DETAILED PROJECT REPORT
ON
VFD FITMENT IN HOT AIR BLOWING SYSTEM IN DRIER HAVING 30 HP MOTOR
(JORHAT TEA CLUSTER)






Bureau of Energy Efficiency

Prepared By

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VFD FITMENT IN HOT AIR BLOWING SYSTEM IN DRIER HAVING 30 HP MOTOR

JORHAT TEA CLUSTER

BEE, 2010

Detailed Project Report on VFD fitment in Hot Air Blowing System of Drier having 30 HP motor, Jorhat Tea Cluster, Assam (India)

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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
SCUM	Standard Cubic Meter
SIDBI	Small Industrial Development Bank of India
MoMSME	Ministry of Micro Small and Medium Enterprises
VFD	Variable Frequency Drive

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

During tea processing, drying is the most energy intensive process where the moisture from the fermented tea leaves is removed by blowing hot air. In this process the moisture content of the fermented tea leaves is brought down from 55 – 60% to 2.5 – 3%. To bring this moisture content, hot air produced in the coal fired heater or NG fired burner is pushed through the dryer by means of a blower which rotates at a constant speed. And in the existing condition, the variation in the process air requirement is taken care of by means of manually controlled damper control mechanism.

This DPR highlights the details of the study conducted for replacing the existing system of variation in the hot air flow rate into the drying chamber by increasing the system resistance through manual damper control mechanism with automated variation in the hot air flow rate by varying the speed of the hot air fan, 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)	2.09
2	Expected Electricity Savings	kWh/annum	25236
3	Monetary benefit	(` in Lakh)/annum	1.88
4	Simple payback period	Yrs	1.11

S. No	Particular	Unit	Value
5	NPV	(`in Lakh)	5.12
6	IRR	%age	71.98
7	ROI	%age	28.29
8	DSCR	Ratio	3.78
9	CO_2 Reduction	Tonne / Annum	26.00
10	Process down time	Days	01

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 factories 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 the 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	Kg 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

The fermented tea leaves are dried or fired for two reasons, firstly, to stop fermentation of the tea leaves and secondly, to reduce the moisture content to about 3%. To carry out this process of drying of the tea leaves, clean and odorless hot air is passed through the fermented tea particles in the dryer. As the objective of the drying process during the manufacture of tea is to stop fermentation by removing the moisture content in the fermented tea leaves, so the quantity of heat or the quantity of the hot air required for optimum drying is dependent on the moisture content of the fermented tea leaves.

Under the existing condition ambient air is heated up in the Natural Gas Burner or Coal fired Air heaters. This heated air is fed to the drying chamber by means of a blower. The variation in the quantity of the hot process air as per the process requirement is presently taken care by means of manually operated damper controlled mechanism and not by varying the speed of the blower motor. And as a measure of precaution to take care of the extreme process condition the speed of the blower motor is kept at its rated speed. Irrespective of the variation in the quantity of the process air, the speed of the hot air blower and thus the energy consumption by the hot air blower motor remains constant.

During the energy audit in the tea factories it was observed that the driers are operated with the dampers being, at least, 20% close to a maximum of 40% closed position. Thus if variation in the air flow rate can be achieved through variation in the speed of the blower, then in such case the speed of the blower can be reduced by a safe margin of 15% of the present speed. This existing method of operation of the hot air blowing system where the hot air blower is operating at a higher speed has resulted in wastage of electrical energy.

Electrical Energy Charges

Table 4: Average per unit cost of electrical power

	Per Unit Cost Of Electrical Energy
Grid Availability	70%
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

During the process of drying, the moisture of fermented leaves is reduced from 55 – 60% to 2.5 – 3% by means of blowing hot air through the fermented tea leaves spread over the drier. The hot air blower is used to create the draft required for blowing this hot process air through the fermented tea leaves so as to remove the moisture from the fermented tea leaves.

1.4 Baseline establishment for existing technology

The baseline is prepared on the basis of a typical tea factory of Jorhat Cluster with a production capacity of 1000 MT per annum with the hot air blowing system having hot air blower motor of 30 HP and V – belt type power transmission system. The detailed baseline is as below;

Table 5: Baseline of the existing technology

S. No.	Particulars	Baseline module
1	Hot Air Blower motor	30 HP TEFC, 3Ø, induction motor
2.	Power Transmission mechanism	V – belt
3.	Hot Air control mechanism	Damper controlled
4.	Damper position	Minimum 20% close to a maximum of 40%

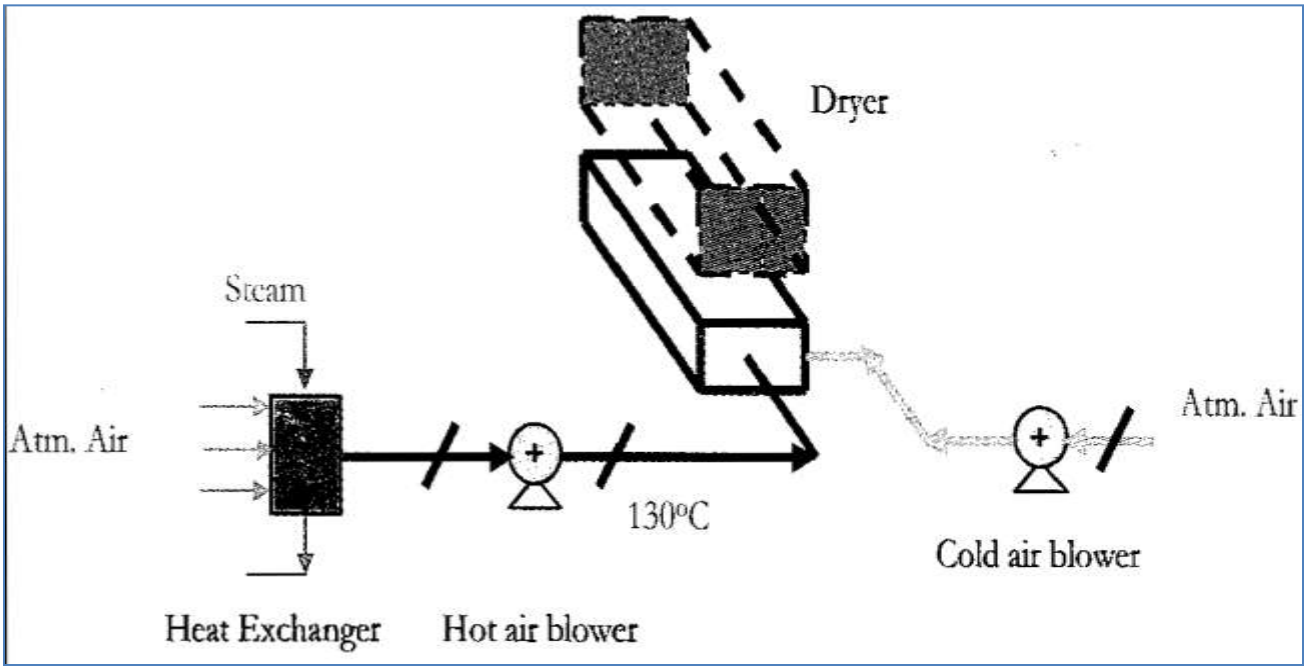


Figure 1: Schematic layout of the Hot Air Blowing System in Jorhat Tea Cluster

1.4.1 Design and operating parameters

The existing process air controlling is done by means of manual control of the dampers fitted between the hot air blower and the drier. Normally the units work for 10 to 12 hours a day and about 300 days a year.

1.4.2 Operating efficiency Analysis:

As described above, the hot air blower pulls the hot air generated from the heater and pushes it to the drier through a manually controlled damper mechanism. Under the existing condition, irrespective of the quantity of the hot air required for the process the hot air blower moves at constant speed. For this the power consumed by the hot air blower depends on the

- Motor rated capacity of the hot air blower
- Power consumed by the motor.
- Total hours of operation of the blower.

The power consumption by the hot air blower motor of 30 HP rated capacity in typical tea factory of Jorhat Cluster is as tabulated in Table 6 below

Table 6: Average electrical power consumption by 30 HP capacity hot air blower motor

S. No.	UNIT	Measured Power (kW)
1	Unit 1	18.70
2	Unit 2	17.70
3	Unit 3	17.50

S. No.	UNIT	Measured Power (kW)
4	Unit 4	22.00
5	Unit 5	23.30
6	Unit 6	21.50
7	Unit 7	22.00
8	Unit 8	23.40
Total		166.10
Average		20.76
Annual consumption in kWh		74745

Considering an average operation of 12 hours per day for 300 days in a year, the power consumption by the hot air blower for a typical factory is 74736 kWh.

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 electrical energy requirement is amongst the highest during the drying process of tea and the acceptability for efficient electrical equipments/ technology 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 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 the technology of VFD is well established, yet the retrofits are modified by the LSP to suit the purpose of tea factories. And as drying is a very vital process in tea manufacturing, so initially there may be a slight doubt amongst the tea factory owners to accept this technology. However, the technology has been tested in some of the tea factories and is found to be successful.
- There is no repairing center for VFD in Assam and the nearest repairing center is in Kolkata. For this reason the downtime period in case of malfunctioning of the VFD will be high.

2. PROPOSED EQUIPMENT FOR ENERGY EFFICENCY IMPROVEMENT

2.1 Description of proposed equipment

In this proposed technology the system resistance is put to minimum by removing the damper control mechanism. In absence of the damper control mechanism the flow of air into the dryer chamber as per the process requirement, is regulated by controlling the speed of the motor of the ID fan by means of Variable Frequency Drives (VFDs).

As the flow of air is directly proportional to the speed of the ID fan, so the air flow to the dryer chamber can be varied adequately by varying the speed of the ID fan.

Now, the speed of the induction motor associated with the ID fan is varied by the VFD through variation in the input frequency to the induction motor, as per the following equation;

$$\text{Speed (N) of the fan} = \frac{120 * \text{Input Frequency in Hz}}{\text{Number of poles of the motor}}$$

As the input power to the induction motor of the ID fan comes via the VFD, so the speed of the ID fan can be easily altered by altering the frequency in the VFD.
Again as per the fan laws,

Fan input power = Constant (K) * (Speed of the Fan) ^{3}

Thus going by the Fan Law, if the speed of the fan is reduced by 10% then the power input to the fan can be reduced by 27%.

2.1.1 Details of proposed equipment

During the energy audit it was revealed that the damper installed between the hot air blower and the drier for controlling the flow of hot air to the drier is kept at minimum 20% closed position at all the times. For this reason in the proposed technology, the output frequency from the VFD will be set such that the hot air blower fan rotates at 15% reduction of the RPM of the ID Fan supplying process air to the drier chamber as in this proposed technology the system resistance will be bought to minimum by fully opening the damper.

A Variable Frequency Drive(VFD) actually lowers the motor voltage if the ratio of the drive & driven pulleys is such that the motor actually runs at frequency 85% of the rated 50 Hz , to keep the voltage – frequency 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 Air-flow 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 hot air blower is lower (because of the lower flow rate & lower air pressure) .This in turn lowers the motor input Power.

At 15% rpm reduction in speed of the hot air blower, the Affinity Laws state that the Air Flow(Q) reduces by 15%,the pressure generated reduces by a factor of $(0.15)^2$ or 22.5%,and the power requirement goes down by $(0.15)^3$ or 33.75%.

2.1.2 Equipment/Technology Specification

The proposed technology will have a VFD suitable for a 30 HP TEFC, 3Ø, induction motor. For the purpose of ensuring proper working environment for the VFD under the harsh industrial conditions generally prevalent in the most of the tea Drier rooms, the VFD panel (powdered coated) has 1P55 protection such that no dust can get anywhere near the VFD.

2.1.3 Integration with Existing Equipment

For the purpose of installation of this proposed equipment, the Y/D starter under the existing condition needs to be replaced with the VFD so that the operation of the hot air blower motor is controlled by the VFD. Thus this proposed technology of speed reduction of the hot air blower motor through installation of VFD can be suitably integrated with the existing system.

2.1.4 Superiority over existing system

The proposed technology, apart from being more energy efficient than the existing one and is technologically superior as it ensures smooth operation of the rotating equipments due to gradual start – up which is not so in case of the existing technology. Use of this equipment reduces the overall plant energy cost. 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

This technology though new to the tea factories in Jorhat Cluster is being in use in other process industries. And as the cost of electrical power for tea factories of this cluster is high so some of the reputed companies marketing this products are targeting the tea factories of this cluster.

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

01 day is required to install and to give trial run of this proposed burner in place of the existing burner. Thus the process down time required is 01 days.

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:

- Proper training to the workers as the flow of hot process air will be governed through speed variation of the motor governed by the VFD.

2.3 Suitable unit for implementation of proposed technology

The measure & technology is suitable for the all tea factories of Jorhat Cluster as well as for tea factories outside this cluster, as all the tea factories has got a hot air blower to push the hot air to the drier. 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 30 number units of this cluster, where energy audit was carried out.

3. ECONOMIC BENEFITS FROM PROPOSED TECHNOLOGY

3.1 Technical benefit

3.1.1 Fuel saving

There will be no Coal or Natural Gas saving due to the adoption of this technology, but there will be savings in HSD consumption due to reduced load on the DG set. But 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

Replacement of the damper mechanism to control the flow of hot process air by varying the speed of the motor through VFD controlled mechanism will yield a consistent savings in electricity. The detailed savings in electricity is as tabulated in Table 7 below;

Table 7: Electricity Saving due to adoption of the proposed technology

Existing Input power, kW	Estimated Input power after VFD fitment, kW	Savings in power per hour, kW/ Hr	Hours of operation per year, Hrs	Estimated savings in power, kWh
20.76	13.75	7.01	3600	25236

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 25236 kWh of electrical power for the unit. Please refer following table.

Table 8: 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/ year*	*25236*
3)	*Expected Monetary Saving per Annum*	*`/ annum*	*188008*
4)	Expected Investment Needed for the proposed technology	` (in lacs)	2.09
5)	Simple Payback	Yrs	1.11
		Months	13

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

3.3 Social benefits

3.3.1 Improvement in working environment

Use of VFD drive technology in Tea Industry reduces the electrical 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 of about 26.0 tonne 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 electrical system.

4 INSTALLATION OF PROPOSED EQUIPMENT

4.1 Cost of project

4.1.1 Equipment cost

Cost of the proposed VFD with panel and with standard accessories and mountings, including taxes @5% works out to be ` 180999

4.1.2 Erection, commissioning and other misc. cost

The details of project cost is as given in table 9 below-

Table 9: Details of proposed technology project cost

Details of Proposed Technology Project Cost			
SN	**Particulars**	**Unit**	**Value**
1	Cost of proposed equipment	` (in Lacs)	1.81
2	Erection & Commissioning cost	` (in Lacs)	0.10
2	Other charges (Including Contingency @ 10%)	` (in Lacs)	0.18
	Total cost	` (in Lacs)	2.09

4.2 Arrangements of funds

4.2.1 Entrepreneur’s contribution

Entrepreneur will contribute 25% of the total project cost i.e. ` 0.52 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. ` 1.57 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.
- Repayment period is taken as 5 years excluding the initial moratorium period of 6 months
- 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.
- It is considered that the motor will be operative for 12 hours a day and for 300 days a year.
- To arrive at a more competitive evaluation, the rise in the energy price is not taken into consideration, as monetary value of the savings is directly proportional to the energy price.
- 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 ` 1.88 lakhs based on the assumptions as mentioned above.

Considering the above assumptions, the net cash accrual starts with ` 1.58 lakh in the first year of operation and to ` 8.39 lakh at the end of eighth year of operation.

4.3.2 Simple payback period

The estimated payback period is about 1.11 years or about 13 months.

4.3.3 Net Present Value (NPV)

The Net present value of the investment at 10% works out to be ` 5.12 lakh.

4.3.4 Internal rate of return (IRR)

The after tax IRR of the project works out to be 71.98%.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 28.29%.

4.4 Sensitivity analysis

Sensitivity analysis to assess the cushioning affect of this proposed technology for the hot air blowing system in the drier 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 10: Sensitivity Analysis

Particulars	IRR	NPV	ROI	DSCR
Normal	71.98 %	5.12	28.29%	3.78
5% increase in savings	76.13 %	5.48	28.39%	3.97
5% decrease in savings	67.84%	4.76	28.18%	3.60

4.5 Procurement and Implementation Schedule

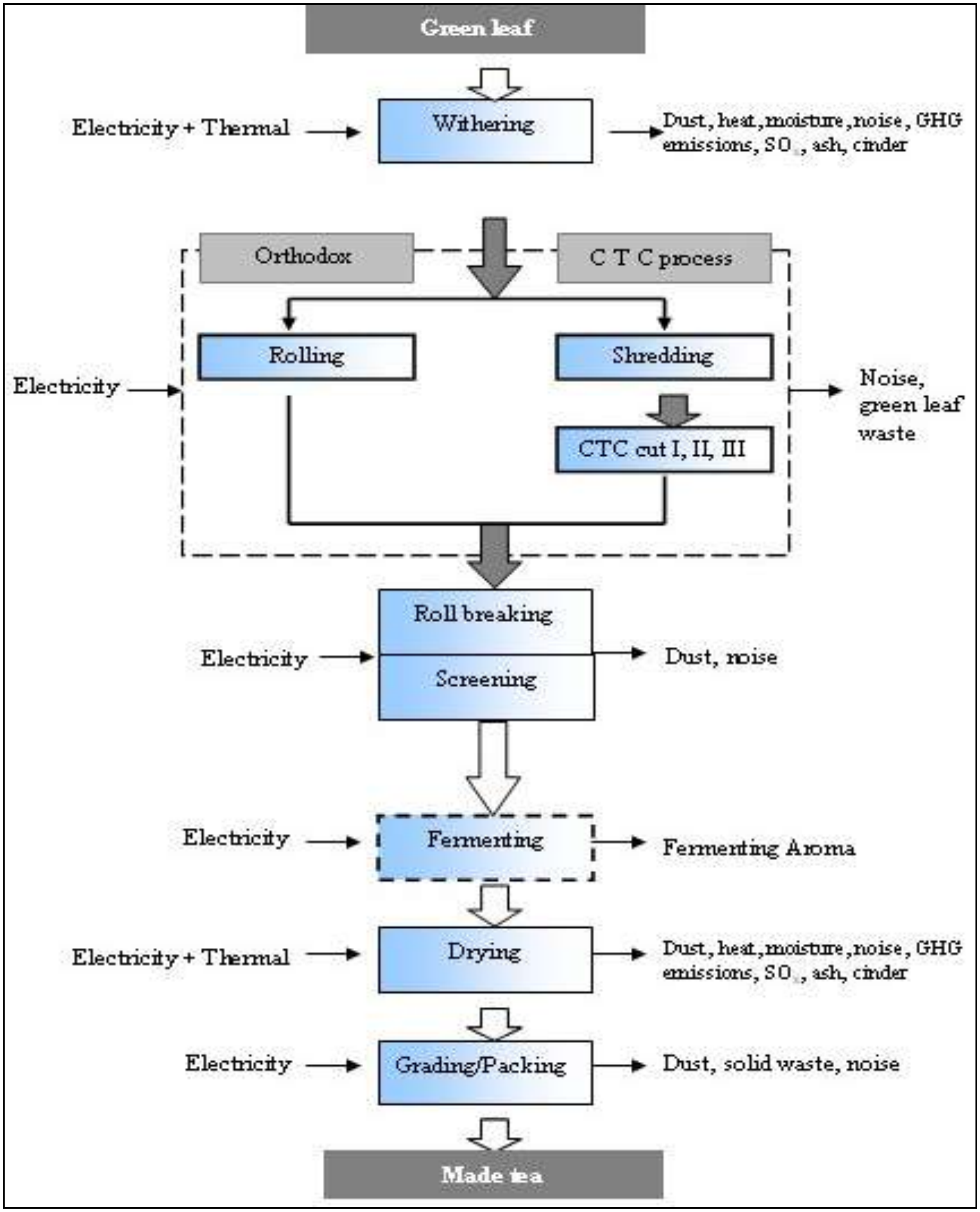
Total time required for procurement and implementation for proposed project are about 10 to 12 weeks and details of procurement and implementation schedules are shown in Annexure 6.

Table 11: Procurement and implementation schedule

S. No.	Activities	Weeks			
		1	-	11	12
1	Order Placement				
2	Delivery				
3	Erection & commissioning				
4	Testing and trial				
5	On site operator training				

Annexure

Annexure 1: Process Flow Diagram



Annexure 2: Energy audit data used for baseline establishment

The specifications of existing hot air blowing system fitted with the typical drier is

S. No.	Details	Specification
1)	Hot air blower motor Particulars	30 HP TEFC, 3Ø induction motor
2)	Air flow rate control mechanism	Manual Damper controlled with damper kept at minimum 20% close to a maximum of 40% position
3)	Input power to the hot air blower motor	20.76 kW

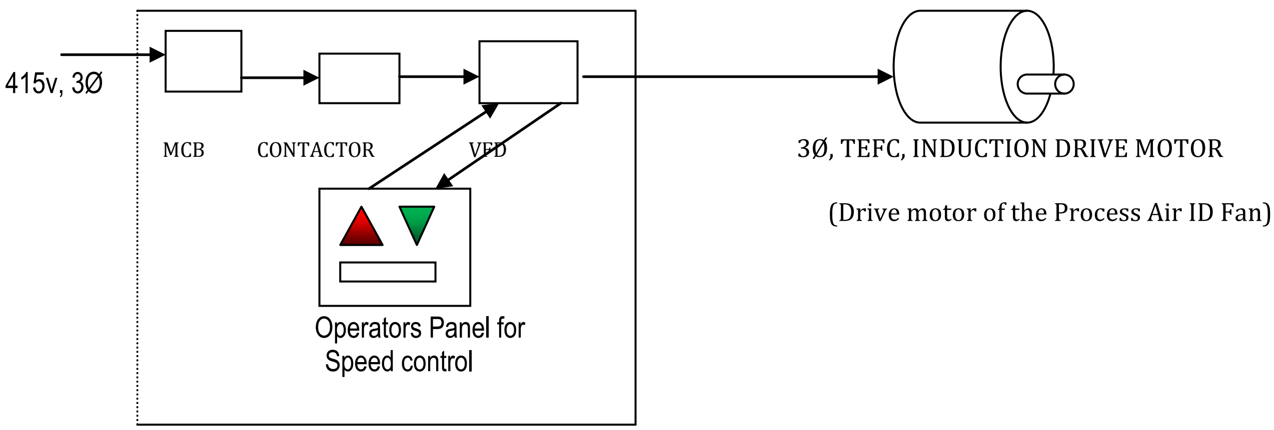
Annexure 3: Detailed technology assessment report

The detailed technology assessment of the technology is as detailed

S. No.	Parameter	Unit	Value
1	Working Hours for Dryer/ Day	Hrs/Day	12
2	Working Days/ Year	Days/ Year	300
3	Actual electrical power Consumption under existing condition	kW/ hour	20.76
4	Expected kW consumption after installation of the proposed technology	kW/ hour	13.75
5	Electricity saving	kW/ hour	7.01
6	Cost of electricity	`/kWh	7.45
7	Expected electricity Saving per Annum	kWh/Annum	25236
8	Expected Monetary Saving per Annum	` (In lacs)/Annum	1.88
9	Expected Investment Needed for replacing existing Damper with VFD	`(In lacs).	2.09
10	Simple Payback	Yrs	1.11
		Months	13

Annexure 4: Drawings for proposed electrical & civil works

Only minor electrical work with no civil work is required for the installation of the equipments for this technology. The electrical layout plan for this proposed technology is as pictorially



VFD PANEL for 3phase Induction Motor

Annexure 5: Detailed financial analysis

Name of the Technology	VFD CONTROLLED HOT AIR BLOWING SYSTEM		
Rated Capacity	30 HP HOT AIR BLOWER MOTOR		
Details	**Unit**	**Value**	**Basis**
Installed Capacity	HP of blower motor	30	
No of working days	Days	300	
No of Working Hr. per day	Hrs.	12	
Proposed Investment			
Plant & Machinery	` (in Lacs)	1.81	
Civil Work	` (in Lacs)	0.00	
Erection & Commissioning	` (in Lacs)	0.10	
Investment without EPC	` (in Lacs)	1.91	
Misc. Cost	` (in Lacs)	0.18	
Total Investment	` (in Lacs)	2.09	
Financing pattern			
Own Funds (Equity)	` (in Lacs)	0.52	Feasibility Study
Loan Funds (Term Loan)	` (in Lacs)	1.57	Feasibility Study
Loan Tenure	Years	7.00	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	kW/Year	25236	
Cost of Electricity	`/kW	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	1.57	0.08	1.49	0.18
2	1.49	0.24	1.25	0.14
3	1.25	0.31	0.94	0.11
4	0.94	0.39	0.55	0.08
5	0.55	0.39	0.16	0.04
6	0.16	0.16	0.00	0.00
		1.57		

WDV Depreciation

` (in lakh)

Particulars / years	1	2
Plant and Machinery		
Cost	2.09	0.42
Depreciation	1.67	0.33
WDV	0.42	0.08

Projected Profitability **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Electricity savings	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
Total Revenue (A)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
Expenses								
O & M Expenses	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06
Total Expenses (B)	0.04	0.04	0.05	0.05	0.05	0.05	0.06	0.06
PBDIT (A)-(B)	1.84	1.84	1.83	1.83	1.83	1.83	1.82	1.82
Interest	0.18	0.14	0.11	0.09	0.05	0.01	0.00	0.00
PBDT	1.66	1.70	1.72	1.75	1.78	1.82	1.82	1.82
Depreciation	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
PBT	1.55	1.59	1.61	1.64	1.67	1.71	1.71	1.71
Income tax	0.00	0.46	0.58	0.59	0.60	0.62	0.62	0.62
Profit after tax (PAT)	1.55	1.12	1.02	1.04	1.06	1.09	1.09	1.09

Computation of Tax **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	1.55	1.59	1.61	1.64	1.67	1.71	1.71	1.71
Add: Book depreciation	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Less: WDV depreciation	1.67	0.33	-	-	-	-	-	-
Taxable profit	(0.02)	1.36	1.72	1.75	1.78	1.82	1.82	1.82
Income Tax	-	0.46	0.58	0.59	0.60	0.62	0.62	0.62

Projected Balance Sheet **` (in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Share Capital (D)	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52
Reserves & Surplus (E)	1.55	2.67	3.69	4.74	5.80	6.89	7.98	9.08
Term Loans (F)	1.49	1.25	0.98	0.66	0.26	0.00	0.00	0.00
Total Liabilities (D)+(E)+(F)	3.56	4.45	5.20	5.92	6.58	7.41	8.51	9.60
Assets	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Gross Fixed Assets	2.09	2.09	2.09	2.09	2.09	2.09	2.09	2.09
Less Accumulated Depreciation	0.11	0.22	0.33	0.44	0.55	0.66	0.77	0.88
Net Fixed Assets	1.98	1.87	1.76	1.65	1.54	1.43	1.32	1.21
Cash & Bank Balance	1.58	2.58	3.44	4.27	5.04	5.98	7.19	8.39
TOTAL ASSETS	3.56	4.45	5.20	5.92	6.58	7.41	8.51	9.60
Net Worth	2.07	3.19	4.22	5.26	6.32	7.41	8.51	9.60
Debt Equity Ratio	2.85	2.40	1.87	1.26	0.49	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	0.52	-	-	-	-	-	-	-	-
Term Loan	1.57								
Profit After tax		1.55	1.59	1.02	1.04	1.06	1.09	1.09	1.09
Depreciation		0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Total Sources	2.09	1.66	1.23	1.13	1.15	1.17	1.20	1.20	1.20
Application									
Capital Expenditure	2.09								
Repayment Of Loan	-	0.08	0.24	0.28	0.32	0.40	0.26	0.00	0.00
Total Application	2.09	0.08	0.24	0.28	0.32	0.40	0.26	0.00	0.00

Net Surplus	0.00	1.58	1.00	0.86	0.83	0.77	0.94	1.20	1.20
Add: Opening Balance	-	-	1.58	2.58	3.44	4.27	5.04	5.98	7.19
Closing Balance	0.00	1.58	2.58	3.44	4.27	5.04	5.98	7.19	8.39

IRR **`(in lakh)**

Particulars / months	0	1	2	3	4	5	6	7	8
Profit after Tax		1.55	1.12	1.02	1.04	1.06	1.09	1.09	1.09
Depreciation		0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Interest on Term Loan		0.18	0.14	0.11	0.09	0.05	0.01	-	-
Cash outflow	(2.09)	-	-	-	-	-	-	-	-
Net Cash flow	(2.09)	1.84	1.37	1.25	1.24	1.22	1.21	1.20	1.20
IRR	71.98%								
NPV	5.12								

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

Particulars / Years	1	2	3	4	5	6	7	8
Variable Expenses								
O & M Expenses (75%)	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Sub Total(G)	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Fixed Expenses								
O & M Expenses (25%)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Interest on Term Loan	0.18	0.14	0.11	0.09	0.05	0.01	0.00	0.00
Depreciation (H)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
Sub Total (I)	0.30	0.26	0.24	0.21	0.17	0.13	0.12	0.13
Sales (J)	1.88	1.88	1.88	1.88	1.88	1.88	1.88	1.88
Contribution (K)	1.85	1.85	1.85	1.84	1.84	1.84	1.84	1.84
Break Even Point (L= G/I)%	16.37%	14.06%	12.82%	11.31%	9.42%	7.15%	6.77%	6.81%
Cash Break Even {(I)-(H)}%	10.40%	8.08%	6.83%	5.32%	3.43%	1.15%	0.76%	0.80%
Break Even Sales (J)*(L)	0.31	0.26	0.24	0.21	0.18	0.13	0.13	0.13

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

Particulars / Years	1	2	3	4	5	6	7	8	Total
Net Profit Before Taxes	1.55	1.59	1.61	1.64	1.67	1.71	1.71	1.71	13.18
Net Worth	2.07	3.19	4.22	5.26	6.32	7.41	8.51	9.60	46.58
									28.29 %

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

Particulars / Years	1	2	3	4	5	6	7	8	Total
Cash Inflow									
Profit after Tax	1.55	1.12	1.02	1.04	1.06	1.09	1.09	1.09	6.89
Depreciation	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.66
Interest on Term Loan	0.18	0.14	0.11	0.09	0.05	0.01	0.00	0.00	0.58
Total (M)	1.84	1.37	1.25	1.24	1.22	1.21	1.20	1.20	8.13

DEBT

Interest on Term Loan	0.18	0.14	0.11	0.09	0.05	0.01	0.00	0.00	0.58
Repayment of Term Loan	0.08	0.24	0.28	0.32	0.40	0.26	0.00	0.00	1.57
Total (N)	0.26	0.37	0.39	0.41	0.45	0.27	0.00	0.00	2.15
DSCR (M/N)	7.06	3.68	3.20	3.05	2.72	4.51	0.00	0.00	3.78
Average DSCR	3.78								

Annexure 6: Procurement and implementation schedule

Week wise break up of implementation Schedule

SN	Activities	Days		
		1	2	3
1	Fabrication of the jigs and fixtures			
2.	Installation and commissioning			
3	Testing and trial			
4	On site operator training			

Annexure 7: Details of technology service providers

S. No.	Name of Service Provider	Address	Contact Person and No.
1	M/s Magnum Automation Systems	A.T. Road, Lahoal, Dibrugarh Assam	Mr. Jasbir Singh: Phone: +919957574040

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

Magnum Automation Systems

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

Buyer's name,
M/s XYZ,
………………………….,
………………………….,

Our Ref No: MAS/….
Dated: 29th June, 2011.

Dear Sir,

Subject: Quotation for the 1) **EE, 22.35 kW, VFD based ID FAN DRIVE Controller** for your Drier / VFBD.

Reference: Your query No. ………….,

Thanks for the query to us and as required, we are appending below the rates of the ECM noted above, for placement of your Order.

1) To being the cost of the ***EE ID FAN DRIVE Controller*** for your Drier (model……….) with the Controller configuration programmed to match the requisite Air flow rate for Drier's rated throughput.

VFD Model No: **CIMR-AD4A0044FMA** of *YASKWA*, Japan MAKE, marketed in India by L&T, having rated Power of **22.35 kW** (ND)

The VARIABLE FREQUENCY DRIVE will be housed in an **IP55** protected Panel with necessary protection devices as are prescribed by L&T.

Rate: ₹ **1.72380** (Lacs)
Sales tax (VAT extra): 5%.

Installation & Commissioning at your factory:
₹ ***9750.00.***

TERMS & Conditions of our Offer:

1) Our QUOTATION **is valid for 4 weeks** from its date & thereafter our written extension will be required.

2) **ADVANCE**: **80% of the basic price with order**, and **balance against Proforma Invoice prior** to delivery.

3) Mode of Payment: a) by direct deposit in our account No.**31652358055**; IFSC Code: **SBIN0000071** with SBI, **Dibrugarh**, through any **SBI *cbs* branch**.

b) By *transfer through* **NIFT**.
c) By an a/c Payee Cheque.

L&T SWITCHGEAR
SAFE & SURE
Authorised Stockist & ISP www. lntebg.com

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

4) **Delivery**: within *21 days of receipt of Commercial Purchase order* along with Advance.

5) The Customer must place the order in writing especially for EC Products, as the Document may be required for Subsidy claims by BEE, New Delhi.

6) The out state Customer must submit C-Form with the Order.

7) The Electrical equipment supplied must be run within the rated Voltage/Loading range-otherwise the **manufacturer's warranty** will not be enforceable. In the case of **PNG**, the client should ascertain that the fuel supplied is at the right pressure, calorific value, is free from unnatural high %age of Moisture, and other impurities, etc.

8) **The delivery date** promised/mentioned is subject to the ***"Force majeure Clause"*** due to unforeseen circumstances or conditions beyond our Control or within our jurisdiction.

9) **Delivery/transport**: The Client will arrange for the transport of Goods to the place of installation in proper condition with all care necessary for fragile goods.

10) The machine will be ***under our AMC for 12 months from the date of commissioning***, and handing over to you.

11) We are one of the **BEE's Approved manufacturer/supplier for this controller**, and you are free to communicate any problem that you may face from us to **BEE** and/or **ASDA, Guwahati**. Our rates are duly approved by the BEE, New Delhi.

We do hope you will favour us with your valued Order, and it will be our endeavour to give you Excellent products and Services.

Thanking You,

Yours faithfully,
For Magnum Automation Systems,

Jasbir Singh.
Cert.EA.

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

Petroleum Conservation & Research Association
Office Address :- Western Region
C-5, Keshava Building, Bandra-Kurla Complex; Mumbai – 400051
Website: www.pcra.org

India SME Technology Services Ltd
DFC Building, Plot No.37-38,
D-Block, Pankha Road,
Institutional Area, Janakpuri, New Delhi-110058
Tel: +91-11-28525534, Fax: +91-11-28525535
Website: www.techsmall.com