg of coal and that of Natural as 9400 kcal per standard cubic meter (scum), it is revealed that the thermal energy required by tea factories using Natural Gas is same as that for tea factories using Coal. Thus mere switching over to natural gas from coal for meeting the thermal energy requirement does not indicate enhancing energy efficiency in the tea process. In the present scenario this means on reduction in the energy cost as the price of Natural Gas is less than that of coal. Also in case of tea factories using natural gas there is no blockage of capital for maintaining inventory of natural gas which is not so in case of coal. Thus the opportunity of attaining energy efficiency is same for tea factories using natural gas as for tea factories using coal for meeting its thermal energy requirement.

Energy efficiency study in withering section

Bulk of the electricity consumption is consumed at withering by the electric three phase motor driven axial fans, which operates continuously for about 12 hours in high grown and 18 hours for low grown regions.

The corresponding electrical energy requirement for 1000 kg Green Leaf trough is 4 kW. This is equivalent to 0.22 kWh/kg made tea for 12 hr withers, and 0.32 kWh/kg for 18 hour withers. This clearly shows there is a great potential in electrical energy reduction.

Trough Length m (ft)	Capacity (kg)	Air Flow Required (m3/min)	Equivalent Power @20mm Hg (kW)	Installed Motor Size kW (hp)	Calculated Motor Rating (kW)	Oversize %
18.3 (60)	988	593	1.45	3.7 (5)	3.7	**0**
21.9 (72)	1183	710	1.74	5.5 (7.5)	4.4	**25**
25.6 (84)	1382	829	2.03	7.4 (10)	5.2	**42**
30.5 (100)	1647	988	2.42	11.0 (15)	6.2	**77**
36.6 (120)	1976	1186	2.91	11.0 (15)	7.4	**49**

*(75% efficiency, 25% Safety Factor allowed)

By improving the trough design, mainly withering in two stages, high air pressure at initial stages, low pressure at later stages and replacing oversized motors with better efficient motors, it is estimated that the electricity consumption can be reduced by 30–50%, equivalent to a savings of 28 GWh per annum at the national level.

During the processing of tea the percentage of removal of moisture is 3%. Thus theoretically amount of energy is required. But the study of the 30 tea factories in this cluster has revealed that the energy required is .
For the purpose of analyzing the energy efficiency of the present technology practiced for tea processing in this cluster, Specific energy consumption is being developed.

Specific Energy Consumption

Specific energy consumption is estimated in terms of kWh per kg of tea produced. In tea industry, the specific energy consumption is calculated for both thermal and electrical energy as per equation (1) and (2).

$$\text{Specific thermal energy consumption} = \frac{\text{Total thermal energy consumption (kWh)}}{\text{Total amount of Made Tea produced (kg)}} \quad \text{........(1)}$$

$$\text{Specific electricity consumption} = \frac{\text{Total electric energy consumption (kWh)}}{\text{Total amount of Made Tea produced (kg)}} \quad \text{.........(2)}$$

The specific energy consumption could be used to verify compatibility and comparison with benchmarks, if available. It helps to ensure quick assessment of the improvements and weaknesses on the process. It also allows determination of achievable quantifiable goals, which can be a measure for the success or failure of an energy saving project. For monitoring individual process, specific energy consumption of each process can be calculated to identify the energy wastage in a process and it helps in identifying energy intensive operations.

Conventionally, the total specific energy consumption is estimated by adding the specific thermal consumption and the specific electrical energy consumption. In such calculations, the efficiency of the electrical energy is not taken in to account. The total specific primary energy consumption could be the best way to compare the various production processes and to compare alternate energy sources.

Table 3g : Specific Energy Consumption Details

Factory (Tea processing)	Average production (tonnes of made tea per year)	Specific Energy Consumption	
		Electricity (kWh per kg of made tea)	Thermal (kWh per kg of made tea)
Factory 1	402.5 (CTC)	0.672	6.50
Factory 2	394.5 (CTC)	0.680	7.08
Factory 3	486.4	0.729	5.65
Factory 4	(Orthodox)	0.540	7.06
Factory 5	1453.8 (CTC)	0.665	8.14
Factory 6	625.5 (CTC)	0.772	7.48
	712.5 (DUEL)		

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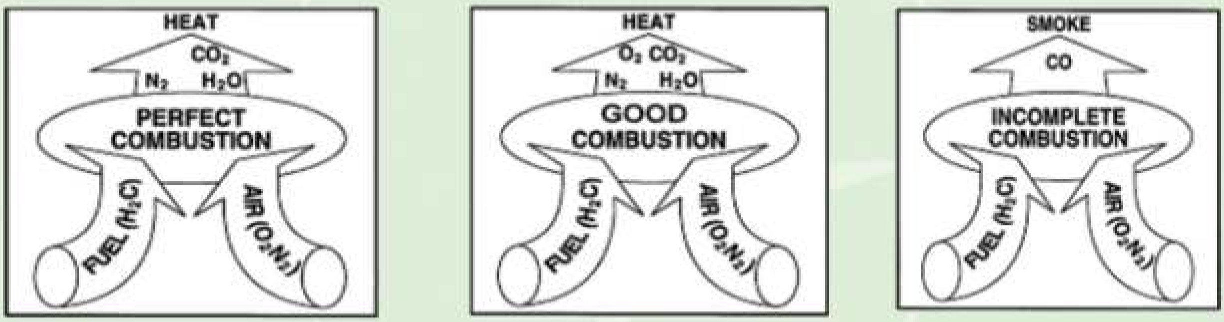
4: Energy Conservation Measures:

4.1.1- Installation of AFRC (Air fuel ratio controller) in stoker fired coal heater.

Existing situation:

In most of the tea factories where stoker fired coal heaters are used for drying process it was observed that the excess air and fuel feed is never regulated /controlled. Whenever there is high temperature at the drier end then it is controlled by opening the gates, which causes heat loss to the atmosphere. Sometime the excess air is too high hence there is high stack loss. Therefore, it is required to control the excess air and also optimize coal feeding to the heater to enhance the efficiency of the heater.



In practice, mixing is never perfect, a certain amount of excess air is needed to complete combustion and ensure that release of the entire heat contained in fuel oil.

If too much air than what is required for completing combustion were allowed to enter, additional heat would be lost in heating the surplus air to the chimney temperature. This would result in increased stack losses.

Less air would lead to the incomplete combustion and smoke. Hence, there is an optimum excess air level for each type of fuel.

Proposed technology

By controlling and monitoring the excess air and coal feed, higher heater efficiency can be achieved. Installation of automatic air fuel ratio controller (AFRC) with minor modification in heater can control excess air and coal feed .

AFRC is basically a VFD which controls the speed of both excess air and coal feed motors as per the temperature requirement at the drier side. Some factories in the cluster has been using this equipment with actual saving in coal up to 20 %.

Table-4a : saving calculation for Installation of AFRC:

Parameter	Unit	Upto 5 lakhs kg of made tea	Between 5-15 lakhs kg of made tea	Above 15 lakhs kg
Annual coal consumption	tpa	390.64	1107.21	1457.63
Annual cost of coal @ ₹ 4500/tons	₹	1757899	4982451	6559350
Saving in coal after installation of AFRC (Automatic air fuel ration controller)- @15 % saving	tpa	59	166	219
Annual Monetary saving @ 4500/ton in lakhs	₹	2.64	7.47	9.84
Total Cost of AFRC per heater in lakhs	₹	2.75	2.75	2.75
No. of AFRC to be installed	kloe	2.0	3.0	4.0
Initial Investment in lakhs	₹	5.5	8.25	11
Payback	**Months**	**25.03**	**13.25**	**13.42**

Barriers in implementation: The Technology is new and there is no local service provider in the cluster. Also the acceptance level of the claimed saving is yet to be verified.

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4.1.2- Installation of Variable Frequency Drive (VFD) in hot air ID (Hot air Exhauster) fan in Dryers.

Present practice:

In the tea manufacturing process cycle drying is required:

A. To stop fermentation going on in the fermented leaf mass (*because fermentation beyond a certain point of time actually lowers the Liquoring quality of teas*),
B. To extend the keeping quality or shelf life of the tea manufactured. Tealeaf with moisture content of 67 to 70% will lead to rapid *fungal growth* and the tea will get damaged within 30 to 50 minutes.

Hence without drying the tea leaf mass after it has fermented to an optimum level, tea manufacture is not feasible.

Drying consumes **2.50-3.70 kWh** $_{\text{thermal}}$ **/kg Black tea** thermal energy (depending on the kind of drier used) as compared to **0.15-0.215 kWh**$_e$ **/kg black tea** of electrical energy.

Dampers control detailed Energy Audits of tea driers have revealed is that in most cases the loading on the main Motor of the ID Fan is from 48% to 65% and hot air flow to driers, thereby clearly indicating that there exists a scope for Energy Conservation to the extent of 40% to 25%.

Project technology description:

In tea driers ambient air heated by N.G/Coal/FO **fired Air heaters**, is fed to the drying chamber by means of the ID Fan driven by a **TEFC, 3Ø, induction motor**. The ID Fan through a MS Duct fitted with Airflow controller Damper feeds this process air heated to a temperature of 95°C to 125° C to the chamber.

The Air Flow rate Controller Dampers are manually operated to control the **Airflow rate** depending on the quantum of the moisture (present in the fermented teas fed to the drier for drying) to be evaporated. The higher the moisture to be evaporated higher is the Process Air flow required. Thus

Process Air Flow rate is a function of the quantum of the moisture to be evaporated by the thermal energy of the Process Air.

Most of the times, the driers are operated with the dampers being, at least, 20% close to a maximum of 40% closed position. Since the Fan impeller speed if fixed & not changeable instantly, due technologies that were so far available to the tea Engineers, all the operators could do was to *Change the damper open position* to change the flow rate. In any case, the Air Flow Controller Damper actually adds to the Air Resistance thereby leading to the higher Power generation by the fan/motor, resulting to Energy constantly being wasted.

Proposed technology:

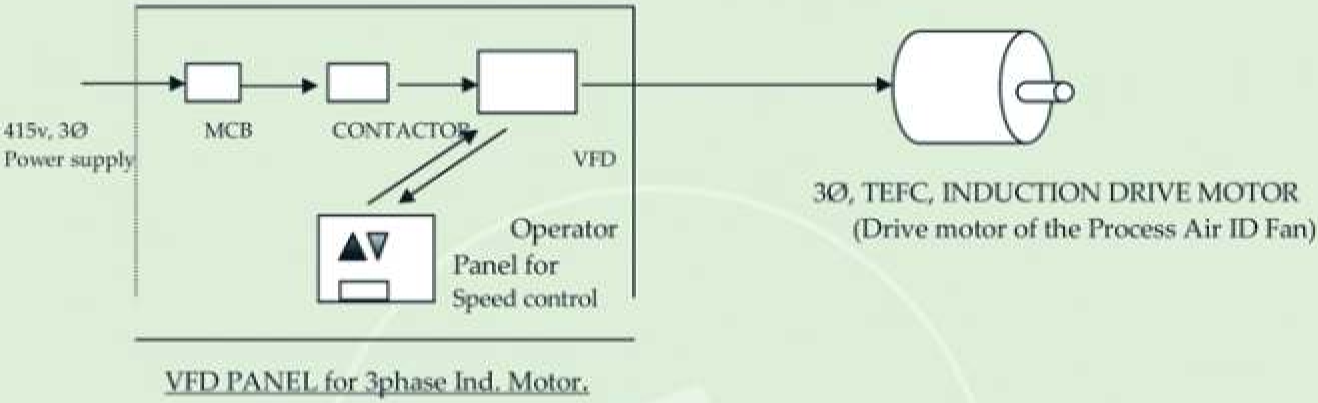
In this project what is planned is: to **optimize the Process Air flow** rate **a)** by keeping the dampers in the full open position and **b)** lowering the flow rate by decreasing the fan impeller rpm, to give the *requisite Flow rate* such that the dynamics of the tea drying process remain same, thereby keeping the tea drying rate unaltered.

A Variable **Frequency Drive (VFD)** actually **lowers the motor voltage** if the ratio of the drive & driven pulleys is such that the motor is actually run at frequency 85% of the rated 50hz, to keep the **V/f** ratio constant such that the operational efficiency improves substantially, thereby leading to **savings** in **Input power** to the ID Fan.

As far the air pressure is concerned, the chamber Airflow resistance goes down due to the complete opening of the Dampers, which are the major cause for increasing the inlet Air resistance of the Chamber. Thus the **Hydraulic Power** developed by the ID FAN is lower (because of the lower flow rate & lower air pressure). This in turn lowers the motor input Power.

Details of the VFD installation:

The single line diagram explains the installation mechanics of the VFD system.



VFD panel for 3phase Ind. Motor.

The Panel can be mounted near the ID Fan or in the main machine panel. The Drier ID fan rpm are also displayed in addition to the power input, input frequency to the motor, etc. Speed is changed from the upper and lowers marked Arrowhead blocks. The system works for more than 15% reduction of the RPM of the ID Fan supplying process Air to the Drier Chamber .It is possible to go in for higher fan speed reductions in case of **lower loading** of the drier or when the ambient air humidity is low as in winter seasons. Calculations are based on 15% rpm reduction of the fan impeller. In case of the VFD Based System higher quantum of Energy is saved when the loading is part of the Full load-this kind of savings are not possible with the existing systems.

At 15% rpm reduction, the ***Affinity Laws*** state that the Air Flow (Q) reduces by 15%,the pressure generated reduces by a factor of $(.15)^2$ or 22.5%,and the power requirement goes down by $(.15)^3$ or 33.75%. With these fundamentals in the background, the following power/energy savings are possible:-

Table:4b -**Energy Saving calculation for VFD in ID fan :**

Particulars	unit	Plant-A	Plant-B
Present fan installed capacity	kW	18.5	22.5
Present power consumption	kW	13	18
Estimated power reduction post VFD	kW	4	6
Estimated operating hours of fan	hr/annum	4000	4500
Estimated power saving potential	kWh/annum	16000	27000
Energy charges	₹/ kWh	7.45	7.45
Estimated cost saving	₹/ Annum	119200	201150
Initial investment	₹	150000	200000
Payback	months	15.1	11.9

Barriers in Implementation:

Although the concept of VFD in energy saving is well established now, but the factories have inhibition about the technology as it requires change in process by fully opening the damper position.

The concept has been tested by the LSP in one of the factory successfully without any change in production and quality of the product (made tea).

4.1.3 Energy Efficient Gas Burners for use in Tea Drier's D.F. Heaters.

The present gas Burners employed in over 1500 installations in the tea estates of Upper Assam are of fixed air/gas ratio with no operator control/adjustment thereby leading to inefficient operation/performance.

In an ideal burner, the **excess air** provided is within **5 to 10 %** of the stoichiometric ratio.

Excess air more or less than the above ratios means in-efficient combustion, which is more often the case with the kind of Burners now in practice in the tea industry.

Minimizing these Combustion losses requires flame monitoring and periodic tuning. Ideally, the fuel/air ratio is automatically controlled based on the percentage of O_2 in the stack, and an unburned hydrocarbons indication. These automated systems are called O_2 trim packages & are expensive.

Proposed technology:

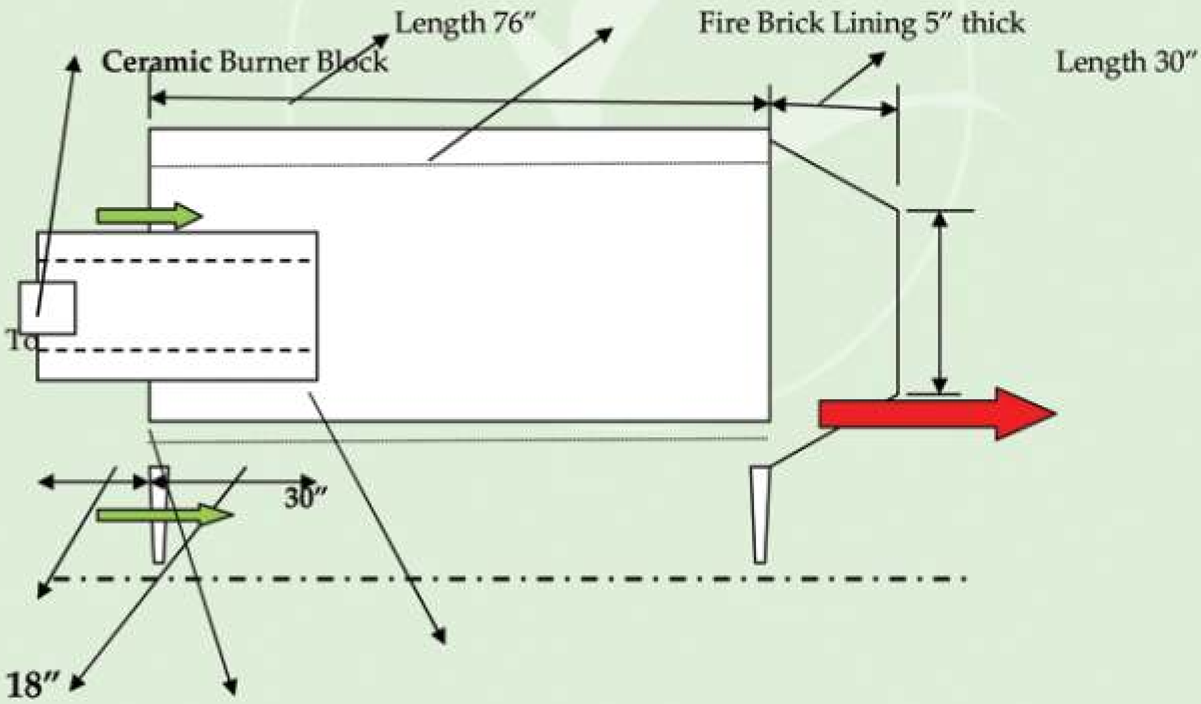
The burner proposed under this project are with ***variable gas/air ratio setting,*** which can be set anytime the operator finds that the flame is not up to the mark. The Color of the flame is a very important indicator of efficient combustion. The photo below show an energy efficient combustion by such a gas burner working under actual conditions under trial in a tea factory drier Air Heater.

One of the most important functions of the burner is to burn **the entire fuel** (gas in our case) with the **least possible quantity of Excess Air**, which gives the highest thermal efficiency.

(Fig-4a : Blue color of flame)

(Fig. 4b: View of the Gas Burners (2 Nos. to match the heat energy input) fitted on the DF heater)

The schematic diagram shows a typical DF HEATER used in tea Driers.



Inner cylindrical Block of dia 36″ x 48″length. It houses the burner block.

AMBIENT Air being sucked by the ID FAN FOR HEATING BY THE GAS BURNER.

Table-4 c-1: Saving calculation for Energy Efficient Gas burners:

	Drier make/model	Drying capacity Kg(dmt)/hr	gas consumption SCUM/kg(DMT)	GAS COMSUMED in scum/hr	savings in gas consumed in scum/hr	savings in gas in Rs/hr	Savings-₹/kg DMT	Savings in ₹/yr (2700hrs)	investment in ₹	Payback period in year
std burner	Kilburn EE Model	350	0.269	94.08						
EE GAS Burner	Kilburn EE Model	350	0.199	69.72	24.36	199.75	0.57072	539330	351927	0.7
std burner	Tepest 6m	300	0.242	72.6						
EE GAS Burner	Tepest 6m	300	0.194	58.2	14.4	118.08	0.3936	318816	235641	0.7
std burner	Super Quality	200	0.33	66						
EE GAS Burner	Super Quality	200	0.264	52.8	13.2	108.24	0.5412	292248	227083	0.8
std burner	6ft ECP	150	0.375	56.25						
EE GAS Burner	6ft ECP	150	0.3	45	11.25	92.25	0.615	249075	192186	0.8

Table 4 c-2 : Payback calculation Energy Efficient Gas burners :

Burner Type	Drier Type	Gas Flow@M³/Sec Rate Reqd.	Type Of Burner Reqd:	Total Burner Costing-Rs.	Savings in ₹	Payback Period(YEAR)
Energy efficient Burner	Kilburn Model EE	69.93	PC45+PC60	3.31743	5.06444	0.66
Energy efficient Burner	TEMPEST 6M	58.2	PC90	1.90422	3.77494	0.5
Energy efficient Burner	SUPER QUALITY	52.8	PC75	2.25319	3.43035	0.66
Energy efficient Burner	6 Ft ECP	45	PC60	1.90422	2.92359	0.65

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Barriers in implementation: This is a new technology and the factories are apprehensive about the success of the technology. However, some factories have implmentated the project successfully.

4.1.4: Energy saving by energy efficient motors in withering and CTC:

Although most of the gardens are using standard motors for withering and CTC, concept of energy efficient motors has been introduced by some of the factories.

The energy efficient motors have additional windings when compared to the conventional motors. An energy efficient motor produces a given amount of work with less energy than a standard motor. Though the initial cost of energy efficient motor is higher than the conventional motor, its running cost and the power consumption are much less when compared to those of the conventional motor.

Energy saving calculation:

Energy saving estimation by replacement of standard motors by energy efficient motors for CTC, withering and Drier Id fan motors is given in the table below:

Table-4d: **Energy saving calculation of EE motors**

Particulars	unit	withering	CTC	drying ID fan
Present installed capacity	kW	5	18.75	22.5
Present power consumption	kW	3.5	12	15
Estimated efficiency at present of Standard motors	%	80	82.5	85
Estimated efficiency at present of EE (Energy Efficient -eff1) motors	%	90	92	93.7
Estimated power saving by EE motors	kW	0.5	0.85	1.5
Estimated Annual operating hours	hours	2800	3200	3600
Estimated saving in power	kW/annum	1400	2720	5400
Energy charges @₹7.45/unit	₹/annum	10430	20264	40230
Initial investment	₹	15000	25000	45000
Payback	months	17.3	14.8	13.4

Barriers in Implementation:

Lack of local service provider and manufacturer of eff1 type motors in the cluster.

4.1.5: Replace the V type belt (mechanical power transmission system) in to Flat type.

Belts are used for power transmission in the tea manufacturing process in CTC and hot air ID fan . The power transmission is due to the friction between the belts and pulleys . V belts are used extensively in the CTC machines and drier ID fan.

Disadvantages of V belts

A. There is more energy consumption in V- belts due to the wedging in and wedging out actions.
B. There is more bending loss due to the larger bending cross section in V belts.
C. Over a period of time it gets elongated due to moisture absorption, tends to become loose.
D. Frictional engagement is between the lateral wedge surfaces of the belt.

Proposed technology:

The existing V-belts can be replaced by modern synthetic flat belts.

Advantages of Flat belts

A. Slippage is less in flat belts because of the larger contact area.
B. Wear and tear is less due to lesser frictional engagement and higher abrasive properties
C. The efficiency of flat belt is higher than that of V belt
D. Frictional engagement is on the outer pulley dia.

(Fig-5a: V-belts in CTC)

(Fig-5b: Flat belts in CTC)

Table-4e : Saving calculation for changing V-belts with synthetic flat belts:

Particulars	unit	CTC	Drying ID fan
Present installed capacity	kW	18.75	22.5
Present power consumption	kW	12	15
Estimated transmission loss by V-belts @ 5% of total kW	kW	0.6	0.75
Estimated transmission loss by flat belts @ 3% of total kW	kW	0.24	0.3
Estimated power saving	kW	0.36	0.45
Estimated Annual operating hours	Hours	3200	3600
Estimated saving in power	kW/annum	1152	1620
Energy charges @ ₹ 7.45/unit	₹/annum	8582.4	12069
Intial investment	₹	20000	25000
Payback	Months	28.0	25

Barriers in implementation:

No local service provider for the proposed technology. Also change in belts also requires pulley modification, Industries are reluctant to fiddle with pulley arrangement as it might create problem for CTC.

4.1.6 : Installation of Energy Efficient Air Blowing System for Withering :

During the study for the 30 tea factories it was observed that substantial reduction in the consumption of electrical energy could be achieved through installation of energy efficient system for blowing air. During the study it was observed that most of the tea factories have inefficient fans for which the amount of air discharged per unit of electrical energy consumed is much lower. Though present days energy efficient fans can produce 13000 cfm of air per kW of electrical energy, but the average discharge of air by the fans that are being installed is 8500 cubic feet per minute (cfm) per kW. Apart from this the outlet as well as the inlet of the fans are not aerodynamic resulting in increased system resistance, thus reducing the overall fan efficiency.

Apart from the above, it was observed that the process requirement demands higher airflow at the beginning of withering and reduced airflow towards the end. But as the fans that are being installed rotates with a single speed, so the variation in the requirement of air is presently being achieved through damper control mechanism, which is energy inefficient.

Proposed Technology:

Based on the above circumstances it is being proposed to improve the electrical energy utilization through:

- Installation of energy efficient fans better cfm per unit of electrical power.
- Modification of the inlet as well as the outlet of the fans to make it aerodynamic so that the system resistance is reduced.
- Present Al/steel fan blades of withering axial flow fans can be replaced by energy efficient FRP (fiber reinforced plastic) blades.
- As the requirement of airflow varies with the time of withering and control of airflow is done through dampers or single fan operation. VFD can be tried for airflow control.

Through the adoption of the above technology it is estimated that there can be a reduction of about 20% in the electrical energy consumption during withering.

Table –4f :Saving calculation by changing to FRP blades in withering trough fans :

Particulars	unit	Fan size	Fan size
Present installed capacity	HP	7.5	5
Present power consumption	kW	4.5	3.5
Saving in % by changing to FRP blades	%	10	8
Estimated power saving by changing to FRP blades	kW	0.45	0.28
Estimated Annual operating hours	hours	3200	3200
Estimated saving in power	kW/annum	1440	896
Energy charges @ ₹ 7.45/unit	₹/annum	10728	6675.2
Intial investment	₹	35000	30000
Payback	months	39.1	53.9

Barriers in implementation:

Payback period is very long also there are cases of breakage of FRP fans during operation. Lack of local service provider is also an issue.

4.1.7 : Modification of coal fired heaters to enhance its efficency.

Under the present circumstances, the coal fired heaters installed in the tea gardens in the cluster are either of stoker feeder type or of manual feeder type . In both the cases, the combustion air is fed into the heater through a single port. This results in non – uniform distribution of the combustion air. For this, when the temperature in the burner rises due to the burning of the coal layer coming in touch with the combustion air at first, there is formation of coal lump inside the burner due to the uneven burning of coal. For this reason only the outside layer of the coal lump thus formed gets burnt, leaving the coal within the lump un – burnt due to absence of combustion air. This leads to, firstly, increase in un – burnt coal loss and secondly, increase in heat loss due to excess air as the combustion air in the burner is utilized to burn only the coal in the outer layer of the lump. The resulting affect is thus decrease in the efficiency of the burner. The efficiency of the most of the heaters in the cluster was found to be below 30% mostly due to high amount of un-burnt losses.

The un – burnt coal loss can be decreased by proper mixing of the coal with the combustion air. And controlling of the flow of the inlet air into the heater can lead to the decrease in the heat loss due to excess air.

Proposed Technology:

In the proposed technology, the heater design will be such that there will be multiple inlet port for combustion air instead of single inlet port as in case of the present heaters. Due to multiple inlet port for combustion air, there will be equal distribution of combustion air in every cross section of the heater, leading to uniform combustion of the coal. In this proposed technology each of the multiple ports will have a control mechanism to control the flow of combustion air, for which the operator can maintain a proper air – fuel mixture within the heater by observing the color of the flame.

Further, with the objective to reduce the un – burnt coal loss in the burner, this coal fired heater will have a manually operated lever controlled coal lump breaker. The lump breaker is not made automated initially, to make these heaters economical and secondly, keeping in view the semi – skilled nature of the operators.

Payback Calculation:

In the conventional dryer burners that are presently being used, the average coal consumption is 0.9 for each kg of made tea in comparison to an average coal consumption of 0.75 kg for each kg of made tea in this energy efficient coal fired heaters. **Thus adoption of this energy efficient coal fired burners will help achieve a coal saving of 0.15kg for each kg of made tea**. The financial calculation is tabulated as below;

Table-4g: Saving calculation for heater modification

Dryer capacity (kg/ Hr)	Saving of coal per Hr (kg)	Yearly saving of coal in kg (3000 hrs)	Yearly saving (Rupees in lacs)	Investment (Rupees in lacs)	Payback Period (Months)
350	52.5	157500	708750	7	11.9
300	45	135000	607500	6	11.9
200	30	90000	405000	4.25	12.6
150	22.5	67500	303750	4	15.8

Barrier in implementation:

1) Local entrepreneur has designed the technology; there is no research paper on the proposed technology. However, the technology has been installed successfully in one of the estate in Assam.

2) For implementing the proposed technology one month shut down of heater is required. Hence, it can be tested only during the lean season when one heater can be taken for modification.

Energy saving in CTC machine

3.1.8 : Improve the operational loading of CTC Motor

Power Consumption in CTC Machine depends on

1. Installed motor capacity and % loading
2. Roller speeds – 600 to 1100 RPM
3. Feeding rate of green leaf – NRC – RC
4. Uniformity of feeding

5. Roller meshing clearance
6. Line voltage – 420
7. Operating power factor – 0.99

Motor loading survey

In most of the gardens surveyed it was observed that the loading of the CTC motors are low up to the extent of 25-30% loading . As efficiency and power factor of the motor largely depends on the motor loading therefore, there is a scope for energy saving by motor de-rating . As benchmark for motor rating in each stages in CTC (1^{st},2^{nd} and 3^{rd} cut) is not established hence different gardens uses different HP rating motors .

Example:

The nameplate details of a motor are given as Power = 15 kW,

Efficiency h = 0.9

Using a power meter the actual three-phase power drawn is found to be 8 kW. Hence the loading of the motor can be derive as:

Input power at full-rated power in kW, P_{ir} = 15 /0.9 = 16.7 kW

Percentage loading = 8/16.7 = 48 %

4.2 Alternate Energy Sources:

4.2.1: Combined Heat and Power System

Combined heat and power (cogeneration) system is the coincident generation of necessary heat and power - electrical and/or mechanical - or the recovery of low level heat for power production. Two basic types of Combined Heat and Power systems are (a) bottoming cycle in which thermal energy is produced first and (b) topping cycle in which electrical energy is produced first.

The ratio of electricity to steam for tea processing is low. So, for a tea factory, a steam turbine topping cycle is recommended. Thermal match cogeneration system offers higher overall efficiency in tea manufacture. The topping cycle Combined Heat and Power system in a typical CTC factory works as follows: Steam is generated in a boiler with a working pressure of 2.4 N/mm^2, using coal as fuel. The capacity of the boiler is 4.5 tons/hr. Steam temperature at boiler outlet is 300°C. Then high-pressure super heated steam expands in a steam turbine the turbine drives a generator, producing electricity amounting to 250 kVA. The exhaust steam from the turbine goes to a heat exchanger where it heats the cold air. The hot air thus produced is fed in to the tea dryer using a fan. The steam condensate coming out of the radiator is collected by a steam trap and recycled with the boiler feed water.

Taking 26% losses of energy in the system and 50% use in dryer, the remaining 24% shaft output is available as bonus energy. Thus there is a scope to meet 33% of the electricity demand of the CTC factory after meeting the thermal energy requirement using the same amount of coal.

For the Combined Heat and Power system of the above capacity, approximate cost of the equipment is Rs. 1 crore and the payback period is around 6 years.

4.2.2: Bio – mass gasification for electrical and thermal energy requirement:

Most of the tea estates are having a large area of plantation, there is a good potential of availability of biomass, which can be any agro waste or wood. Therefore, installation of biomass gasifier will be viable project. In this system solid agricultural waste or forest waste is converted to a combustible gas by chemical process. This gas is popularly known as Producer Gas and is having high heat value. After thorough cleaning of the gas, the same can be fired with a suitable burner to obtain a temperature up to 1000 – 1050 ^{0}C .

SPECIFIC ADVANTAGE

The unique features of our plant are as follows:-

i) Gasifier plant can run continuously 24 hours a day and up to 350 days in a year as per requirement.

ii) The plant can run on any agro waste/forest waste whichever available locally. It is a multi fuel system.

iii) Dual – fuel burner is provided where either gas or oil can be fired. Hence, uninterrupted operation is assured.

iv) Since gas is fired indirectly, there is no adverse effect on the product.

v) Accurate temperature can be controlled in the oven by censors and instruments as in case of oil.

vi) The system is environment-friendly.

Commercial viability:

Commercial viability for such plant is highly encouraging. As the rule of thumb, 5 kgs of wood can replace a liter of oil. and more or less 50% of running cost can be saved by setting of such plant.

To encourage reduction of oil consumption, the ministry of New and Renewable Energy is providing cash subsidy to clients- if installed by an approved manufacturer of the said ministry.

Project will qualify for a subsidy of **Rs. 2.0 lacs & 1.5 lacs respectively** as per prevailing guide - line. Further, depreciation @ 80% of the project cost is allowed in the first year itself by the Income Tax authorities. This also gives considerable financial gain to the investors.

Technical Specification of the Gas Engine Generators: Power unit of 250 kW comprises of the following:

- 250 kWe (1 x 250 kWe) Producer Gas Engine Alternator sets along with all associated instrumentation and control systems,
- Electrical power export and in-house utilizing systems, pollution monitoring and control devices, base frame etc.

Table –4h : ***Pay back for a Synthetic gas gen-set with Woody Biomass Gassifer.***

Sr.	Description	Unit	Qty
A	***Gen-set Output***		
1	Electrical Power @ cos phi = Unity from each engine	kW	250
2	Total Nos. of engines	Nos.	1
5	Total Installed Capacity	KW	250
3	Auxiliary Consumption for Gasifier	kW	22.23
4	Auxiliary consumption of engine	KW	12
6	Operating hours	Hrs.	7200
9	**Net power available (= Total Electrical power at given genset load - auxiliary consumption)**	**kW**	**215.67**
10	**Net power available per annum**	**Lac kWh**	**15.53**
B	***Gas & Electricity price***		
	Cost of Electricity available		
1	Cost of Electricity through Grid	₹ /kWh	5.9
2	Cost of Electricity through DG	₹ /kWh	11
3	**Total cost of electricity assuming 70 % from Grid and 30% from DG**	₹ /kWh	8.5
4	Cost of Woody Biomass (based on a single piece of bamboo)	Rs./Kg	1.5
C	*Capital Investment of power plant*		
1	Cost of Gas Genset with mechanical skid, Ex works	₹. Lac	85
2	Cost of Additional BOP for Gas Genset	₹. Lac	10.67
3	Cost of Gasifier with gas piping between Gasifier and Gas genset	₹. Lac	36.67
4	Air to Air hot water generator (from exhaust)	₹. Lac	13.33
5	Water to Air hot water generator (from JW)	₹. Lac	10
6	Excise Duty on local supplies @ 10.3%	₹. Lac	13.63
7	Sales Tax 2%	₹. Lac	3.39
8	Transportation charges for Gas Genset	₹. Lac	0.83
9	Engineering and Supervision of commissioning of GG	₹. Lac	2.5
10	E&C cost for Gasifier	₹. Lac	4
11	Service tax @ 10.3%	₹. Lac	0.67
12	Insurances (Transit insurance for imported, indigenous material and erection all risk)	₹. Lac	0.26
13	Cost of Woody Biomass storage shed, ash handling etc.	₹. Lac	4
14	Cost of Genset room.	₹. Lac	5
15	Total estimated project cost (sum of C1 to C16)	₹. Lac	189.95
D	*Fixed Cost of Gas genset*		
1	Interest on project @	₹. Lac	-
2	Depreciation @ 7%	₹. Lac	13.3
3	*Total Fixed operating cost per kWh*	₹ /kWh	0.86

E	*Operating (Variable) Cost of Gas Genset*		
1	Calorific value of Woody Biomass (bamboo)	Kcal / Kg	3,800.00
2	Gasifier efficiency.	%	85
3	Fuel input at GG inlet	Kcal / Kg	3,230.00
4	Specific fuel consumption for wood gas	Kcal / KWh	2,566.24
5	Consumption of Woody Biomass	Kg/KWh	0.79
6	*Woody Biomass (bamboo) cost per kWh*	₹ /kWh	1.19
Lube oil cost			
7	Lube Oil Consumption per annum @ 0.33 gms./KWh	Ltr.	528.66
8	Lube Oil Changes @ 8 changes per year	Ltr.	560
9	Lube Oil Cost per annum (@ Rs. 115.00 per Lt.)	Rs. Lac	1.25
10	*Lube oil cost/KWh*	₹ /kWh	0.1
Average Indicative spares cost per unit			
11	For genset upto 31999 op hour	₹ /kWh	0.35
12	Operation and maintenance cost of the entire system	₹ /kWh	0.3
13	*Total operating (variable) cost / kWh*	₹ /kWh	1.92
D	***Heat Recovery from Exhaust***		
1	Consumption of coal for cooling	LacKg/Annum	16
2	Calorific value of Coal	Kcal/Kg	5000
3	Heat input from coal per annum	Lac cal/Annum	80000
4	Exhaust heat available from 1 gensets per annum	Lac cal/Annum	9466
5	Saving in coal consumption	Lac kg/Annum	1.9
6	Price of Coal	₹ / Kg	8.13
7	Saving per annum	₹ Lac	15.38
E	*Heat Recovery from JW*		
1	LPG consumption for primary cooling	Kg/Annum	170000
2	Calorific value of LPG	Kcal/Kg	11000
3	Heat input from LPG per annum	Lac cal/annum	18700
4	JW heat available from 1 gensets per annum	Lac cal/annum	8999.04
5	Saving in LPG consumption	Lac Kg/Annum	0.8
6	Saving per annum	Rs. Lac	14.44
G	***Payback Calculation***		
1	Saving in power cost compared to Grid	Rs./KWh	6.54
2	Annual Savings in power cost compared to grid	Rs. Lac	102.14
3	Saving in Coal and LPG consumption per annum	Rs. Lac	29.82
4	Total Annual Savings		131.96
5	Subsidy from MNRE @ 1 Crore per MW	Rs. Lac	25
6	**Payback Period for Power Plant.**	Years	2.23

Barriers in Implementation: Availability of bio-mass is an issue, also the project does not have existing example and the tea factories are reluctant about trying something new.

4.2 : Other Energy Efficient Technologies/emerging technologies

4.3.1 Hybrid solar-wind system for power generation

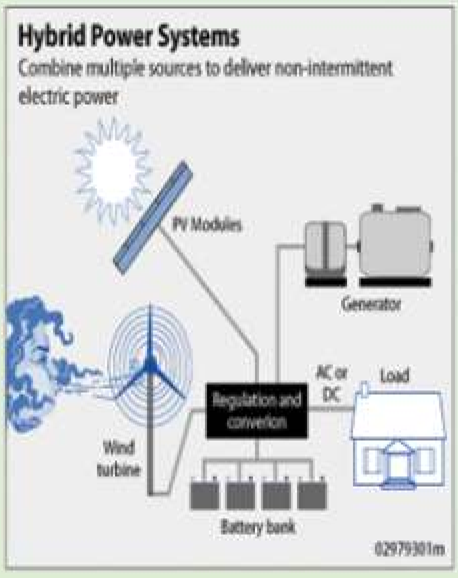
Wind speeds are often low in periods (summer, eventually) when the sun resources are at their best. On the other hand, the wind is often stronger in seasons (the winter, in many cases…) when there are less sun resources. That can make solar-wind hybrid solutions an alternative to consider.

When to consider an hybrid solar-wind system

In the tea estates having enclosed withering trough there is constant flow of wind form the trough, the measured wind speed recorded was 10-12 m/sec . This wind can be trapped to installed wind turbine to generate electricity. Also there are different and opposite wind and solar resource patterns. And those different patterns can make the hybrid systems the best option for electricity production.

The combination (HITA HYBRID SOLAR POWER)

The combination involved on hybrid systems is rather obvious: to get a target goal of, say, 120 kWh of electricity per month we can use a single 3kW wind turbine (instead of a 6kW one...) and a solar system with a smaller array of modules.



Size and price

An hybrid wind-solar electric system demands an higher initial investment than single larger systems: large wind and solar PV systems are proportionally cheaper than two smaller systems...

But the hybrid solution is the best option whenever there is a significant improvement in terms of output and efficiency - which happens when the sun and the wind resources have opposite cycles and intensities during the same day or in some seasons.

4.3.2 : Use of Heat Pump for heat recovery from dryer exhaust

The exhaust gas from the tea dryer has high moisture content and vented out to the atmosphere at a moderately high temperature. This heat from the exhaust of the tea dryer can be effectively used to pre – heat the inlet air to the heater of the dryer by using a heat pump. A heat pump is basically a thermodynamic cycle using vapor compression cycle. This cycle operates in a closed cycle with the circulating substance being kept physically separated from the source (waste heat from the dryer) and the user (inlet air to the dryer heater). The heat pump comprises of evaporator, compressor, condenser and the throttle valve. The waste heat from the dryer is used to heat the circulating substance in the evaporator. This heated up circulating substance is than compressed in the compressor through external electrical power, thus raising the temperature and pressure of the circulating substance. This high quality heat of the circulating substance is then used to pre – heat the inlet air to the dryer heater in the condenser. After passing through the condenser, the pressure of the circulating substance is reduced to that of the evaporator level in the throttling valve and the cycle repeats.

It has been found through research work that Energy required by using heat pump and recycle is only 185.8 kJ/s (electrical energy = 86.75 kJ/s and thermal energy = 99.05 kJ/s) whereas that required without using them is 400 kJ/s.

For a dryer of capacity 200 kg tea/hour in 2 shifts, approximate net investment required for heat pump system is Rs. 4.62 lakhs and payback period is less than 2 years.

4.3.3 : Single Motor operation in CTC:

Presently the process of CTC is completed in three stages 1st ,2nd and 3rd Cut, one motor is used in each cut . The concept of single motor operation for CTC was discussed with the tea factories during the audit and everybody has agreed with the concept. The idea is to run the CTC with bigger size single motor instead of three individual motors.

The project if implemented will be having following advantages:

1) Saving in energy as single bigger motor will have better efficiency then three smaller motors.
2) Saving in inventory cost.
3) Reduction in contract demand as there will be reduction in connected load of the plant.
4) Better power factor as the loading in motor will improve

4.3.4 : Pre withering machine:

Institute of Himalayan Bioresearch Technology (IHBT) has discovered that it was possible to accelerate both chemical and physical withering of green leaf by creating control stress.

On the basis of this concept Mesco Equipment (P) Ltd Kolkatta has designed and developed a pre-withering machine.

They have claimed that both physical and chemical wither is achieved in 4-1/2 to 5-1/2 hours for CTC and 5-1/2 to 6-1/2 hours for Orthodox.

(Fig-7a: Pre- withering machine in use)

BENEFITS

1. Time saving—4:30 hrs to 5:30 hrs for CTC and 5:30 hrs to 6 hrs for Orthodox.
2. Saving of energy by substantial reduction of number of tough fan used.
3. Saving of fuel as hot air is not required.
4. Saving of man days.
5. Reduces the trough area requirement by 27% to 40% by pre-treatment of green leaf.

4.3.5 : Energy saving in dryer by shifting hot air blower to suction side:

The existing FF model dryer consists of two fans for catering the hot air as well as the cold air. A heat exchanger has been placed in the suction of the hot air blower that heats the air to a level of 130 °C. Previously, the dryer had individual fuel burning system (TD oil fired).

Observations:

Following losses are observed in the existing system:

- As the air is heated in the suction of the hot air blower, the air density decreases by 25% resulting in increase in volume by 25%. The power consumption of fans and blowers are determined by three basic parameters namely flow (volume of air), head and the efficiency of the fan/blower system. Hence, the increase of air volume due to increase in temperature results in higher power consumption in the blower.
- Already, both the blowers (hot air and cold air), having extra capacity, makes the operator to partially close the dampers to regulate the flow. This is introducing additional pressure drop across the dampers and in turn results in wastage of power.

Recommendation

The following recommendations can address the above-mentioned losses.

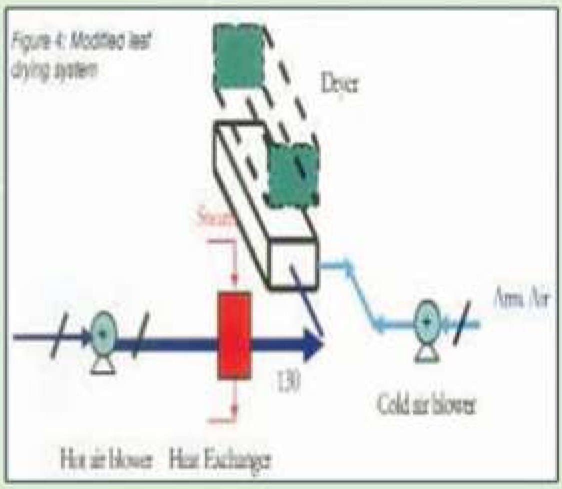


Figure 4: Modified leaf drying system

- It is recommend relocating the heat exchanger to discharge side of the hot air blower from the suction side of the blower. The schematic diagram of the proposed system is shown in Figure 4. By relocating the heat exchanger, the air volume handled by the blower will come down that will result in power savings.

- To address the pressure drop across the damper, it is recommended to install variable frequency drive (VFD) that can be used to regulate the flow by means of speed regulation. These two measures helped save electrical energy worth Rs. 3.5 lacs with an investment of about Rs. 2 lacs.

4.3.6 : Saving in Illumination :

Presently tea estates are using large numbers of tube lights in various locations of the factories like withering troughs, sorting rooms, CTC room fermentation room, drying room etc. The type of tube lights used is T-12 type with magnetic choke.

Recommendation :
It is recommended to replace all tube lights with T-5 type with electronic choke. This type of tube has longer lifespan and also gives better lumens per kW of power . The saving calculation for replacement of tube lights is depicted in the table below: -

Table-4i : *replacement all tube lights with T-5 type*

Description	Units	Qty
Energy consumed by T-12 tubes	watts	40
Energy consumed by magnetic choke	watts	14
Total Energy Consumed	watts	54
No of hours per annum	Hours	3800
Energy consumed per annum per tube	kW	207
Avg no of tubes in Factories	no	150
Total Energy Consumed per annum	kWh	31050
Energy Consumed by T-5 tubes with electronic chokes	Watts	34
Total energy consumed per annum for 150 nos tubes for 3800 hours burning	kWh	19380
Energy saved by replacement	kWh	11670
Monetary saving @ ₹ 7.45 / kWh	₹	86941.5
Initial Investment	₹	90000
Payback	Months	12

Barrier in Implementation: Unavailability of service provider in the cluster and initial high price of T-5 tube lights.

4.4: Sector Specific Barriers in Implementation

Crisis has prevailed in the tea industry after the dissolution of the erstwhile USSR and also rising competition from countries like Sri Lanka, Kenya, etc. These factors were coupled by the lesser yield from the tea bushes due to old age, the concentration of the industry was thus to get proper remuneration for its produces rather than achieving energy efficiency. But this year the situation has improved and the industry is becoming positive towards attaining energy efficiency, this is more so due to increase in the cost of energy sources

The tea factories in this cluster are mostly located in remote areas and there is lack of institutional support for imparting training to the in – house human resource. For this reason there is a hurdle in proper preventive and predictive maintenance of the equipments, resulting in under optimum utilization of the equipments leading to higher energy consumption.

Due to higher cost of energy efficient equipments coupled with authenticated third party performance certification for these equipments, there is barrier for adoption for new energy efficient technology, despite the interest for making the tea processing energy efficient. This is more so in case of first generation entrepreneurs, who are vibrant but have financial limitations. For this reason, it is proposed that adoption of new energy efficient technology and utilization of new and renewable energy for tea processing be introduced through proper risk guarantee scheme. This approach if becomes successful can have a far reaching impact towards making the tea processing energy efficient and utilization of new and renewable energy sources for tea processing

Information Barriers:

1. Due to absence of any authenticated third party organization for achieving energy efficiency in this sector, there is an information bottleneck regarding the specific energy consumption about equipment and/ or technologies leading to inadequate information for decision-making on factory modernization.
2. Though the thermal energy consumption constitutes about 70 – 80% of the total energy consumption, yet over the years no significant steps were taken up for thermal energy optimization due to lack of information. For the purpose of reducing the energy cost the tea factories has gone for switching

over of fuel from Coal to Natural Gas, but this has not led to any decrease in the specific thermal energy requirement for producing tea.

3. There is also absence of mechanism for the flow of information about emerging technology options and their performance between the tea factories.

Technology Barriers:

1. Despite the fact that Tea industry is the oldest industry of Assam, and Assam boosts of having the pioneer research organization for tea, yet there has not been any significant interventions regarding the option of utilizing renewable energy in tea sector (e.g., utilization of bio – mass for meeting energy requirement, etc.). This is mainly due to the prevailing concept of enhancing profitability through increase in sales price by quality up gradation rather than enhancing profitability through reduced cost.
2. Due to absence of any scientifically designed operator training program, the operation and maintenance protocols for optimum utilization of thermal energy equipment are not followed.
3. Though the thermal energy requirement is highest during the drying process of tea and the acceptability for fuel-efficient air heater is expected to have a high acceptability, yet there is lack of technological intervention in this regard.

Financial Barriers:

1. The cost of new technology is high. There is inadequate data on return on investments from energy saving alone. This creates barriers to financial decision making for acquisition of new technology.
2. Banks, although willing to lend to the sector are unable to take decisions about lending in the absence of information about techno economic feasibility of energy saving equipment.

5 : Environmental impact :

The tea industries contribution to environmental pollution in comparison with other core industries is very small. It generates neither liquid effluent nor hazardous waste material. However, the thermal energy use generates pollutants that are air borne which have substantial impact on the environment in terms of green house emissions. Some solid wastes are also produced in the process.

5.1 Overview of waste generation

The major waste generated in a tea factory is air pollutants and solid waste. Air pollution is particularly emitted from the combustion of fuel to generate hot air. The total quantity of different pollutants generated from different processes depends primarily on production capacity and overall operational efficiency of the tea factory. This is expressed in terms of specific pollution load, that is, the total quantity of typical pollutant generated per total quantity of tea produced. The specific pollution load values can be used to calculate the actual amount of pollution based on the production capacity of a particular factory. It can also be used to compare and control generation of different pollutants if such figures are known for other factories or if standard indicators are available

Fig-8: ***(Ash and clinker generated in coal-fired heaters)***

5.1.1 Solid waste generation

In the withering process, rejected green leaves are the major wastes when the leaves are spread/loaded on the troughs. Small quantities of leftovers and litter are also generated in the rolling and CTC processes. On the average, the tea industry generates about 100kgs of waste green leaves or litter per ton of tea produced.

During drying, tealeaves and fibers could be blown from the dryer. The average blowout is about 2-4% of made tea. In heaters, the use of firewood, coal generates ashes and clinkers. Coal or firewood heaters produce about 100 kgs of ash per ton of made tea on the average.

During sifting, fibers (stake) are produced. In some factories, these fibers are pulverized and recycled in the process as the re-conditioner (RC powder). Otherwise, these fibers and blowouts are denatured, in which every 25 kg of fibrous waste is mixed with 1 kg of lime and buried in pits. Some portions of the denatured wastes are used as fertilizer for tea plantations.

5.1.2 Air pollution

Air pollution in the tea industry mainly comes from emissions of harmful gases during combustion of fuel (coal & fuel oil) in the air heaters for through withering and drying processes. Though some fine tea dusts are also emitted from the drying, screening and packaging processes, these are generally dusts that settles and do not pose any major environmental problem. The main pollutants of concern are carbon dioxide (CO2), carbon monoxide (CO), sulfur dioxide (SO2), nitrogen oxides (Nox), hydrocarbons, dust, fly ash and particulate matters, which are produced during fuel combustion.

5.1.3 Carbon Dioxide Emissions

As a greenhouse gas (GHG), CO2 is the single largest contributor to climate change, constituting about two thirds of the total GHGs jn the atmosphere. The total fuel consumption by the Indian tea industry contributes to CO2 emission by 1.352 million tons per year. Moreover, energy consumption by this sector causes additional indirect CO2 emissions of about 0.62 million tons per year. In total, the tea sector generates about 1.94 million tons of CO2 per year or 2.23 kg of CO2 per ton of made tea. The withering and drying processes, which consume thermal energy, are the major sources of CO2 emissions.

*5.1.*4 Sulfur Dioxide Emissions

Sulfur dioxide is another pollutants emitted from fuel combustion, which is of concern because of its contribution to acid rain. For India, the total SO2 emission is about 13.16 thousand tons per year with a specific SO2 emission of about 0.016 kg SO2/kg made tea.

5.1.5 Other GHG Emission

Other gases such as carbon monoxide, monoxide, methane, nitrogen dioxide, and nitrous oxide also contribute to GHG. The total specific emissions for each of these pollutants vary widely, depending on the type and amount of fuel consumption. In the tea production process, manual control of fuel feed and blowers (for combustion air) is practiced, which could lead to incomplete combustion of the fuels. This could cause a major environmental effect at the factory level when excessive CO is produced because it could lead to fatal suffocation of the workers.

5.2 Other Environmental Impact:

Noise and dust are two other main pollutants generated n tea manufacturing. In the withering process, the noise produced by the trough fan/blower and resultant dust and/or particulate matter from the withered leaves are matters of concern. Recently, many factories are opting to mechanize this process by installing moving perforated belts for laying out green leaves, motorized breakers for leaf separation and automated discharging. This automation minimizes the presence of workers exposed in this hazardous area.

Tea factories are plantation based industry for which generation of bio – mass is substantial. Apart from this as tea making is a labor intensive industry so there is further generation of bio – mass from the labor quarters, which are located within the vicinity of the tea factories. Under the present scenario, these bio – mass is being degraded in the usual course and there is no commercial utilization of this bio – mass, thus resulting in the emission of methane in the environment. The direct impact of gasification of bio – mass will be on the reduction of this methane generation taking place due to degradation of the bio – mass.

Again as the residue of the bio – gasification unit can be utilized as a good source of organic fertilizer for the tea garden, so this will help in the reduction of the use of chemical fertilizer. Thus the indirect impact from the bio – mass gasification will be reduction in the GHG emission due to production and transportation of the chemical fertilizer.

5.3 Sustainability Assessment

5.3.1 Socio - economic effects

The project does not have any specific proposals for ensuring **social sustainability**. Barrier identification in the initial phase suggests that crisis in the tea industry as a result of non-remunerative prices and the current practices that undermine the value of information-based analysis are socio economic barriers. But the project team expects that social sustainability would get addressed in the process of implementation of barrier removal strategies. The project is not competent to intervene in the economic downturn of the industry but its interventions would contribute to improved profitability for each factory.

6. Conclusion :

In this section summary of outcome of energy use and technology studies conducted in Jorhat tea cluster is discussed, which include identified energy conservation measures, its energy & monetary benefits, payback period, issues in implementation are discussed. Details of the same are furnished in table below:

Table- 6a: *Summary of energy saving proposals in Jorhat tea cluster*

S. No	Energy conservation measure	Annual Energy/Fuel saving	Annual Monetary saving (Rs. lakhs)	Implementation cost (Rs. Lakhs)	Simple payback period (in months)	No of units this can be implemented	Annual energy saving potential in cluster
1	Replacement of T-12 type tube lights and magnetic choke with T-5 type tube lights and electronic choke for lighting.	11670 kWh	0.86	1.2	17	130	1517 MWh
2	Use of energy efficient fan blades (FRP blades)	50000 kWh	2.2	8.5	46.4	90	4,500 MWh
3	Proper sizing of CTC motors (most of the motors were grossly under loaded).	40000 kWh	2.4	5	25.0	100	4,000 MWh
4	Use of synthetic flat belts instead of v-belts in motors.	11000 kWh	0.82	4	58.5	120	1320 MWh
5	Replacement of standard NG burners by EE burners	52 kloe	4.5	5	13.3	50	2600 kloe
6	Use of VFD for hot air ID fan	20000 kWh	1.5	2.5	20.0	110	2,200 MWh
7	Use of heat pump for re-circulation of exhaust hot air for preheating inlet air.	9 KLOE	3.4	7	24.7	90	810 kloe
8	Utilizing wind energy coming out from enclosed type withering troughs for power generation.	30000 kWh	2.1	4.5	25.7	45	1,350 MWh

S. No	Energy conservation measures	Annual Energy/Fuel saving	Annual Monetary saving (Rs. lakhs)	Implementation cost (Rs. Lakhs)	Simple payback period (in months)	No of units this can be implemented	Annual energy saving potential in cluster
9	Energy saving by energy efficient motors in withering and CTC	55120 kWh	4.1	8.5	24.9	100	5512 MWh
10	Modification of coal fired heaters to enhance its efficiency	49.5 kloe	5	7	16.8	35	1732 kloe
11	Installation of AFRC (air fuel ratio controller in coal heaters).	67.5 kloe	3.8	5	15.8	45	3000 kloe
12	Energy saving in dryer by shifting hot air blower to suction side	12 kloe	4	7	21.0	40	1000 kloe
13	Bio-mass gasification to meet thermal energy requirement	60 kloe	4.5	8	21.3	40	2400 kloe

Major energy sources being used in cluster are Coal, Natural gas, Furnace oil, HSD and Electrical energy. Annual energy consumption of above mentioned sources in different type of operations in Jorhat cluster is presented in table below:

Table 6b : *Annual energy consumption of various energy sources in Jorhat tea cluster:*

Classification	Electricity (kWh/annum)	NG (scum/annum)	HSD (KL)	coal consumption (tpa)	FO (KL)
Large	36927180	15407592	4994	26362	288
Medium	44769963	11939840	5859	35623	165
Small	6053907	2241047	4098	7924	98

Table 6c : ***Annual energy saving potential from various energy sources in Jorhat tea cluster:***

Classification	Fuel savings					Electricity savings
	Coal (lakh kg/yr)	Wood (T/Yr)	HSD (kl/Yr)	FO/RFO (kl/yr)	NG (lakhs sm^3/yr)	kWh/year
Small factories	20.53	NA	530	26	9.69	**3,115,054**
Medium factories	32.83	NA	770	42	15.9	6,500,366
Large factories	40.97	NA	1050	55	18.35	5,900,345
Total Saving	**94.33**		**2350**	**123**	**43.94**	**15515765**

Total Annual energy consumption in the cluster is around **84,252 kloe (kilo litre of Oil Equivalent).** After implementation of proposed energy conservation measures will save the 15,515,765 kWh of electrical energy, 94.33 lakhs kg of coal, 2350 kls of HSD, 123 kls of FO and 43.94 lakhs sm3 of NG. Annual energy saving potential identified in cluster is around ***12,446 kloe***, which is around 14.77% of total energy consumption.

6.1 Financing of the EE Measures

Financing is often projected as one of the major roadblocks for implementing new technology including EE measures. The project will work to facilitate a financing arrangement in the form of risk mitigating measures for EE projects being undertaken by the units in the 25 clusters. Such a scheme could be implemented through CGFTI, SIDBI and the lead banks in various districts. Such a fund is being proposed by the World Bank as a part of multilateral funding for SMEs. The Bureau would work to facilitate the formation of this risk mitigating measure/fund.

The partial guarantee fund for MSMEs will cover 30% of the risk guarantee, along with the entrepreneur sharing 30% and the banks the remaining 40% of the risk. The Bureau estimates that a funding of approximately ₹40 crore would be required to give shape to this fund . However, only facilitation of the formation of this fund and not the fund itself is a part of the Bureaus activities .

The output of the activity will be an arrangement between the world bank and with SIDBI/lead banks which will fund collaterals for EE measures.

6.2 Short listed Technologies for DPRs

Following Technologies had been short listed for DPR preparation:

1) Bio – mass gasification for electrical and thermal energy requirement
2) Energy Efficient Gas Burners for use in Tea Drier's D.F. Heaters
3) Installation of AFRC (Air fuel ratio controller) in stoker fired coal heater.
4) Installation of Variable Frequency Drive (VFD) in hot air ID (Hot air Exhauster) fan in Dryers.
5) Energy saving by energy efficient motors in withering and CTC.
6) Hybrid solar-wind system for power generation.
7) Modification of coal fired heaters by improving its thermal conductivity.

7 : Small Group Activities/Total Energy Management

1. Introduction

Energy is one of the most important resources to sustain our lives. At present we still depend a lot on fossil fuels and other kinds of non-renewable energy. The extensive use of renewable energy including solar energy needs more time for technology development.

In this situation Energy Conservation (EC) is the critical needs in any countries in the world.

Of special importance of Energy Conservation are the following two aspects:

(1) Economic factors

(2) Environmental impacts

1.1Economic factors of Energy Conservation

Energy saving is important and effective at all levels of human organizations – in the whole world, as a nation, as companies or individuals. Energy Conservation reduces the energy costs and improves the profitability.

Notably, the wave of energy conservation had struck the Indian intelligential 3 years earlier when a Fuel Policy Committee was set up by the Government of India in 1970, which finally bore fruits three decades hence in the form of enactment of the much awaited Energy Conservation Act, 2001 by the Government of India. This Act made provisions for setting up of the Bureau of Energy Efficiency, a body corporate incorporated under the Act, for supervising and monitoring the efforts on energy conservation in India.

Brief History of energy efficiency movement in India and associated major milestones are as follows

- 1974: setting up of fuel efficiency team by IOC, NPC and DGTD (focus still on industry)
- 1975: setting up of PCAG (NPC main support provider) : focus expanded to include agriculture, domestic and transport

- 1978: Energy Policy Report of GOI: for the first time, EE as an integral part of national energy policy – provided detailed investigation into options for promoting EE
- Post 1980, several organizations started working in EC area on specific programs (conduct of audits, training, promotion, awareness creation, demonstration projects, films, booklets, awareness campaigns, consultant/product directories)
  - Some line Ministries and organizations like BICP, BIS, NPC, PCRA, REC, Ministry of Agriculture, TERI, IGIDR, CSIR, PETS (NPTI)
  - State energy development agencies
  - Industry associations
  - All India financial institutions

The Government of India set up Bureau of Energy Efficiency (BEE) on 1st March 2002 under the provisions of the Energy Conservation Act, 2001. The mission of the Bureau of Energy Efficiency is to assist in developing policies and strategies with a thrust on self-regulation and market principles, within the overall framework of the Energy Conservation Act, 2001 with the primary objective of reducing energy intensity of the Indian economy. This will be achieved with active participation of all stakeholders, resulting in accelerated and sustained adoption of energy efficiency in all sectors

Private companies are also sensitive to energy costs, which directly affects their profitability and even their viability in many cases. Especially factories in the industrial sectors are of much concern, because reduced costs by Energy Conservation mean the more competitive product prices in the world markets and that is good for the national trade balance, too.

1.2Environmental impacts of Energy Conservation

Energy Conservation is closely related also to the environmental issues. The problem of global warming or climate change is caused by emission of carbon dioxide and other Green House Gases (GHG). Energy Conservation, especially saving use of fossil fuels, shall be the first among the various countermeasures of the problem, with due considerations of the aforementioned economic factors.

2 Small Group Activities (SGA)

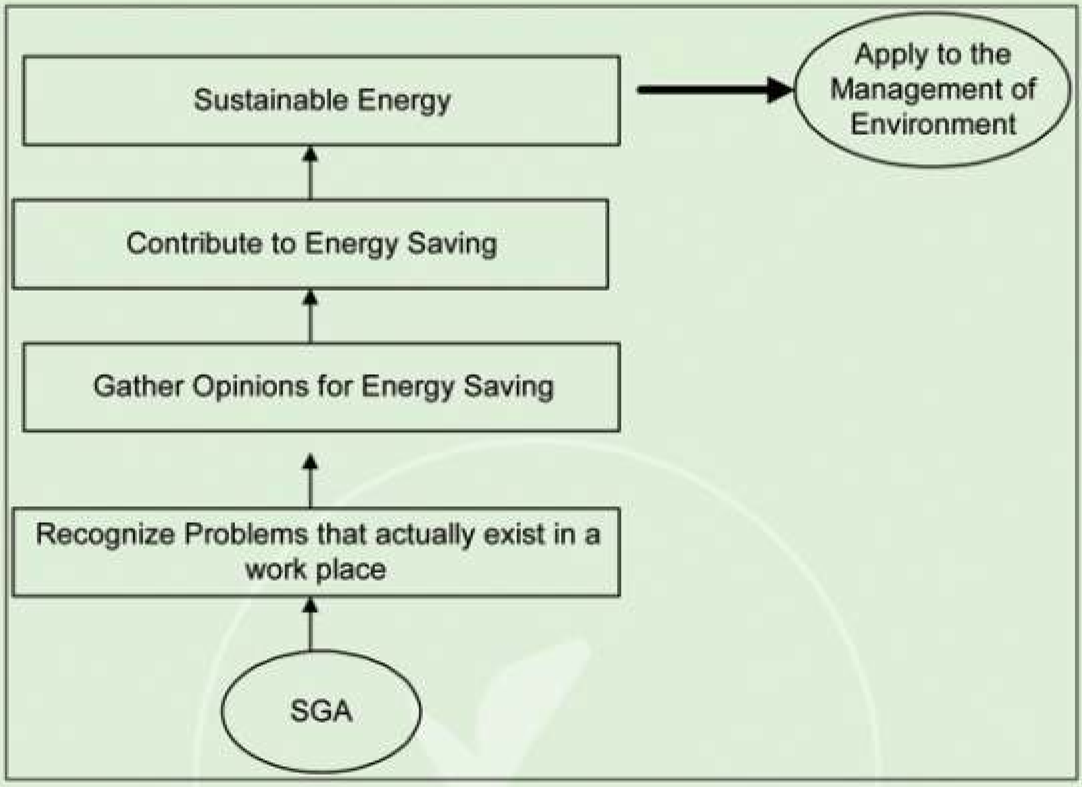
Small Group Activity (SGA) gives employees the problem solving tools they need to eliminate obstacles to Total Productivity, the culmination of zero break-downs, zero defects, and zero waste. Enterprising employees identify the problem, be it in "man, material, method, or machine," and develop cost-effective and practical methods for solving the problem.

2.1Importance of SGA

SGA are activities by group of employees at operator (working Group) level. They aim to solve problems that occur at the place taken care of by each employee and put emphasis on participation and team work. Factories can apply small group activities to many kinds of work along with normal work or other measures that are already underway. The burden on employees will not increase because of small group activities. They are not only bringing benefits to factories but also boosting the knowledge and ability in performing jobs of employees, improving communication among employees, increasing creativity, and make it possible to express their own proposal with less hesitation to management. As a result, employees will start to think "This is our problem." This SGA can be applied to Energy Conservation, too, with successful results, as shown in Figure 13.

2.2How SGA leads to Energy Conservation?

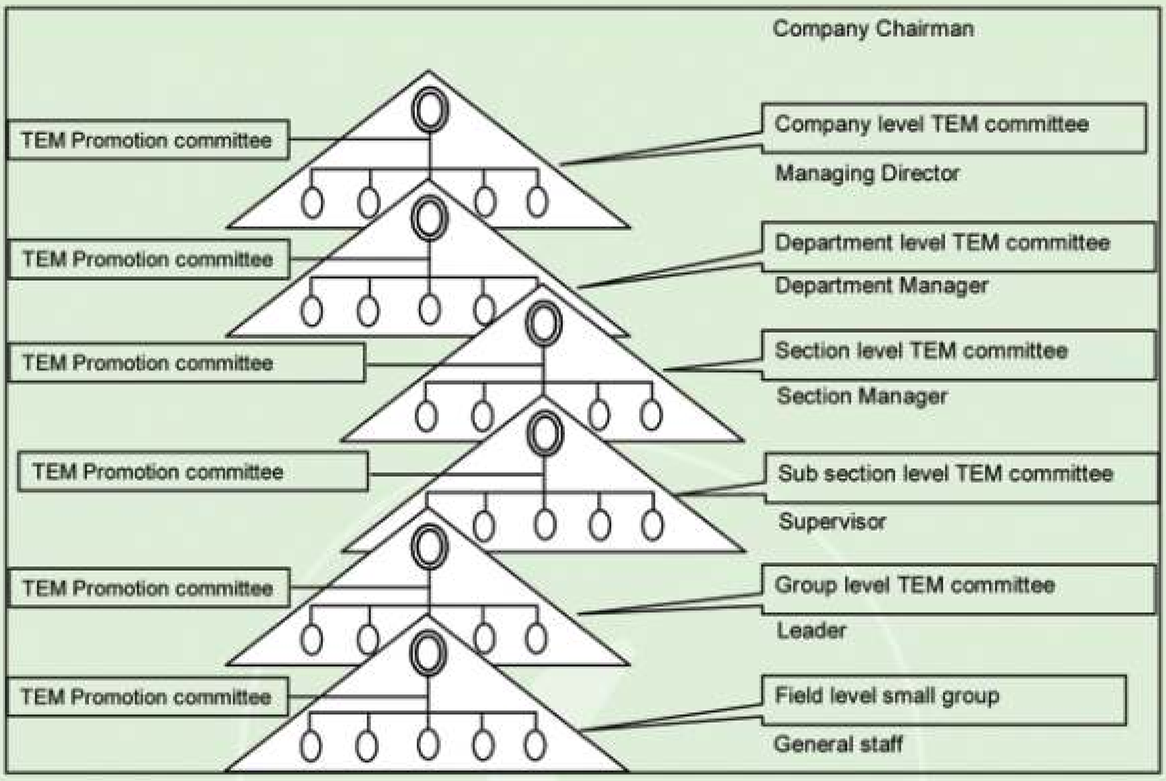
An excellent example of organizational structure that promotes energy management emphasizing participation is that they form overlapping small groups as in figure 14. The feature of this structure is that a small group for energy management is distributed to various sections as in figure 15, which is a recipe for success of Total Energy Management (TEM) and makes various communications and management of activities more efficient and effective.



Relationship of SGA and energy saving

Small group activities for total energy management (TEM) are the activities in which employees of all levels in production or management, starting from the top to the bottom, participate in order to reduce loss related to their own job by improving their job. In order for the activities to succeed, management of all levels must provide support in necessary training and equipment, communication of policies, and the setting of problems to solve.

Small group activities for TEM can be divided into 4 or 5 levels depending on the scale of the organization. This division is in order to emphasize the fact that everyone must improve in their job under the responsibility to each other. It also enables us to make improvement without overlapping. The following example shows utilizing the existing job-related organization as much as possible, as already mentioned in Part 2, 2."Strategy for Improving the Efficiency of Energy Usage further", Step 2 Proper EC Organization including Assignment of Energy Manager (page 12).



Example of Organizational Structure with Overlapping

- Provide advice for Total Energy Management to various groups
- Persons in charge of the office must be those with good personal relationship, friendly, and with spirit of good service

2.2.3 Medium level

- Define the policies of each department that are consistent with the policy of the Total Energy Management and the target of the company
- Define numerical targets to sub-groups apart from the target of the company as a whole
- Follow-up the progress in order to provide to sub-groups
- Report the progress along with suggestions and opinions to upper level committee periodically

2.2.4 Workers/Operators level

- Implement small group activities with various themes and achieve target
- Report progress and problems encountered during implementation to upper level committee periodically
- Ask for support, suggestions, and opinions from upper level committee

Responsibility of Energy Conservation committee

- Gather and analyze information on costs related to energy every month
- Analyze and solve problems related to energy
- Find a method for energy conservation
- Prepare energy conservation plan
- Follow-up the result of implementing the plan
- Perform activities such as public relationship for encouraging employees to participate

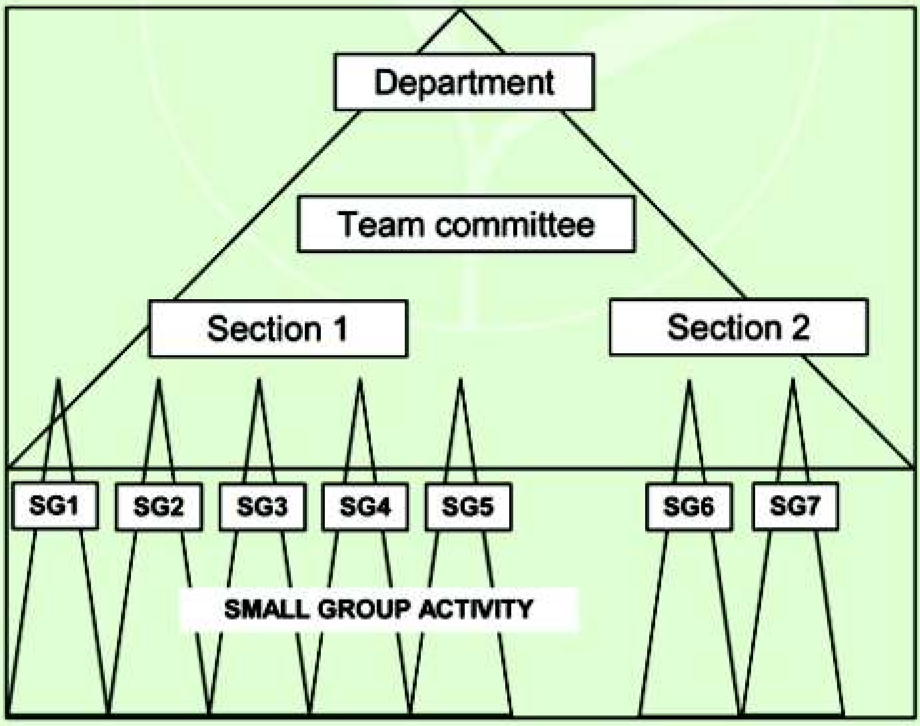
Positioning of SGA in Main Job Structure

2.2.1 Executives level

- Define the policy and target for Total Energy Management
- Follow-up and manage activities to make sure that activities are implemented according to the policy
- Consider opinions and suggestions from the promotion office
- Consider reports from promotion committee from various levels

2.2.2 Level of Total Energy Management promotion office

- Make sure that whole activities are done in the correct direction, without delay and smoothly
- Find a suitable method that makes it possible to implement activities



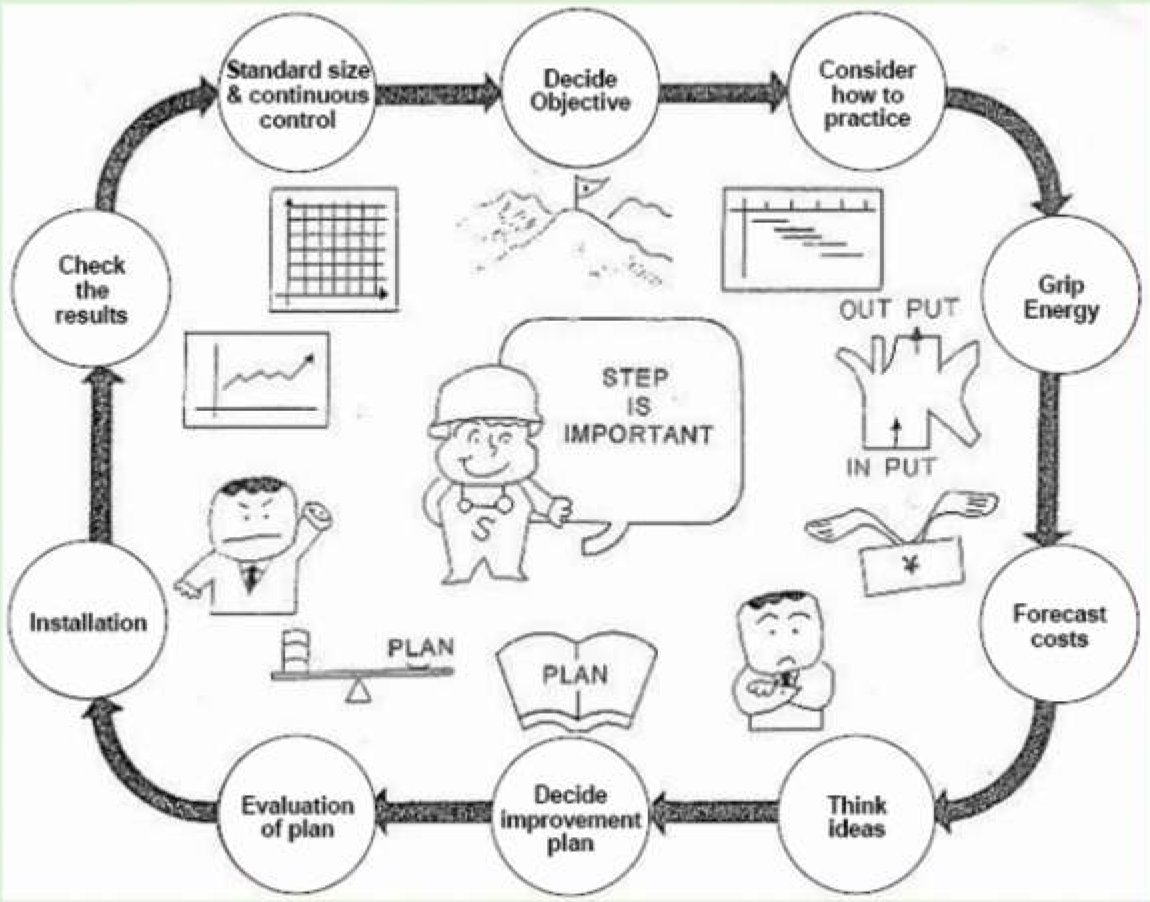
continuously and without slowdown

- Listen to opinions and suggestions from small groups in order to use for improving

- Offer training to small group in each department

2.3Steps of Small Group Activities for Energy Conservation

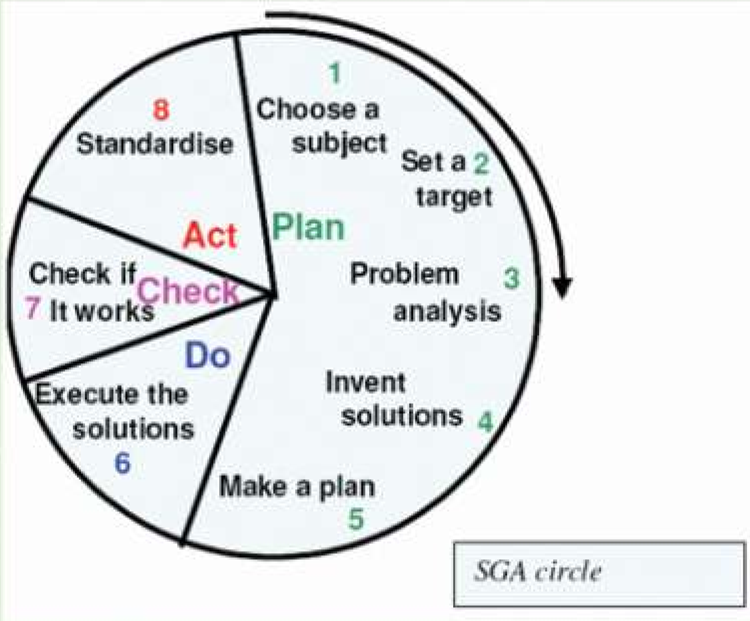
Small group activities for Energy Conservation can be done by using "10 Stages for



Success", based on "PDCA Management Cycle", as shown below and in pictorial forms

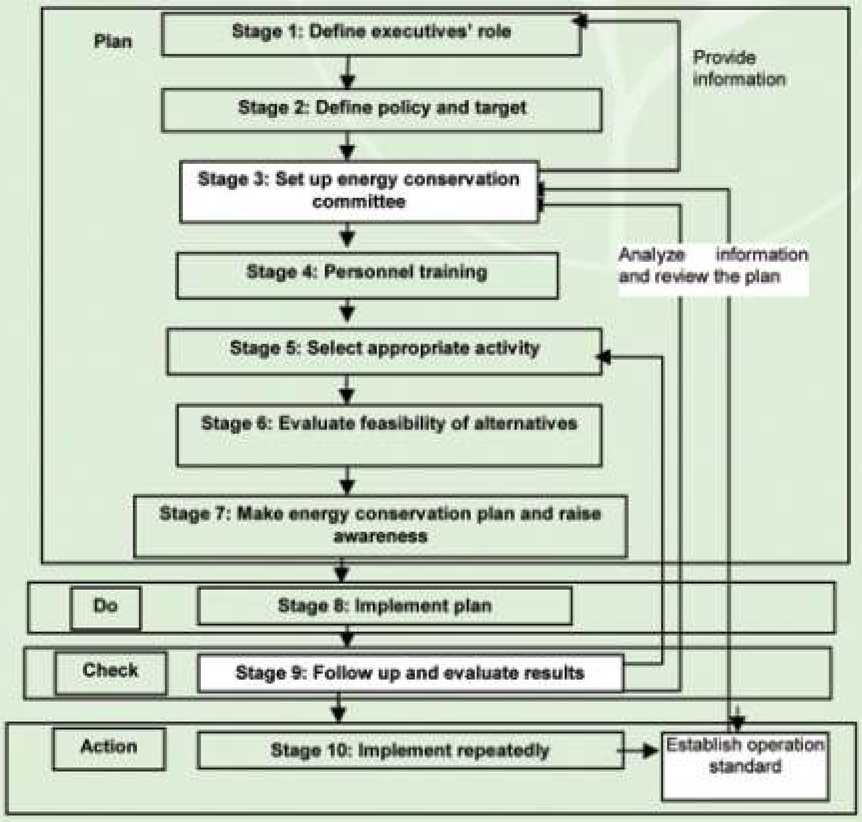
- Plan: Make an efficient plan in order to improve operation
- Do: Implement according to the plan

- Check: Check if implementation was according to the plan
- Act: Judge what to improve, what to learn and what to do from what we have checked
-



SGA circle

Please note that these stages are substantially the same as "Key Steps" explained earlier, but put more stress on utilization of SGA. So readers could read and use either method up to their preference.



10 Stages for Success

2.3.1 Stage 1: Define Executive's Role

In promoting small group activities, support must be provided such as basic environmental support. Therefore, executives must provide follow up support to employees of their companies.

- Establish a special unit that provides support to small group activities
- Prepare a system for managing small group activities in the company
- Prepare annual plan for small group activities
- Prepare a venue for meeting, consultation, advice or suggestion
- Establish a system for giving rewards to high achieving employees
- Establish a reporting system starting from informing what to do until reporting of the results
- Establish a fair system for evaluating results
- Establish a system for providing support and training to employees

2.3.2 Stage 2: Define Policy and Target

- Executives must announce a policy of supporting small group activities.
- Energy conservation committee must act as an advisor in order to set a numerical target that is consistent with total energy management (TEM) policy and the target of the organization. Specific targets must be set for each group.

We can see that responsibilities in stages 1 and 2 are mainly those of executives and committee. Responsibility of employees will become clearer from stage 3 and afterwards.

2.3.3 Stage 3: Set up Energy Conservation Committee

The principle of small group activities (SGA) is to divide into groups based on the scope of responsibility. The size of the group will depend on the size of organization. However, size of the group should not be too large. Usually a size of 5 to 10 persons is considered appropriate. It is important to define responsibilities clearly so that every member of the group can have their responsibility and participate in the activities.

2.3.4 Stage 4: Personnel Training

This stage will help employees to have more knowledge and understanding, have new ideas, and have more belief in their own responsibility.

2.3.5 Stage 5: Select Appropriate Activity

In doing small group activities, each member must be able to think, express their own ideas, and make decisions based on reality and by investigating electrical equipment, machines, and office equipment that exist in the area of their responsibility. Items to consider include size, number, where to use, situation of usage, current situation, and the number of hours usage per day.

By this we can evaluate the current situation of energy usage. Also by judging if there are more machines than needed, we can choose suitable activities and real problems for the organization.

2.3.6 Stage 6: Evaluate feasibility of alternatives (Analyze problems and decide on the measures and activities in each point)

Each group will gather ideas on the reasons for the problems, obstacles, and how to solve problems in order to decide on the problems, measures, and importance of activities and thus evaluate on the feasibility of activities to do based on advice from department manager. Basically, the following activities are not suitable for small group activities.

- Highly technical issues
- Issues that require a long time or many people to implement

We have identified the following problems through small group activities.

- Issues on material quality or production that influence energy usage
- Behavior on energy usage
- Efficiency of machines or equipment that uses energy
- Awareness toward environment and energy usage
- Safety costs for energy conservation

2.3.7 Stage 7: Make Energy Conservation Plan and Raise Awareness

Each group must prepare its activity plan. Generally, implementation for small group activities takes 6 months to 1 year. Activities to be implemented should correspond to the objectives of each group. Besides, it might help to listen to opinions of all organizations in order to receive support from all other organizations.

2.3.8 Stage 8: Implement Plan

Implement according to the plan of each group.

2.3.9 Stage 9: Follow Up and Evaluate Results

After implementing the plan, each member of small groups will follow up and evaluate the result by analyzing result, search for strong and weak points of activities, find a way to improve the activities and report on general achievement.

2.3.10 Stage 10: Implement Repeatedly

Energy conservation is an activity that must be implemented repeatedly. Therefore, it is necessary to implement each activity repeated and make improvement to each activity. If we are satisfied with the results, by achieving the objectives of activities, we should provide rewards in order to give motivation for continuing the small group activities and implement creative activities.

Dos and Don'ts in Energy Conservation

- ✓ Don't Emphasize the mistakes in the past. It is better to talk about the present.
- ✓ Don't Be worried about the theory or principles. Don't spend too much time in discussion or analysis of problems in meeting rooms.
- ✓ Don't Think that an activity can be done perfectly from the beginning. It is necessary to do the job continuously by having experiences and judging by ourselves.
- ✓ Do Start with an activity that requires small amount of investment.
- ✓ Do Raise awareness so that all employees understand the necessity and importance of energy conservation and participate in it.
- ✓ Do Start the activity now without postponing to tomorrow.

2.4Tools that are Used Often for Small Group Activities for Energy Conservation

2.4.1 5S

5S is a contraction derived from the Japanese words **Seiri, Seito, Seiso, Seiketsu,** and **Shitsuke**. It is simple methodology that is also extremely useful in practical and realistic life. 5S is a set of actions to be followed through every day activities to advance the operational surroundings and circumstances. 5S is made in order to provide fortification to every personage in diverse profitable and industrialized fields. 5S is an extremely practical contrivance and skill set for anyone who wants to generate a more prolific environment within the workplace or who wants to make it their profession to make other people's businesses more proficient and productive. 5S occupy a list of products including eyewear, ear protectors and safety gears. Look into these different products that make up the significance of an industrialized security supply. Lean Six Sigma experts promise or guarantee for the efficiency of 5S as an enlightening enhancement to better working surroundings in an association. If you dig up Six Sigma guidance that is paid for by your company, you will be in a position to work for your company and make things better for you as well as for everyone. 5S is very useful in lots of industries and job markets, but can often fail simply because of the lack of recognition concerning changes in the office.

5S consists of five steps that are crucial for the completion of 5S. The 5S steps are described as follows-

1.Seiri / Sort- This is very logical term in, which identification of the contents take place, data base of the products have been created and, then any kind of sorting take place just to arrange the products and removal of unwanted items. Classification of the products is necessary, which is called Red Tagging. It is important just to identify factors, right from whether it is needed, existing amount obligatory amount, occurrence of necessity, and so on.

2.Seito / Systemize- This step in 5S process consists of removal of unwanted items permanently and one more task that to be take place is decision that means you have to decide that what is required to be in what place. Place the items in such manner that you could retrieve them within 30 seconds of requirement.

3.Seiso / Brush away/ Sweep- Examine al the items on the daily basis. The process is not that much time consuming, but essential to clean up your workplace and most required in 5S. The conscientiousness to keep the office clean should be circulated between everyone in the group.

4.Seiketsu / Homogenize- This important step of 5S involves the visual control, which is important to keep your organization well- organized and clean. It is a complete evaluation to improve the working conditions.

5.Shitsuke / Self Control- This step is quite essential, but critical because it involves all the discipline to ensure the 5S standards, it also takes charge of dedication and commitment.

2.4.2 QCC (Quality control circle)

QCC (Quality control circle) means controlling quality through group activities. For this, it is necessary to work hand in hand and achieve objective quality or customers' request. With this, we can find weak points, find the cause of problems, gather ideas for problem solving and systematically prepare quality and thus, solve problems such as material loss, production costs, working hours, or productivity. This is also a very useful tool to tackle with Energy Conservation problem. So many factories or institutions are encouraged to utilize this tool.

ANNEXURE - 1

List of summary of recommendation of detailed energy audit report :

Plant –1:

RECOMMENDATIONS	Estimated saving in Fuel/power	Annual Saving (in Rs)	Implementation cost	Payback
Providing damper to other fan during single fan operation in withering trough	33000 kwh	Rs 2 lakhs	Nil	immediate
Providing Insulation and blocking leakage from dampers and joints of the Hot Air Duct for Withering	5238 scum of NG	Rs 31740/-	Rs 20000	8 months
Installation Energy Efficient Gas Burners for use in Drier's D.F. Heaters.	62850 scum of NG	Rs 3.81 lakhs	Rs 2.5 lakhs	8 months
Reducing the Contract Demand from 596 kva to 500 kva		Rs 176,000	Nil	Immediate
Providing VFD in drier ID Fan:	15116 kwh	Rs 113370	2 lakhs	20 months
Saving by replacing under loaded motors by suitable lower size motors	24000 kwh	1.5 lakhs	2.8 lakhs	18 months

Plant-2:

RECOMMENDATIONS	Estimated saving in Fuel/power	Saving potential in Rs	Implementation cost	Payback
Blocking Air Leakage in withering troughs	25000 kwh.	1.5 lakhs	nil	Immediate
Installation of Energy Efficient Gas Burners for use in Tea Drier's D.F. Heaters.	24330 kwh	Rs 1.47 lakhs	Rs 1.5 lakhs	13 months
Installation of Flat belts instead of V-belts.	5300 kwh	Rs 34,980	1.5 lakhs	4 yrs
Changing of all t-12 type tube lights to energy efficient T-5 Type tube lights	6000 kwh	36,000	50000	16 months
Saving by replacing under loaded motors by suitable lower size motors	18000 kwh	1.18 lakhs	2 lakhs	20 months

Plant-3:

RECOMMENDATIONS	Estimated saving in Fuel/power	Saving potential in Rs	Implementation cost	Payback
Installation of lighting voltage servo transformer.	*5300 kWh*	Rs31800	1 lakhs	3 yrs
Providing Insulation at the Hot Air Duct and blocking the hot air leakage from dampers and joints for Withering	1967 lts of HSD	Rs 68845	Rs 10000	2 months
Installation of APFC (Automatic power factor controller)		Rs 64000	1.2 Lakhs	2 yrs
Installation of AFRC (Air fuel ratio controller)	114705 kgs of coal	Rs 516176	6 lakhs	15 months
Replacement of V belts for power transmission in motors to modern synthetic flat belts	8400 kwh	Rs50400	2 LAKHS	4 YRS
Changing withering fans to FRP from present Al blades	20700 kwh	Rs 124,200	4.5 lakhs	4 yrs

Plant-4:

RECOMMENDATIONS	Estimated saving in Fuel/power	Saving potential in Rs	Implementation cost	Payback
Installation of lighting voltage servo transformer.	*3840 kWh*	Rs 23040	.50 lakhs	28 months
Providing Insulation at the Hot Air Duct and blocking the hot air leakage from dampers and joints for Withering	1967 lts of HSD	Rs 68845	Rs 10000	2 months
Installation of APFC (Automatic power factor controller)		Rs 64000	1.2 Lakhs	2 yrs
Installation of AFRC (Air fuel ratio controller)	145561 kgs of coal	Rs 655026	6 lakhs	11 months
Replacement of V belts for power transmission in motors to modern synthetic flat belts	8400 kwh	Rs50400	2 LAKHS	4 YRS
Changing withering fans to FRP from present Al blades	20700 kwh	Rs 124,200	4.5 lakhs	4 yrs
Providing VFD in drier ID Fan	14116 kwh	Rs 105870	Rs 1.5 lakhs	1.5 yrs

Plant –5:

RECOMMENDATIONS	Estimated saving in Fuel/power	Saving potential in Rs	Implementation cost	Payback
Providing Damper in the duct of the withering fans to prevent leakage of air	2700 kwh.	17,000	Nil	Immediate
Energy Efficient Withering Troughs	17125 kWHr	85600@Rs 6/unit	1.07 lakhs	15 months
Installation of AVR to correct the voltage	8000 kwh	56000	2.5 lakhs	4.8 yrs
Replacement of conventional coal fired heater with energy efficient - stoker coal fired heater.	80,000 kgs of coal	Rs 3.6 lakhs	Rs 12 lakhs	4 yrs
Installation of VFD for hot air ID fan in coal heaters .	15 % of total units consumed by ID fan		30,000	2 Yrs
Changing of all t-12 type tube lights to energy efficient T-5 Type tube lights	6000 kwh	36,000	50000	16 months

Plant-6:

RECOMMENDATIONS	Estimated saving in Fuel/power	Annual Saving potential in Rs	Implementation cost	Payback
Blocking Air Leakage in withering troughs	50000 kwh	Rs 3 lakhs	1 Lakh	4 months
Providing Insulation at the hot Air Duct and blocking air leakage from joints and dampers by proper sealing in Withering hot air supply.	1150 ltrs of HSD	Rs 43700/-	Rs 40000	11 months
Changing Al blade fan to FRP fan and slight midification in withering troughs	41000 kwh	Rs 2.46 lakhs	9 lakhs	4 yrs
Providing VFD in drier ID Fan:	16000 kwh	Rs 104000	2 lakhs	22 months
Saving by replacing under loaded motors by suitable lower size motors	24000 kwh	1.5 lakhs	2.8 lakhs	18 months

ANNEXURE-2

Availability of Technology/ services:

1) Pre withering machine

Product manufacturer:
MESCO EQUIPMENT (P) LTD.

OFFICE
2A, Ganesh Chandra Avenue
Commerce House,
Kolkata 700 013
West Bengal
India
Tel: 91-33-2213-2181
Fax: 91-33-2213-2058
Mail: mesco@vsnl.net

WORKSHOP
P-239 Benaras Road,
Howrah – 711 108
West Bengal
India
Tel: 91-33-2877-4286, 2651-1207
Fax: 91-33-2651-3122

2) Product manufacturer of flat belts:-

Loom Tech India
Engaged in the production of flat belts.
Address: 351, Motibagan, Chinsurah, District Hooghly, Kolkata, W.B - 712 101, India
Phone: +(91)-(33)-26800552
Mobile / Cell Phone: +(91)-9836484381
Website: http://www.indiamart.com/company/2151577/
Send Trade Enquiry Now

3) Variable Frequency Drive (VFD) in hot air ID fan in Dryers.

Local service provider
M/s Magnum Automation Systems,
A.T.Road, P.O.Lahoal-786010,
Dist.Dibrugarh,(Assam).
Email:jaasbir@gmail.com, Mobile:+91943513065

4) Automatic Air Fuel Ratio Controller (AFRC)

Auratec Instruments Pvt. Ltd.
48, Anboli Nagaram, Saravanampatty
Coimbatore-641035 (Tamil Nadu)
Ph. : +91 422 2668579, 9864092040, 9443368579 (M)
E-mail : auratec@satyam.net.in

4) Automatic Burner Control System / Electronic Fuel / Air – Ratio Control

Local service provider
M/s Magnum Automation Systems,
A.T.Road, P.O.Lahoal-786010,
Dist.Dibrugarh,(Assam).
Email:jaasbir@gmail.com,
Mobile:+919435130659.

5) Bio-mass gasifier – (local service provider)

Prokash Datta
Managing Director
Cleanopolis Energy Systems India Private Limited (CESIPL)
Harmony Complex, 10, Rukmini Nagar Main Road,
Dispur, Guwahati - 781006, Assam

(M) + 91 9954763193
(O) + 91 361 2235585

6) Modification of coal Fired heaters (local service provider)

Mukut Ch. Deka
MD , Luit Refractories Pvt Ltd
Jorabat , Assam

Ph-9435112706

ANNEXURE-3

MAGNUM AUTOMATION SYSTEMS

A.T. ROAD, P.O. : LAHOAL-786010, DIST. : DIBRUGARH (ASSAM)

Phone: +919957574040

Email:info.magnumauto@gmail.com

Dated: 14 Sept.2010

Quotation: For *Variable Frequency Drives* for different models of Tea Drier Process Air ID Fan drive motors.

The installation of the VFD for the main process Air ID Fan drive has 3 options which are:
Option A: VFD replaces the existing Star Delta starter with on other changes.

Option B: same as Option A + the motor drive and the fan driven V Pulleys are replaced with flat Pulleys to incorporate the ***Hi efficiency Nylon flat belts*** for lower transmission Losses.

Option C: all features of Option B + down sizing the Drive motor to the requisite(lower) power rating capacity EFF1 category motor.

vfd *DRIVES*:

The rates quoted are in **Rs. Lacs &** are inclusive of applicable VAT & installation Labour charges for tea factories in Assam for the 3 motor sizes depending on the Drier size & make .

motor power rating:	11kW	15kW	18kW
OPTION A	1.3283	1.4468	1.5868
OPTION B	1.4587	1.5772	1.7743
OPTION C	1.7837	1.9522	2.2493

TERMS & CONDITIONS:

1 The vendor will purchase the old Pulleys & belts @Rs.14/kg in case of options B & C
2 In case of Option C, the Vendor will purchase the old motor @Rs. 430 *per hp of the Old motor*.
3 The existing Star-Delta Starter will be become spare, and the cables from the start delta starter to the existing motor will be utilized for the VFD Drive.

Normal delivery period from the date of the order to the date of Commissioning will be 5 weeks for option A but 6 weeks for Option B & C.

For MAGNUM AUOTMATION SYSTEMS

MAGNUM AUTOMATION SYSTEMS

A.T.Road, P.O.Lahoal-786010, Dist.Dibrugarh,(Assam).
Phone: +919957574040
Email:info.magnumauto@gmail.com

Dated: 14 Sept.2010

Quotation: for ***Energy efficient Automatic Gas Burners*** for different models of **Tea Drier DF Heaters.**

There are 7 nos of GAS BURNERS suitable for different sizes of the DF Heaters depending on the Quantum of process Air required.

The rates quoted for **EE Automatic N.Gas Burners** of different sizes:

MODEL	Capacity in $KWHr_{thermal}$	basic price: Rs.	Price Rs. : incl. installation charges & VAT	PRV+Hose Pipes	TOTAL:Rs.
PE 5	50	43750	56416	19614	76030
PE10	10	58345	71741	19614	91355
PE30	220	77800	92169	19614	111783
PE45	325	123475	140127	19614	159741
PE60	460	154375	172572	19614	192186
PE75	600	187610	207469	19614	227083
PE90	725	195760	216027	19614	235641

Terms & Conditions:

1 Above prices do not include the cost of MS pipe if reqd for installation.

2 The vendor will try to utilize old materials that are usable from the existing set-up.

3 MS Channels & Angles that are required for fitting the New Burners will be 100 kgs approx. & need to be supplied by the Purchaser.

4 Power (415V 3Ø) will be supplied by the purchaser to the installation team in case it is required.

For Magnum Automation Systems.

ANNEXURE-4

LIST OF MAJOR ASSOCIATIONS IN JORHAT TEA CLUSTER:

1) Assam Branch of Indian Tea Association (ABITA),

Cinnamara,-Zone-2

Jorhat 785008, ASSAM

Avijit Sharma	Secretary	0376	236-0953 236-1262

Email : abitazone2@gmail.com

2) Tea Association of India (TAI)

NH-37 , Tarajan , Jorhat, Assam
Secretary : Mr J N Baruah ,
Ph- 0376-2370019 (O), 2370020 (R)
Fax No. 0376- 2370020 M. No. 9435054458
E-mail: taiab.jorhat@gmail.com

3) Assam Tea Planters Association (ATPA)

A.T. Road
Tarajan, P.B. No. 21
Jorhat 785 001 ,
Secretary : Mr J Bora
Phone (+91 376) - 320057 & 321608
Email : info@atpa.in

4) North East Tea Associations (NETA)

Bengenkhowa, G. F. Road,
Golaghat - 785 702, Assam.
Secretary : Mr Dipak Kumar Dowerah,
M. No. 9435054458.
E-mail : neta_assamtea@yahoo.com

Bureau of Energy Efficiency (BEE)
(Ministry of Power, Government of India)
4th Floor, Sewa Bhawan, R. K. Puram, New Delhi – 110066
Ph.: +91 – 11 – 26179699 (5 Lines), Fax: +91 – 11 – 26178352
Websites:www.bee-india.nic.in, www.energymanagertraining.com