DETAILED PROJECT REPORT
ON
ENERGY EFFICIENT MOTOR OF 15 kW IN HOT AIR BLOWER OF DRIER
(JORHAT TEA CLUSTER)






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Bureau of Energy Efficiency

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TECHNOLOGICAL UPGRADATION WITH ENERGY EFFICIENT MOTOR (15 kW) IN HOT AIR BLOWER OF DRYER

JORHAT TEA CLUSTER

BEE, 2010

Detailed Project Report on Energy Efficient Motors (15 kW), Jorhat Tea Cluster, Assam (India)

New Delhi: Bureau of Energy Efficiency;

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For more information

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Petroleum Conservation Research Association

Guwahati

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List of Abbreviation

BEE	Bureau of Energy Efficiency
MSME	Micro Small and Medium Enterprises
CDM	Clean Development Mechanism
DPR	Detailed Project Report
DSCR	Debt Service Coverage Ratio
DSH	De-super Heater
GHG	Green House Gases
IRR	Internal Rate of Return
MT	Million Tonne
MW	Mega Watt
NPV	Net Present Value
ROI	Return on Investment
SCM	Standard Cubic Meter
MoMSME	Ministry of Micro Small and Medium Enterprises
SIDBI	Small Industrial Development Bank of India

EXECUTIVE SUMMARY

Petroleum Conservation Research Association (PCRA) is executing the BEE – SME program for Jorhat Tea Cluster, supported by Bureau of Energy Efficiency (BEE) with an overall objective of improving the energy efficiency in cluster units.

Jorhat cluster is one of the largest tea clusters in India; accordingly this cluster was chosen for energy efficiency improvements by implementing energy efficient measures/technologies, so as to facilitate maximum replication in other tea clusters in India. The main energy forms used in the cluster units are grid electricity, Natural gas, coal, and Diesel oil mainly to provide power during off – grid period

In tea industry of this cluster, about 62% of total energy is consumed in tea drying, which is used to remove the moisture from the fermented tea. During the energy audit that was carried out in the tea factories of this cluster, it was revealed that the electrical energy in terms of its equivalent calorific value consists of only about 10% of the total energy requirement of the tea factories. But when considered in terms of monetary value, the cost incurred by the tea factories towards meeting the electrical energy requirement is about 41% of the total energy cost.

This DPR highlights the details of the study conducted for the use of Energy Efficient Motor Technology in the hot air blower used in Drying, possible Energy saving and its monetary benefit, availability of the technologies/design, local service providers, technical features & proposed equipment specifications, various barriers in implementation, environmental aspects, estimated GHG reductions, capital cost, financial analysis, sensitivity analysis in different scenarios and schedule of Project Implementation.

This bankable DPR also found eligible for subsidy scheme of MoMSME for "Technology and Quality Upgradation Support to Micro, Small and Medium Enterprises" under "National Manufacturing and Competitiveness Programme". The key indicators of the DPR including the Project cost, debt equity ratio, monetary benefit and other necessary parameters are given in table below:

S. No.	Particular	Unit	Value
1	Project cost	(` in Lakh)	0.79
2	Expected Electricity Savings	kWh/annum	3672
3	Monetary benefit	(` in Lakh)/annum	0.27
4	Simple payback period	Yrs	2.93
5	NPV	(` in Lakh)	0.26
6	IRR	%age	19.53
7	ROI	%age	24.64

S. No.	Particular	Unit	Value
8	DSCR	Ratio	1.47
9	CO_2 Reduction	Tonne per annum	3.78
10	Process down time	Days	02

The projected profitability and cash flow statements indicate that the project implementation will be financially viable and technically feasible solution for Jorhat Tea Cluster.

ABOUT BEE'S SME PROGRAM

Bureau of Energy Efficiency (BEE) is implementing a BEE-SME Programme to improve the energy performance in 25 selected SMEs clusters. Gujarat Dairy Cluster is one of them. The BEE's SME Programme intends to enhance the energy efficiency awareness by funding/subsidizing need based studies in SME clusters and giving energy conservation recommendations. For addressing the specific problems of these SMEs and enhancing energy efficiency in the clusters, BEE will be focusing on energy efficiency, energy conservation and technology up-gradation through studies and pilot projects in these SMEs clusters.

***Major activities in the BEE -SME program are furnished below*:**

Activity 1: Energy use and technology audit

The energy use technology studies would provide information on technology status, best operating practices, gaps in skills and knowledge on energy conservation opportunities, energy saving potential and new energy efficient technologies, etc for each of the sub sector in SMEs.

Activity 2: Capacity building of stake holders in cluster on energy efficiency

In most of the cases SME entrepreneurs are dependent on the locally available technologies, service providers for various reasons. To address this issue BEE has also undertaken capacity building of local service providers and entrepreneurs/ Managers of SMEs on energy efficiency improvement in their units as well as clusters. The local service providers will be trained in order to be able to provide the local services in setting up of energy efficiency projects in the clusters

Activity 3: Implementation of energy efficiency measures

To implement the technology up-gradation project in the clusters, BEE has proposed to prepare the technology based detailed project reports (DPRs) for a minimum of five technologies in three capacities for each technology.

Activity 4: Facilitation of innovative financing mechanisms for implementation of energy efficiency projects

The objective of this activity is to facilitate the uptake of energy efficiency measures through innovative financing mechanisms without creating market distortion.

1 INTRODUCTION

1.1 Briefing about Jorhat Tea Cluster

1.1.1 About Jorhat Tea Cluster

This SME cluster chosen for BEE's SME cluster development program comprises of the tea factories located in the erstwhile undivided Jorhat district of upper Assam that is presently comprised of Jorhat and Golaghat districts. The Jorhat Tea Cluster has about 150 tea factories. Majority of these tea factories have their own plantations, while the tea factories not having their own plantations depends on the tea gardens that does not have tea factories. The tea factories having their own plantation are owned either by group companies like APPL, Williamson & Magor, etc or by families having ownership through inheritance. These tea factories were mostly established during pre – independence period. Whereas the tea factories which does not have their own plantation were established after the late 80's and are owned by first generation entrepreneurs.

Existing Production Process:

The tea factory under Jorhat Tea cluster produces mainly produces CTC (Cut, tear and curl) and Orthodox type of tea. For the production of CTC type of tea the green tea leaves are shredded and then cut, tear and curled in the CTC (cutting, tearing and curling) machine. Whereas for the production of orthodox tea the green tea leaves are twisted through continuous circular motion of the rollers of the rolling machine. But for both these types of tea being manufactured in this cluster, the tea leaves are dried in dryers to remove the moisture before the made tea is finally sorted and packed. The drying process is the most energy intensive and to carry out the drying, the tea factories of this cluster use either coal or natural gas as fuel. The pictorial representation of tea manufacturing process that is being presently followed in Jorhat Tea Cluster is depicted in Annexure 1.

Withering:

The green tea leaves plucked from the garden are first withered to remove the surface moisture and partially the internal moisture. Withering promotes the dissipation of heat generated due to continuous respiration. The withering process which takes about 10 hours on an average, reduces the moisture content of green leaves to 55% in case of orthodox tea and to 70% in case of CTC tea production.

In Jorhat tea Cluster two types of withering process is being adopted by the tea factories. The first is the "Open Trough Withering" and second is the "Enclosed Trough Withering". In the first case, the area over the withering trough is kept open and the air from the withering fan passes from the bottom of the withering trough and released to the environment through the tea leaves. In the second case, the area over the withering trough is enclosed and the air from the withering fan is released to the environment through a single outlet after being passed through the tea leaves.

CTC:

In this process the withered tea leaves are shredded in the rotor – vane and then cut torn and curled in the CTC machine. During this process the enzymes of the tea leaves are released in the rotor – vane and the curling of the tea leaves initiates the fermentation process. Most of the juice that comes out of the tea leaves during shredding in the rotor – vane is evaporated due to friction in the CTC machine, for which the moisture content in the tea leaves after CTC is reduced from 70 % to 55 %.

Rolling:

This process after withering is adopted by tea factories to produce orthodox type of tea. The chemical compounds of the tea leaves are released to initiate oxidation in the fermentation process. Rolling twist the leaves and at the same time, breaks the leaf to release enzymes for oxidation.

Fermentation:

This is the least energy intensive step in the entire tea manufacturing process. During the fermentation process the tea leaves are left for oxidation, to which there occurs notable chemical as well as physical change. The color of the tea leaves is changed to reddish brown. The flavor and liquor of the tea leaves is attained in this stage.

Drying:

The fermented tea particles are dried or fired to arrest the fermentation and to reduce the moisture to about 3%. Clean and odorless hot air is passed through the fermented tea particles in dryers. The temperature of the hot air varies between 90^0 – 160^0C 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 type (ECP) dryer or Fluidized Bed Dryer (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 90^0. The ECP dryer has an advantage to dry both leafy grades and powered grades. In the VFBD, tea particles are pneumatically fluidized by hot air at 140 – 160^0C. Uniform drying is ensured in VFBD and better quality tea could be produced. This is also more energy efficient method compared to ECP dryers with less mechanical controls.

1.2 Energy Performance in Existing Situation

1.2.1 Energy Consumption Profile

For the purpose of tea processing, both electrical as well as thermal energy are required. In the tea factories of Jorhat Tea Cluster, the electrical energy requirement is fulfilled by electrical power available through grid whereas the main source of thermal energy is either coal or Natural Gas.

The summary of the annual energy consumption in different production capacities of the tea factories of this cluster that uses coal as the thermal energy source as revealed during the energy audit is given in Table – 1 below;

Table 1: Annual Energy Consumption by Tea factories using coal

Parameter	Unit	Up to 500 MT of made tea	500 – 1500 MT of made tea	Above 1500 MT of made tea
Annual electrical energy consumption	kWh	221197.4	688252.8	862896.8
Annual coal consumption	MT	390.64	1107.21	1457.63
Annual HSD consumption	KL	27.66	88.69	136.43
Total Annual Energy consumption	MCal	2, 034, 504	5, 869, 315	7, 923, 604
Total Annual Energy consumption in one unit of the different capacity	Kloe	222.5	646.1	866.6
Average annual Made Tea production	MT	450	1000	1900

And the summary of the annual energy consumption of the tea factories of this cluster that uses NG as the thermal energy source is given in Table – 2 below;

Table 2: Annual Energy Consumption by Tea factories using Natural Gas

Parameter	Unit	Up to 500 MT of made tea	500 – 1500 MT of made tea	Above 1500 MT of made tea
Annual electrical energy consumption	kWh	234896.8	656332.6	805998.7
Annual NG consumption	Scum	216602	431594.8	629896.2
Annual HSD consumption	KL	30	92	145
Total Annual Energy consumption	MCal	2, 581, 390	5, 627, 756	8, 190, 163
Total Annual Energy consumption in one unit of the different capacity	Kloe	258.1	562.8	819.0
Average annual Made Tea production	MT	480	960	2100

1.2.2 Average Annual Production

Tea factories are agro based industries, and the operation of the tea factories depends on the availability of the tea leaves in the tea gardens. The tea factories depends on either their own in – house production of green tea leaves or on green tea leaves plucked from tea gardens without factories or both. The peak production season for tea factories in Jorhat Cluster starts with the beginning of spring, i.e., from the month of March – April and lasts till the end of autumn or beginning of winter, i.e., till the month of October – November. During this period most of the tea factories run on round the clock basis as the green tea leaves cannot be stored. The tea factories remain non – operational for about two to three months in a year between the months of December to March.

The average tea production in the tea factories of Jorhat Cluster where Energy Audit was carried out is 1002 tones of made tea per annum.

1.2.3 Specific Fuel Consumption & Specific Electricity Consumption

Similar to any other type of industry, the specific energy consumption in the tea factories of this cluster also depends on the scale of production, which has been evaluated during the energy audit. Thus keeping this into consideration, the tea factories of this cluster is broadly divided into three groups and the specific energy consumption is evaluated separately.

In this context it is noteworthy to mention that bifurcation of the tea factories base on production is specific to this report only and there is no official notification by any authorized bodies in this regard.

The specific energy consumption by the tea factories is given in Table – 3 below;

Table 3: Specific energy consumption by tea factories

Type of tea factory	kWh/ kg of made tea	Kgs of coal/ kg of made tea	Liters of HSD/ kg of made tea	Scum of NG/ kg of made tea
Large tea factory	0.55	0.72	0.07	0.32
Medium tea factory	0.65	0.82	0.08	0.39
Small tea factory	0.85	1.02	0.09	0.51

1.3 Existing Technology/Equipment

1.3.1 Description of existing technology

Similar to any other industry, in the tea factories of Jorhat Cluster also about 70% of electrical energy is consumed by electric motor. In the tea factories of this cluster, the hot air required for drying is blown by means of hot air blower, which is the main consumer of electrical energy in drying section. By improving efficiency level of motor by retrofitting with premium efficiency energy efficient electric motor (EFF1 level or higher), the electrical energy consumption in dryer can be reduced by around 5%.

Table 4: Existing Motor Specification

SN	Details	Specification
1)	Capacity	15 kW
2)	RPM	1500 RPM
3)	Frame Size	180 L
4)	Type	Foot mounted, Squirrel cage type
5)	Whether Re-wounded	2 Times re-wounded
6)	Other Specifications	415 Volts ± 10%; 3 Phase, 50 HZ ± 5%
7)	Efficiency Level	83.5%

Electrical Energy Charges

Table 5: Average per unit cost of electrical power

Per Unit Cost Of Electrical Energy	
Grid Availability	70%

Per Unit Cost Of Electrical Energy	
DG Power	30%
Average cost of grid power	` 5.5 per unit
Average cost of DG	` 12 per unit
Total Unit Cost	5.5 *0.7 + 12 * 0.3 = ` 7.45/ kWh

1.3.2 Role in process

The electric motor has to play very important role in all industries including tea industry as major electricity is consumed by electric motor. In tea cluster also about 75% of electrical energy consumption is consumed by electric motor. Drying is the process where the major removal of moisture from the tea leaves takes place, which is done by blowing hot air by the blower. For this the highest electrical load is on the hot air blower which consumes the majority of the electrical energy in drying. By improving efficiency level of the hot air blower motor by retrofitting with premium efficiency energy efficient electric motor (eff1 level or higher), the electrical energy consumption in drying can be reduced by around 5%.

1.4 Baseline establishment for existing technology

In a tea factories of Jorhat Cluster the dryers that are general used for drying fermented tea leaves are Vibratory Fluidized Bed Dryer (VFBD), Endless Chain type dryer or Quality type dryer. In all of these types of dryers the hot air is required to be blown through the dryer by means of a blower driven by motor, which is the highest rated electrical device in the dryer section. To baseline for preparation of this report is done on the following baseline;

Table 6: Baseline Establishment

SN	Dryer Particulars	Dryer Type	Motor Rated kW	Measured kW
1)	Dryer Blower Motor	VFBD/ Tempest	15	9.94
		Total	15	9.94
		Total Actual on Load	***15***	***9.94***

The existing consumption for EFF2 or lower efficiency electric motor is 9.94 kW i.e. 35784 kWh/ Annum considering an annual operation for 3600 hours per annum, generally 12 hours a day and 300 days a year.

1.4.1 Design and operating parameters

Under the existing condition most of the dryer blowers are not provided with Super premium energy efficient electric motors. Most of the motors are more than 2-3 times rewound with efficiency level EFF2 or lower level.

1.4.2 Operating efficiency analysis (Existing Loss Study)

Load profile (kW Vs Time) of existing dryer blower using data logger carried for dryers in the tea factories. It was observed that the motor fitted with the dryer blower is subjected to part load. This is because the quantity of hot air requirement for drying depends on the quality of the tea leaves, which in turn depends on the seasonal factor, due to which oversized motors are fitted in the dryer blower.

Stator and Rotor I^2R Losses

These losses are major losses and typically account for 55% to 60% of the total losses. I^2R losses are heating losses resulting from current passing through stator and rotor conductors. I^2R losses are the function of a conductor resistance, the square of current. Resistance of conductor is a function of conductor material, length and cross sectional area. The suitable selection of copper conductor size will reduce the resistance. Reducing the motor current is most readily accomplished by decreasing the magnetizing component of current. This involves lowering the operating flux density and possible shortening of air gap. Rotor I^2R losses are a function of the rotor conductors (usually aluminum) and the rotor slip. Utilization of copper conductors will reduce the winding resistance. Motor operation closer to synchronous speed will also reduce rotor I^2R losses.

Core Losses

Core losses are those found in the stator-rotor magnetic steel and are due to hysteresis effect and eddy current effect during 50 Hz magnetization of the core material. These losses are independent of load and account for 20 – 25 % of the total losses.

The hysteresis losses which are a function of flux density, are be reduced by utilizing low-loss grade of silicon steel laminations. The reduction of flux density is achieved by suitable increase in the core length of stator and rotor. Eddy current losses are generated by circulating current within the core steel laminations. These are reduced by using thinner laminations.

Friction and Windage Losses

Friction and Windage losses results from bearing friction, Windage and circulating air through the motor and account for 8 – 12 % of total losses. These losses are independent of load. The reduction in heat generated by stator and rotor losses permits the use of smaller fan. The Windage losses also reduce with the diameter of fan leading to reduction in Windage losses.

Stray Load-Losses

These losses vary according to square of the load current and are caused by leakage flux induced by load currents in the laminations and account for 4 to 5 % of total losses. These losses are reduced by careful selection of slot numbers, tooth/slot geometry and air gap.

Energy efficient motors cover a wide range of ratings and the full load efficiencies are higher by 3 to 7 %. The mounting dimensions are also maintained as per IS1231 to enable easy replacement.

As a result of the modifications to improve performance, the costs of energy-efficient motors are higher than those of standard motors. The higher cost will often be paid back rapidly in saved operating costs, particularly in new applications or end-of-life motor replacements. In cases where existing motors have not reached the end of their useful life, the economics will be less clearly positive.

Losses	2- Pole average	4- pole average	Factors affecting losses
Core losses	19%	21%	Electrical steel, air gap, saturation
Friction & Windage losses	25%	10%	Fan efficiency, Lubrication, bearing
Stator Copper losses	26%	34%	Conductor area, mean length of turn, heat dissipation
Rotor Copper losses	19%	21%	Bar and end ring area and material
Stray Load losses	11%	14%	Manufacturing process, slot design, air gap

1.5 Barriers in adoption of proposed equipment

1.5.1 Technological barrier

- Due to absence of any scientifically designed operator training program, the operation and maintenance protocols for optimum utilization of electrical energy equipment are not followed.
- Though the motors consumes the bulk of the electrical energy, yet there is lacking in the technical knowledge to operate the motors efficiently and to take care of the extreme situation they resort to fitment of oversize motors, thus making the operation of motors energy in – efficient.
- 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 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 factory entrepreneurs that, energy efficiency initiatives are difficult and the drive to save energy will affect the quality of made tea and thus will lead to business loss. 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.

1.5.2 Financial barrier

- The cost of new technology is high. There is inadequate data on return on investment 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.

1.5.3 Skilled manpower

- The persons working in the tea factories of Jorhat Cluster generally belongs to a particular tribe working for generations in tea factories and they normally lead an isolated life. For this, though the persons are skilled with regard to the operation of the machineries, but innovations as well as consciousness regarding energy conservations lacks amongst the workforce. 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 amongst workforce. These programs should be organized with equipment suppliers.

1.5.4 Barrier specific towards adoption of this technology

- Though it is established that adoption of energy efficient motors will reduce the electrical energy consumption, yet the major barrier is with the disposal of the present standard motors.
- The adoption of energy efficient motors may be expensive if the scrap value of the present motors does not yield sufficient revenue.

2. PROPOSED EQUIPMENT FOR ENERGY EFFICENCY IMPROVEMENT

2.1 Description of proposed equipment

As explained earlier, almost 70% of electricity in industry is consumed by electric motor, any slightest improvement in efficiency of motor results in considerable saving of energy. Pl refers the following graph for various efficiency level of electric motor.

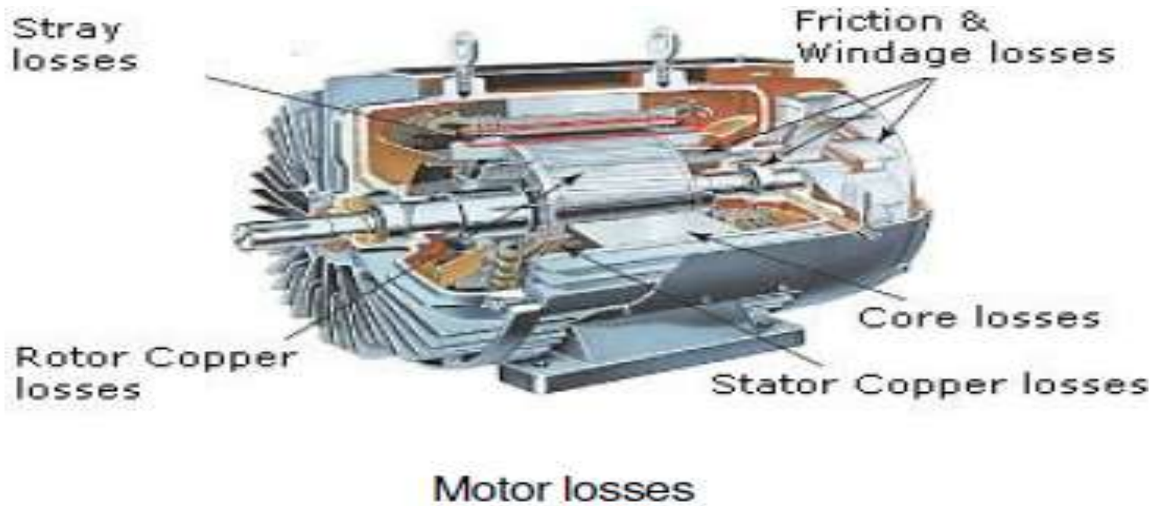


Figure 1: Motor Losses

The energy efficient electric motors are more costly than the conventional standard efficiency electric motor (efficiency level EFF2 or lower), but if we consider the entire life cycle cost (LCC) of electric motor then the results shows different facts.

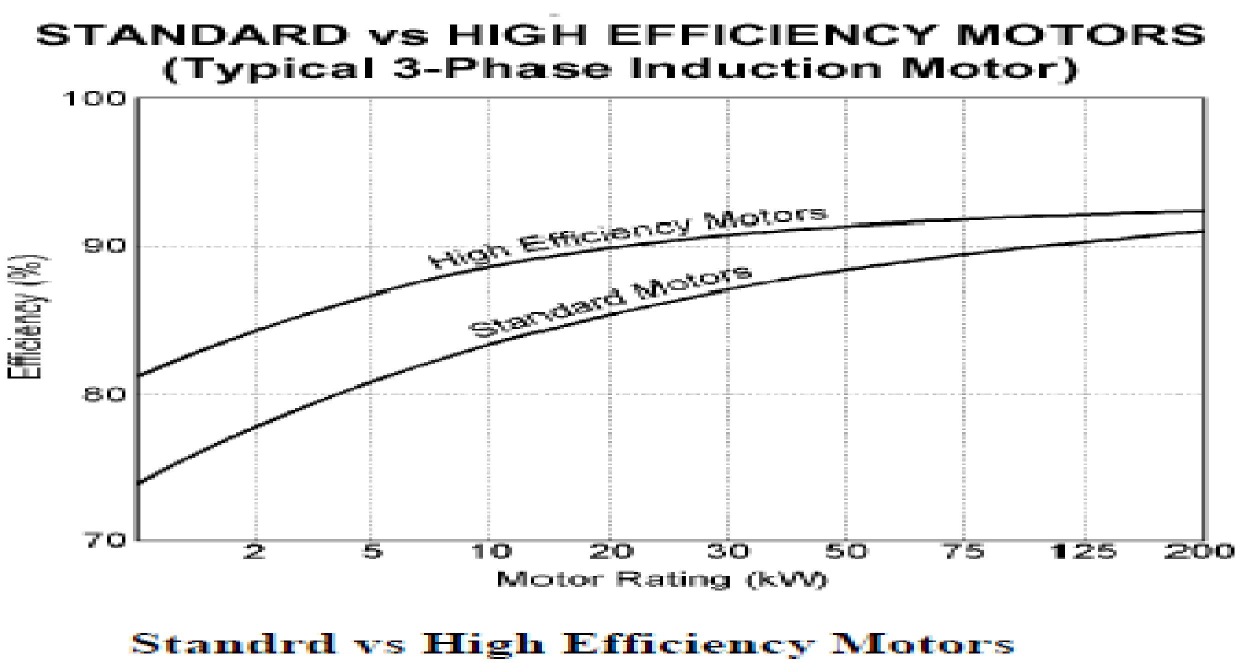


Figure 2: Standard vs High Efficiency Motor kW-Efficiency graph

Energy-efficient motors (EEM) are the ones in which, design improvements are incorporated specifically to increase operating efficiency over motors of standard design. Design improvements focus on reducing intrinsic motor losses. Improvements include the use of lower-loss silicon steel, a longer core (to increase active material), thicker wires (to reduce resistance), thinner laminations, smaller air gap between stator and rotor, copper instead of aluminum bars in the rotor, superior bearings and a smaller fan, etc.

Energy-efficient motors now available in India operate with efficiencies that are typically 3 to 4 percentage points higher than standard motors. In keeping with the stipulations of the BIS, energy-efficient motors are designed to operate without loss in efficiency at loads between 75 % and 100 % of rated capacity. This may result in major benefits in varying load applications. The power factor is about the same or may be higher than for standard motors. Furthermore, energy-efficient motors have lower operating temperatures and noise levels, greater ability to accelerate higher-inertia loads, and are less affected by supply voltage fluctuations.

2.1.1 Details of proposed equipment

Electrical motor (industrial, commercial, domestic and agriculture) alone consumes about 70% of country's total generated power (83000MW). If, by effective energy conservation it is possible to improve the efficiency of drive system by 0.5%, electrical power amounted to 83000 x 0.7 X 0.005 = 290 MW can be saved or alternately generated every day

As mentioned earlier, 70% of electricity consumed by any industry is consumed by electric motor, slightest improvement in efficiency of electric motor impacts energy saving on positive side. The existing motors are of EFF2 or lower efficiency & also many are rewound for many times. The field study of electric motors & detailed energy audit report indicates the scope of energy saving in electric motors.

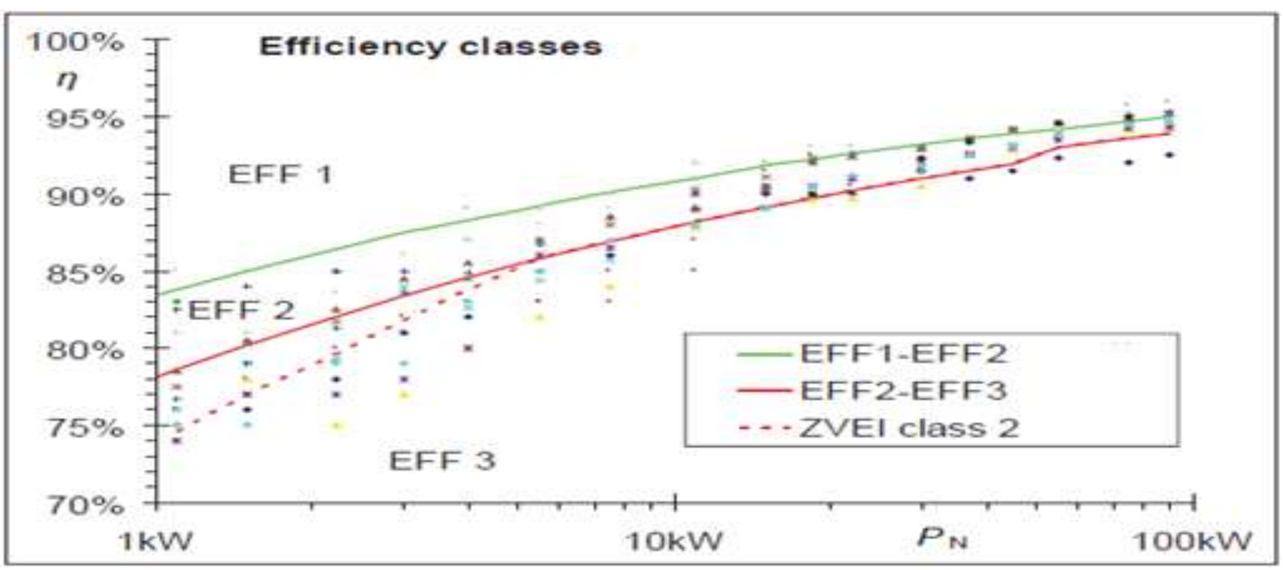


Figure 3: Efficiency Classes

Motor efficiency is the ratio of mechanical power output to the electrical power input, usually expressed as a percentage. Considerable variation exists between the performance of standard and energy-efficiency improved design, materials, and manufacturing techniques enable energy-efficient motors to accomplish more work per unit of electricity consumed. Energy-efficient motors offer other benefits. Because they are constructed with improved manufacturing techniques and superior materials, energy-efficient motors usually have higher service factors, longer insulation and bearing lives, lower waste heat output, and less vibration, all of which increase reliability. Most motor manufacturers offer longer warranties for their most efficient models.

From above graph it is clear that if the motor upgraded from EFF3 or EFF2 will result in energy saving. But due to higher initial cost, industries prefer the standard efficiency electric motor. Please refer following graphs indicating the importance of LCC (Life cycle Cost) concept. The purchase price of electric motor is of the order of 0.9 to 2.3% of total LCC of electric motor.

It can be concluded that by proper awareness creation, propagation of LCC concept, providing financial arrangement for purchase of higher initial cost Energy Efficient electric motor, will help to implement the measure of Energy efficient electric motor.

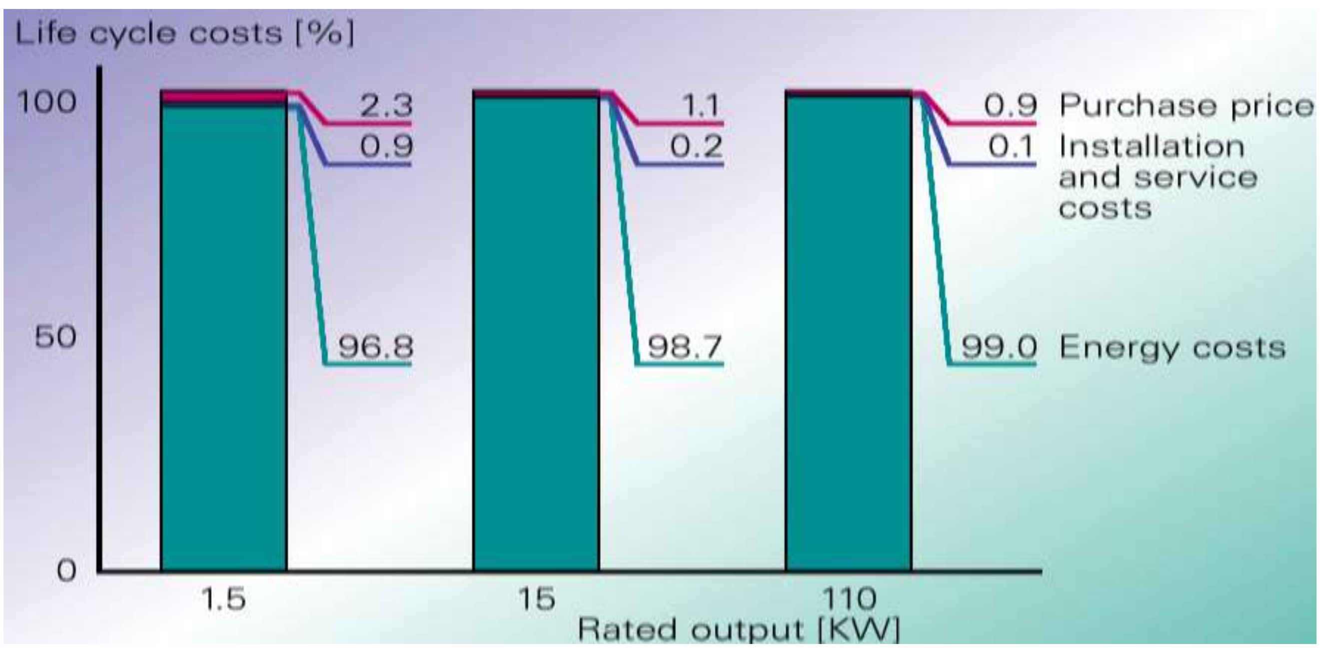


Figure 4: Rated Output (kW)

It has been observed that penetration of energy efficient electric motor in the various industries including dairies from cluster will result in continuous energy saving over the life cycle of electric motor. Please refer the following schematic diagram explaining how efficiency is improved in Energy efficient electric motor.

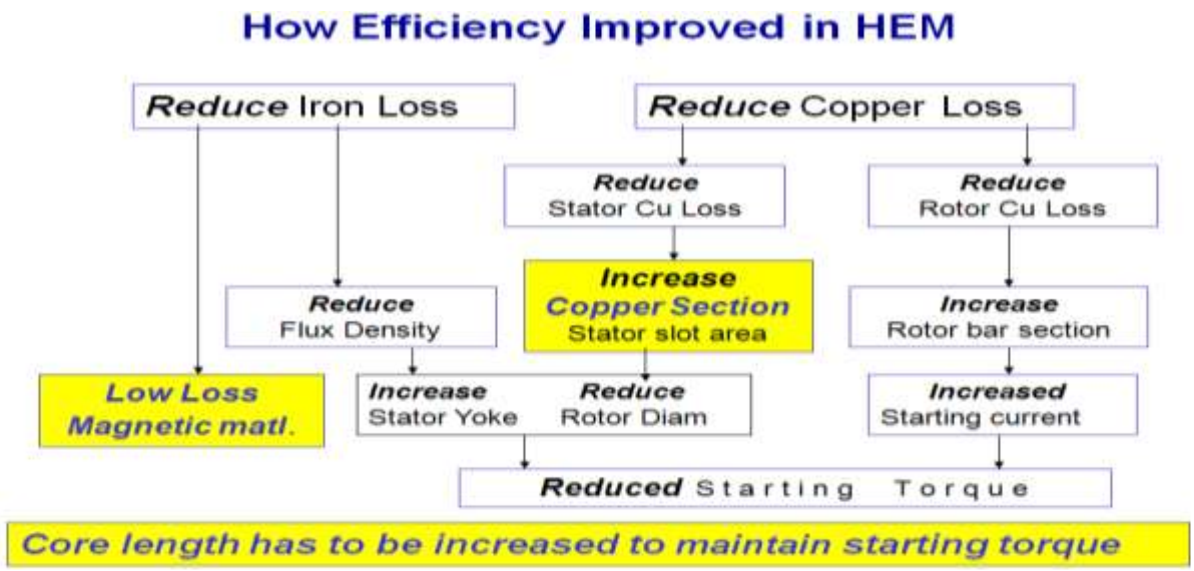


Figure 5: Efficiency Improvement in HEM

A summary of energy efficiency improvements in EEMs

Energy Efficient Motors	
Power Loss Area	**Efficiency Improvement**
1. Iron	Use of thinner gauge, lower loss core steel reduces eddy current losses. Longer core adds more steel to the design, which reduces losses due to lower operating flux densities.
2. Stator I^2R	Use of more copper and larger conductors increases cross sectional area of stator windings. This lowers resistance (R) of the windings and reduces losses due to current flow (I).
3. Rotor I^2R	Use of larger rotor conductor bars increases size of cross section, lowering conductor resistance (R) and losses due to current flow (I).
4. Friction & Windage	Use of low loss fan design reduces losses due to air movement.
5. Stray Load Loss	Use of optimized design and strict quality control procedures minimizes stray load losses.

Figure 6: Efficiency Improvement in EEM

2.1.2 Equipment/Technology Specification

Description

Squirrel Cage type, 3 phase induction motors are provided with belt pulley drive arrangement.

The specification of the energy efficient *eff1* motors are detailed as referred by IS 12615: 2004, IS: 4029 – 1967, IS 325: 1996 including all the amendment as published by the Bureau of Indian Standards.

Table 7: Technical Specification of Proposed Motor

S. No.	Details	Specification
1)	Capacity	15 kW
2)	RPM	1500 RPM
3)	Frame Size	180 L
4)	Type	Foot mounted, Squirrel cage type
5)	Whether Re-wounded	New Motor
6)	Other Specifications	415 Volts ± 10%; 3 Phase, 50 HZ ± 5%
7)	Efficiency Level	93 %

2.1.3 Integration with Existing Equipment

The energy conservation proposal is of the retrofit type, thus old lower efficiency electric motor have to be replaced by new energy efficient electric motor. The new motor can be fully integrated with existing system without any problem as it does not need change in drive arrangement such as starters, does not need change in foundation as same frame size motor being used. No change in cable, belts or pulley is required. The new motor can be fully integrated with existing system without any problem.

2.1.4 Superiority over existing system

The proposed electric motors are more energy efficient that existing one and are technologically superior. Use of this technology reduces the overall plant energy cost. It also reduces the dependency for electricity on the state electricity grid. The proposed measures bear better technology than the existing one results both energy saving and technological up gradation.

2.1.5 Source of equipment

The recommended technology is proven one and in various industries on normal basis. These are running successfully and the unit owners had observed the savings in terms of energy.

2.1.6 Availability of technology/equipment

Energy efficient motors manufactured by reputed companies are available in the market easily. Some of the reputed companies of international repute those are into the field of motor manufacturing have started targeting the tea factories to replace the existing motors with energy efficient motors.

2.1.7 Service providers

Details of technology service providers are shown in Annexure 7.

2.1.8 Terms and conditions in sales of equipment

The suppliers have already extended standard warrantee conditions for exchange, replace or repair against manufacturing defects for a period of 12 months after the date of commissioning. Promoters will have to promptly notify the supplier in writing of obvious defects or deficiencies after detection thereof. Replaced parts shall become the property of the supplier upon request of the supplier.

Supplier is not liable or defects or deficiencies which are resulting from the following reasons, as long as they are not resulting from a default of Supplier: Improper, unsuitable or negligent use, handling and/or operation of the system by promoters or by third parties; use of spare parts other than Genuine Parts; normal wear and tear; use of unsuitable consumables (such as, fuel, oil cooling liquid or any other consumables), particularly the use of consumables not conciliated in the operation manuals; improper building ground; chemical, electro- chemical or electric influences.

All conditions associated with this system are standard in nature. No special clause is incorporated. The conditions are very common in most of the plant & machinery sales.

2.1.9 Process down time

4-5 Hours are required to change the existing normal or standard efficiency electric motor with energy efficient electric motor.

2.2 Life cycle assessment and risks analysis

Life of the equipment is about 15 years. Risk involves in the installation of proposed project are as follows:

- Risk involved in delay in implementation of the proposed project is due to the high initial investment cost.

2.3 Suitable unit for implementation of proposed technology

The measure & technology is suitable for the tea factories of Jorhat Cluster as well as for tea factories outside this cluster. Adoption of this measure will help in building electrical energy efficiency, which is a vital energy consuming area. This measure is suitable for implementation in all the units of this cluster.

3. ECONOMIC BENEFITS FROM PROPOSED TECHNOLOGY

3.1 Technical benefit

3.1.1 Fuel saving

Though there will be saving in the HSD consumption due to reduced load on the DG set, yet the exact amount of savings in HSD could not be evaluated due to lack of proper data regarding electrical energy produced from the burning of HSD in the DG.

3.1.2 Electricity saving

Adoption of energy efficient motors will yield a consistent savings in electricity. The hourly electricity savings in electricity is calculated by the following equation

$$\text{kW Saved} = \text{kW output} \times [\,1/\eta_{old} - 1/\eta_{new}\,]$$

The detailed electricity saving is given in Annexure 3 and the summary is as given below;

Table 8: Energy Savings calculation

Electricity Saving			
1)	Actual electricity consumption by dryer blower motor under existing situation (At 83.5% present motor efficiency)	kW/ Hr	9.94
2)	Expected electricity Consumption by dryer blower motor (At 93% Energy Efficient Motor Efficiency)	kW/ Hr	8.92
3)	Electricity saving	kW/ Hr	1.02
4)	Expected Electrical energy Saving per Annum	kWh/Annum	3672

3.2 Monetary benefits

Implementation of project will result in good, consistent monetary benefit. It is estimated that this system will save on an average 3672 kWh/Annum for the unit. Please refer following table. Total savings due to implementation of the technology would be `27356 per year

Table 9: Monetary benefit (For One Typical Unit of Jorhat Tea Cluster)

Energy and monetary benefit			
1)	Cost of Electricity	`/ kWh	7.45
2)	Expected Saving in kWh/Annum	kWh /Annum	3672
3)	Expected Monetary Saving per Annum	`/Annum	27356
4)	Expected Investment Needed for replacing existing motor with EE motor.	`	79000
5]	Simple Payback	Yrs	2.89
		Months	34.65

Further details of total monetary benefit are given in Annexure 3.

3.3 Social benefits

3.3.1 Improvement in working environment

Use of energy efficient electric motor technology in Tea Industry reduces the energy consumption. This improves efficiency of drying section, which is the most energy intensive process in tea manufacturing and thus reduces CO_2 generation.

3.3.2 Improvement in workers skill

Technical skills of persons will definitely be improved. As the training will be provided by equipment suppliers which improve the technical skills of manpower required for operating of the equipment and also the technology implementation will create awareness among the workforce about energy efficiency and energy saving.

3.4 Environmental benefits

3.4.1 Reduction in effluent generation

There is no impact in effluent generation due to implementation of the project.

3.4.2 Reduction in GHG emission

Implementation of this technology will reduce the CO_2 emissions by the value of 3.78 tons per annum. Reduction in CO_2 emissions will be possible due to Energy saving. This project results in reduction of peak demand and uses off-peak electricity.

3.4.3 Reduction in other emissions like SO_X

Amount of SO_X will be reducing due to improved efficiency of the power plants due to better plant load factor.

4 INSTALLATION OF PROPOSED EQUIPMENT

4.1 Cost of project

4.1.1 Equipment cost

Energy efficient motor with all supportive (viz: installation, erection & commissioning, standard mountings & accessories) and including all taxes is ` 0.79 Lacs per 15 kW electric Motor.

4.1.2 Erection, commissioning and other misc. cost

Total erection and commissioning cost is `0.02 lakh. The details of project cost is as given in table 6 given below-

Table 10: Details of proposed technology project cost

Details of Proposed Technology Project Cost			
SN	Particulars	Unit	Value
1	Cost of Retrofit/Additional Plan & Machinery For Energy Saving	` (in Lacs)	0.75
2	Detail Engineering, Design & related expenses	` (in Lacs)	0.00
3	Erection & Commissioning cost	` (in Lacs)	0.02
4	Cost of civil work	` (in Lacs)	0.01
5	Other charges (Including Contingency)	` (in Lacs)	0.01
6	**Total cost**	` (in Lacs)	0.79

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

Entrepreneur will contribute 25% of the total project cost i.e. ` 0.20 Lakh & financial institutes can extend loan of 75%.

4.2.2 Loan amount.

The term loan is 75% of the total project cost i.e. ` 0.59 Lakh, with repayment of 5 years excluding moratorium of 6 months considered for the estimation purpose.

4.2.3 Terms & conditions of loan

The terms and conditions of the loan with regard to the financial aspect of the loan are;

- Interest rate of the loan is @ 10% per annum on a reducing balance basis, which is SIDBI's interest rate for energy efficient projects.
- Depreciation is provided as per the rates provided in the companies act.

4.3 Financial indicators

The financial indicators for this proposed technology is calculated on the following basis;

- For calculating the financial indicators, the subsidy from MoMSME is not taken into consideration.

- The cost of maintenance and operation is taken as 2% of the capital cost for installation of this technology with a yearly increase @5%

4.3.1 Cash flow analysis

Profitability and cash flow statements have been worked out for a period of 8 years. The project is expected to achieve monthly savings of ` 0.27 lakhs based on the assumptions as mentioned above.

Considering the above assumptions, the net cash accrual starts with ` 0.16 lakh in the first year of operation and to ` 0. 17 lakh at the end of eighth year of operation.

4.3.2 Simple payback period

The estimated payback period is about 2.93 years or about 35 months.

4.3.3 Net Present Value (NPV)

The Net present value of the investment at 10% works out to be `0.26 lakh.

4.3.4 Internal rate of return (IRR)

The after tax IRR of the project works out to be 19.53%.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 24.64%.

4.4 Sensitivity analysis

Sensitivity analysis to assess the cushioning affect of the bio – mass gasifier is carried out in the following two scenarios;

a) Optimistic Scenario: Under this scenario the financial projections are evaluated on the basis of 5% increase in the Electricity savings.

b) Pessimistic Scenario: Under this scenario the financial projections are evaluated on the basis of 5% decrease in the Electricity savings.

The result of the sensitivity analysis is as given below;

Table 11: Sensitivity Analysis

Particulars	IRR	NPV ` lakhs	ROI	DSCR
Normal	19.53%	0.26	24.64%	1.47
5% increase in savings	21.33%	0.31	24.95%	1.54
5% decrease in savings	17.70%	0.21	24.28%	1.39

4.5 Procurement and Implementation Schedule

Total time required for procurement and implementation for proposed project are about 10 to 12 weeks and details of procurement and implementation schedules are shown in Annexure 6.

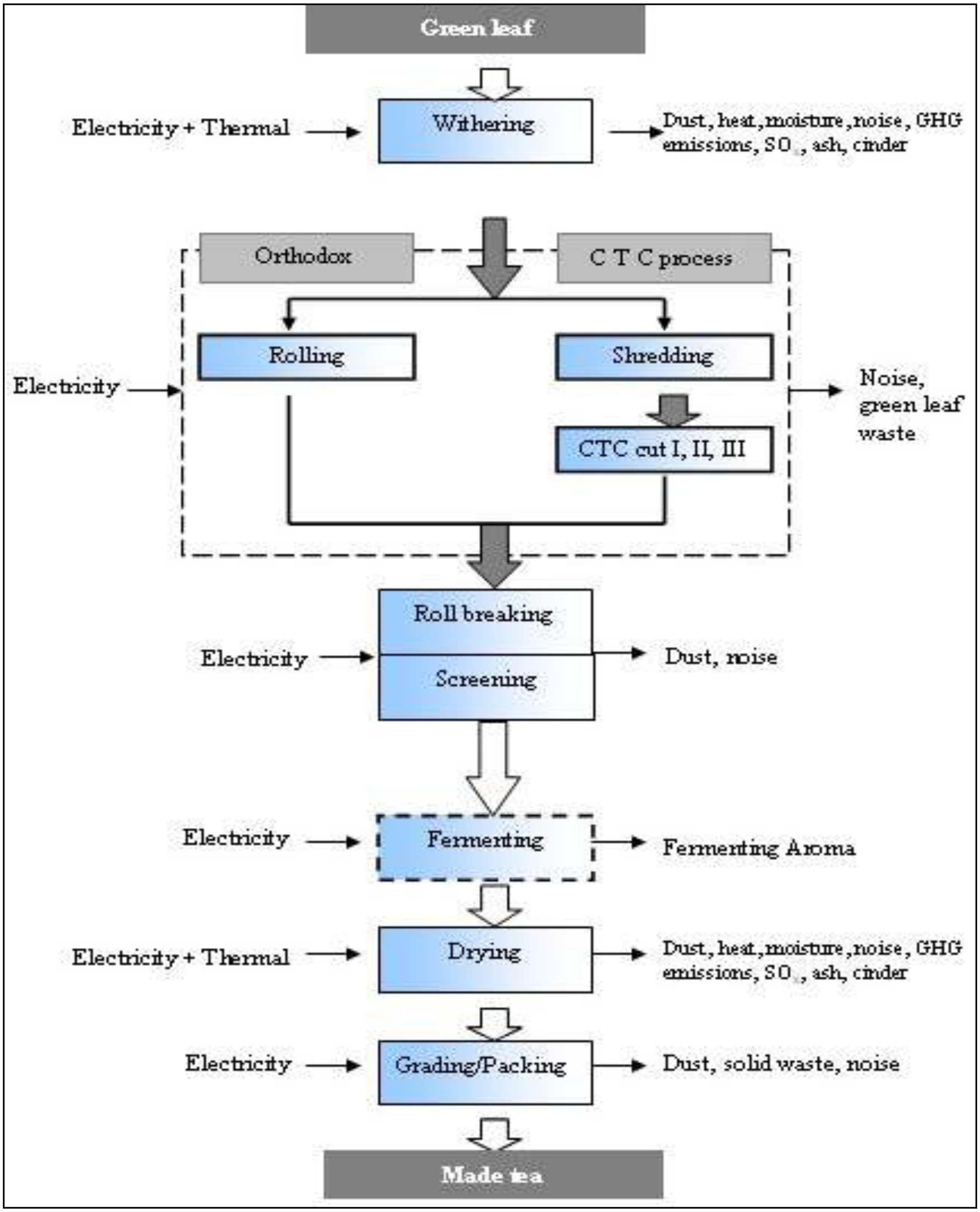
Note: - The word foundation & civil work is alternatively used for installation & erection (that includes minor / major civil work, grouting required for saddle plates, foundation modification etc).

For electric motors as in many cases are very old motors are to be replaced by new energy efficient electric motor. Though frame size is same, it is observed that practically the saddle holes of new EE motor foot mounted electric motor may vary with old motor (We expect such modification in most of the cases). In such cases, modification in civil constructed foundation may require. Also it is now standard practice to introduce threaded tensioning arrangement for electric motor for maintaining proper belt tension. Considering these aspect we have considered the foundation & civil work.

Table 12: Procurement and implementation schedule

SN	Activities	Weeks			
		1	-	11	12
1	Order Placement				
2	Delivery				
3	Foundation & civil work				
4	Erection & commissioning				
5	Cabling & electrical panel fitting				
6	Testing and trial				
7	On site operator training				

Annexure 1: Process Flow Diagram



Annexure 2: Energy audit data used for baseline establishment

The hot air blower of a typical tea factory is as below

S. No.	Dryer Particulars	Dryer Type	Motor Rated kW	Measured kW
1)	Dryer Blower Motor	VFBD	15.00	9.94
		Total	15.00	9.94
		Total Actual on Load	***15.00***	***9.94***

The existing consumption for EFF2 or lower efficiency electric motor is 9.94 kW i.e. 35784 kWh/ Annum.

The specifications of existing electric motor is

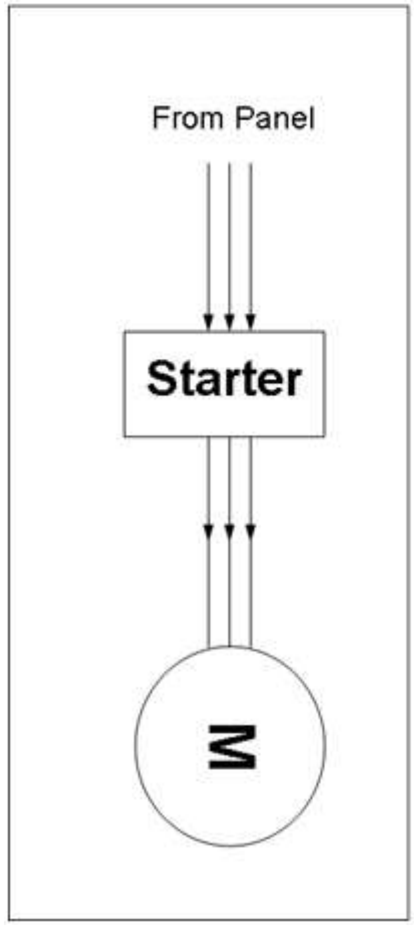
S. No.	Details	Specification
1)	Capacity	15.00 kW
2)	RPM	1500 RPM
3)	Frame Size	200 L
4)	Type	Foot mounted, Squirrel cage type
5)	Whether Re-wounded	2 Times re-wounded
6)	Other Specifications	415 Volts ± 10%; 3 Phase, 50 HZ ± 5%
7)	Efficiency Level	83.5%

Annexure 3: Detailed technology assessment report

S. No	Parameter	Unit	Value
1	Capacity of the motor fitted with the dryer blower	kW	15.0
2	Working Hours for Dryer/ Day	Hrs/Day	12
3	Working Days/ Year	Days/ Year	300
4	Actual electricity Consumption of Compressor (At 83.5% present motor efficiency)	kWh	9.94
5	Actual electricity Consumption of Compressor (At 93% Energy Efficient Motor Efficiency)	kWh	8.92
6	Electricity saving	kWh	1.02
7	Cost of Electricity	`/kWh	7.45
8	Expected Electrical energy Saving per Annum	kWh/Annum	3672
9	Expected Monetary Saving per Annum	`/Annum	27356
10	Expected Investment Needed for replacing existing motor with EE motor.	`	79000
11	Simple Payback	Yrs	2.93
		Months	35

Annexure 4: Drawings for proposed electrical & civil works

No additional civil work is required, only minor readjustment of foundation will be required. No change in electrical circuit as the change is of the retrofit in nature. No other changes required.



Annexure 5: Detailed financial analysis

Name of the Technology	ENERGY EFFICIENT ELECTRIC MOTOR		
Rated Capacity	**22 kW**		
Details	**Unit**	**Value**	**Basis**
Installed Capacity	kW	15	
No of working days	Days	300	
No of Working Hr. per day	Hrs.	12	
Proposed Investment			
Plant & Machinery	` (in lakh)	0.75	
Civil Work	` (in lakh)	0.01	
Erection & Commissioning	` (in lakh)	0.02	
Investment without IDC	` (in lakh)	0.78	
Misc. Cost	` (in lakh)	0.01	
Total Investment	` (in lakh)	0.79	
Financing pattern			
Own Funds (Equity)	` (in lakh)	0.20	Feasibility Study
Loan Funds (Term Loan)	` (in lakh)	0.59	Feasibility Study
Loan Tenure	Years	5.00	Assumed
Moratorium Period	Months	6.00	Assumed
Repayment Period	Months	66.00	Assumed
Interest Rate	%age	10.00%	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	2.00	Feasibility Study
Annual Escalation	%age	5.00	Feasibility Study
Estimation of Revenue			
Electricity Saving	kWh/Year	3672	
Cost of electricity	`/kWh	7.45	
St. line Depn.	%age	5.28	Indian Companies Act
IT Depreciation	%age	80.00	Income Tax Rules
Income Tax	%age	33.99	Income Tax

Estimation of Interest on Term Loan **` (in lakh)**

Years	Opening Balance	Repayment	Closing Balance	Interest
1	0.59	0.03	0.56	0.07
2	0.56	0.09	0.47	0.05
3	0.47	0.12	0.36	0.04
4	0.36	0.15	0.21	0.03
5	0.21	0.15	0.06	0.01
6	0.06	0.06	0.00	0.00
		0.59		

WDV Depreciation **`(in lakh)**

Particulars / years	1	2
Plant and Machinery		
Cost	0.79	0.16
Depreciation	0.63	0.13
WDV	0.16	0.03

Projected Profitability ` (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8
Electricity savings	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Total Revenue (A)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Expenses								
O & M Expenses	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Total Expenses (B)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
PBDIT (A)-(B)	0.26	0.26	0.26	0.26	0.25	0.25	0.25	0.25
Interest	0.07	0.05	0.05	0.03	0.02	0.00	0.00	0.00
PBDT	0.19	0.20	0.21	0.22	0.24	0.25	0.25	0.25
Depreciation	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
PBT	0.15	0.16	0.17	0.18	0.19	0.21	0.21	0.21
Income tax	0.00	0.03	0.07	0.08	0.08	0.09	0.09	0.09
Profit after tax (PAT)	0.15	0.14	0.10	0.10	0.11	0.12	0.12	0.12

Computation of Tax ` (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	0.15	0.16	0.17	0.18	0.19	0.21	0.21	0.21
Add: Book depreciation	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Less: WDV depreciation	0.63	0.13	-	-	-	-	-	-
Taxable profit	(0.44)	0.08	0.21	0.22	0.24	0.25	0.25	0.25
Income Tax	-	0.03	0.07	0.08	0.08	0.09	0.09	0.09

Projected Balance Sheet ` (in lakh)

Particulars / Years	1	2	3	4	5	6	7	8
Share Capital (D)	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Reserves & Surplus (E)	0.15	0.28	0.38	0.48	0.60	0.72	0.85	0.97
Term Loans (F)	0.57	0.51	0.39	0.25	0.07	0.00	0.00	0.00
Total Liabilities (D)+(E)+(F)	0.91	0.99	0.97	0.93	0.86	0.92	1.04	1.17
Assets	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Fixed Assets	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Less Accumulated Depreciation	0.04	0.08	0.13	0.17	0.21	0.25	0.29	0.33
Net Fixed Assets	0.75	0.71	0.66	0.62	0.58	0.54	0.50	0.46
Cash & Bank Balance	0.16	0.28	0.30	0.31	0.28	0.38	0.55	0.71
TOTAL ASSETS	0.91	0.99	0.97	0.93	0.86	0.92	1.04	1.17
Net Worth	0.34	0.48	0.58	0.68	0.80	0.92	1.05	1.17
Debt Equity Ratio	2.88	2.57	1.97	1.26	0.35	0.00	0.00	0.00

Projected Cash Flow ` (in lakh)

Particulars / Years	0	1	2	3	4	5	6	7	8
Sources									
Share Capital	0.20	-	-	-	-	-	-	-	-
Term Loan	0.59								
Profit After tax		0.15	0.14	0.10	0.10	0.11	0.12	0.12	0.12
Depreciation		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Total Sources	0.79	0.19	0.18	0.14	0.15	0.16	0.17	0.17	0.17
Application									
Capital Expenditure	0.79								
Repayment Of Loan	-	0.02	0.06	0.12	0.14	0.18	0.07	0.00	0.00
Total Application	0.79	0.02	0.06	0.12	0.14	0.18	0.07	0.00	0.00

Net Surplus	-	0.16	0.12	0.02	0.01	-0.02	0.10	0.17	0.17
Add: Opening Balance	-	-	0.16	0.28	0.30	0.31	0.28	0.38	0.55
Closing Balance	-	0.16	0.28	0.30	0.31	0.28	0.38	0.55	0.71

IRR **` (in lakh)**

Particulars / months	0	1	2	3	4	5	6	7	8
Profit after Tax		0.15	0.14	0.10	0.10	0.11	0.12	0.12	0.12
Depreciation		0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Interest on Term Loan		0.07	0.05	0.05	0.03	0.02	0.00	-	-
Cash outflow	(0.79)	-	-	-	-	-	-	-	-
Net Cash flow	(0.79)	0.26	0.23	0.18	0.18	0.17	0.17	0.17	0.17
IRR	19.53 %								
NPV	0.26								

Break Even Point **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Variable Expenses								
O & M Expenses (75%)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Sub Total(G)	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02
Fixed Expenses								
O & M Expenses (25%)	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Interest on Term Loan	0.07	0.05	0.05	0.03	0.02	0.00	0.00	0.00
Depreciation (H)	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Sub Total (I)	0.11	0.10	0.09	0.08	0.06	0.05	0.05	0.05
Sales (J)	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Contribution (K)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Break Even Point (L= G/I)%	43.74%	38.29%	35.11%	30.63%	24.96%	18.94%	18.24%	18.40%
Cash Break Even {(I)-(H)}%	27.80%	22.31%	19.09%	14.58%	8.87%	2.80%	2.05%	2.16%
Break Even Sales (J)*(L)	0.12	0.10	0.10	0.08	0.07	0.05	0.05	0.05

Return on Investment **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8	Total
Net Profit Before Taxes	0.15	0.16	0.17	0.18	0.19	0.21	0.21	0.21	1.48
Net Worth	0.34	0.48	0.58	0.68	0.80	0.92	1.05	1.17	6.02
									24.64 %

Debt Service Coverage Ratio **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8	Total
Cash Inflow									
Profit after Tax	0.15	0.14	0.10	0.10	0.11	0.12	0.12	0.12	0.72
Depreciation	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.25
Interest on Term Loan	0.07	0.05	0.05	0.03	0.02	0.00	0.00	0.00	0.22
Total (M)	0.26	0.23	0.18	0.18	0.17	0.17	0.17	0.17	1.20

DEBT

Interest on Term Loan	0.07	0.05	0.05	0.03	0.02	0.00	0.00	0.00	0.22
Repayment of Term Loan	0.02	0.06	0.12	0.14	0.18	0.07	0.00	0.00	0.59
Total (N)	0.09	0.11	0.17	0.17	0.20	0.07	0.00	0.00	0.82
DSCR (M/N)	2.78	2.02	1.12	1.04	0.88	2.35	0.00	0.00	1.47
Average DSCR	1.47								

Annexure 6: Procurement and implementation schedule

Day wise break up of implementation Schedule

SN	Activities	Days			
		1	2	3	4
1	Foundation & civil work				
2	Erection & commissioning				
3	Cabling & electrical panel fitting				
4	Testing and trial				
5	On site operator training				

Annexure 7: Details of technology service providers

S. No.	Name of Service Provider	Address	Contact Person and No.
1	Havels India Limited	160 Rajgarh Road, Guwahati	0361-2458923
2	B. J. Turnkey Services	Decial, Sivasagar, Assam - 785640	Bishwa Jyoti Bhuyan, Ph: 98540 28406
3	Dealers of Crompton Greaves	Assam	
4	L & T Motor Division	Milanpur Road, Bamuni Maidan Guwahati 781 021	Tel: +91-361-2550565 Fax: +91-361-2551308 e-mail: siddhantaas@larsentoubro.com

Annexure 8: Quotations or Techno-commercial bids for new technology/equipment

HAVELLS

Date: 28.06.2011

Sub: **Spl. Price of EFF Motor for Tea Industries**

Output — 4 Pole -- 1500 RPM

KW	Hp	Fram	Cat. Ref.	Each Price
15	20.00	MHHE160LXA4	MHCETLS40015	74955.00
18.5	25.00	MHHE180MXG4	MHCETMS4018X5	96852.00
22	30.00	MHHE180LXG4	MHCETNS40022	107948.00

Note: This price bases on Havells Lafert Motor Price List W.e.f 1st April, 2011.
The prices may change with ut any prior notice.
Excise Duty inclusive, VAT extra as applicabe.
FOR - Guwahati

Thanking You
For Havells India Ltd

Authorised Signatory

HAVELLS INDIA LTD.
160, Rajgarh Road, Guwahati-781007 Ph : 0361- 2458923, 2134521

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