DETAILED PROJECT REPORT
ON
TECHNOLOGICAL UPGRADATION WITH COAL GASIFICATION FOR THERMAL & CAPTIVE GENERATION

(JORHAT TEA CLUSTER)






ENERGY IS LIFE
BEE
CONSERVE IT

Bureau of Energy Efficiency

Prepared By

PCRA

Reviewed By

ISTSL

TECHNOLOGICAL UPGRADATION WITH COAL GASIFICATION FOR THERMAL & 63KVA CAPTIVE GENERATION

JORHAT TEA CLUSTER

BEE, 2010

Detailed Project Report on Coal Gasification to meet thermal requirement and additional captive power generation of 63 kVA, Jorhat Tea Cluster, Assam (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.: **PCRA/JTC/ SAG/** ____

For more information

Bureau of Energy Efficiency (BEE)

(Ministry of Power, Government of India)

4th Floor, Sewa Bhawan

R. K. Puram, New Delhi – 110066

Telephone +91-11-26179699

Fax +91-11-26178352

Websites: www.bee-india.nic.in

Email: jsood@beenet.in/ pktiwari@beenet.in

Acknowledgement

We are sincerely thankful to the Bureau of Energy Efficiency, Ministry of Power, for giving us the opportunity to implement the BEE SME project in “Jorhat Tea Cluster, Jorhat”. We express our sincere gratitude to all concerned officials for their support and guidance during the conduct of this exercise.

Dr. Ajay Mathur, Director General, BEE

Smt. Abha Shukla, Secretary, BEE

Shri Jitendra Sood, Energy Economist, BEE

Shri Pawan Kumar Tiwari, Advisor (SME), BEE

Shri Rajeev Yadav, Project Economist, BEE

Petroleum Conservation Research Association (PCRA) is also thankful to various tea associations like ABITA (Assam Branch of Indian Tea Association), TAI (Tea Association of India), ATPA (Assam Tea Planters Association), NETA (North East Tea Association), etc., for their valuable inputs, co-operation, support and identification of the units for energy use and technology audit studies and facilitating the implementation of BEE SME program in Jorhat Tea Cluster.

We take this opportunity to express our appreciation for the excellent support provided by Local Service Providers, and Equipment Suppliers for their active involvement and their valuable inputs in making the program successful and in completion of the Detailed Project Report (DPR).

PCRA is also thankful to all the owners of the tea factories, plant in charges and all workers of the tea factories for their support during the energy use and technology audit studies and in implementation of the project objectives.

Petroleum Conservation Research Association

Guwahati

Contents

List of Annexure

List of Table

List of Figures

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
IRR	Internal Rate of Return
MT	Metric Tonne
MW	Mega Watt
NPV	Net Present Value
ROI	Return on Investment
SCM	Standard Cubic Meter
SIDBI	Small Industrial Development Bank of India
MoMSME	Ministry of Micro Small and Medium Enterprises

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

Coal is presently being used in the tea factories of this cluster only as the thermal energy source to raise the enthalpy of the process air required for drying with a very low operating efficiency of about 24%. As the coal that is being used in the tea factories have a very high volatile matter content of about 45% - 49%, so optimum utilization of the coal can be made through gasification of coal. By modifying the existing Diesel Generator set to dual fuel mode, partial fulfillment electrical power requirement can be made by using the Producer Gas generated during the coal gasification process. And coke, which is the carbon rich residue in the gasification plant, can be used as fuel in the indirect fired heater for producing hot air required for drying, instead of coal. This technology also helps to enhance the thermal efficiency through pre – heating of the process air by means of waste heat recovery from the dual fuel mode generator.

This DPR highlights the study conducted for optimum utilisation of coal through coal gasification, 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)	17.85
2	Expected Electricity generation	kWh/annum	181440
3	Expected Coal Savings	Tonne/ annum	136.80
4	Expected Additional Diesel consumption	liter/year	9000
5	Net Monetary benefit	(`in Lakh)/annum	16.25
6	Simple payback period	Yrs	1.15
7	NPV	(`in Lakh)	43.54
8	IRR	%age	69.06
9	ROI	%age	28.22
10	DSCR	Ratio	3.73
11	CO_2 reduction	tonne / Year	410.42
12	Process down time	Days	15

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

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	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

Under the existing condition the coal in the tea factories of this cluster is being used only for meeting the thermal energy requirement for carrying out the drying process in tea manufacturing. During drying process, the removal of moisture from the fermented tea leaves is done by passing hot atmospheric air through the drier. Coal is being presently used only as a fuel in the indirect type heater to raise the enthalpy of the atmospheric air for meeting the process requirement.

It was revealed during the energy audit phase that the coal from the coal mines of Upper Assam is being used in the tea factories of this cluster, and this coal has a high percentage of volatile matter content (45 % – 49 %). Based on the revelation during the energy audit, the efficiency of utilization of coal for meeting the thermal energy requirement in a typical tea factory with a drier having a capacity to produce 440 kg of made tea per hour, is evaluated as below;

Table 4: Efficiency of utilization of coal

S. No.	Particulars	Value
1	Moisture required to be removed from fermented leaves for 1 kg of made tea	1.45 kg of moisture
2	Heat required to remove the moisture to get 1 kg of made tea considering the ambient temperature as 300 ^{0}C	950 kcal per kg of made tea.
3	Temperature of Process air required for drying	About 1400 C
4	Existing rate of coal feeding in the heater of the driers with capacity to produce 440 kg of made tea per hour	374 kg of coal per hour
5	Coal required for meeting thermal energy during drying process under the existing condition.	0.85 kg of coal per kg of made tea
6	Calorific value of coal	4500 kcal per kg of coal
7	Thermal energy produced through combustion of coal	3825 kcal per kg of made tea
8	Thermal efficiency during drying process under existing condition	24.83 %

Hence it is revealed from the above that coal which is being presently used only for thermal energy requirement is being used very inefficiently. This is despite the fact that the coal used in these tea factories is having a high content of volatile matter. For this coal gasification and building up thermal efficiency through process air preheating is a good means for making optimum utilization of the coal for meeting not only the thermal energy requirement for drying process, but also partial electrical energy requirement.

Electrical Energy Charges

Table 5: 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

Cost of Coal:

The coal required by these factories is bought from the coal fields located in upper Assam; the coal supplied to cluster has a calorific value of 4500 kcal per kg of coal on an average.

The average price of coal that is supplied to these tea factories is `4.50 per kg of coal.

1.3.2 Role in process

Coal is used as a fuel in the coal heaters to produce hot and odourless, clean air required for drying of the fermented tea leaves in the drier. The objective of the coal fired heaters is to enhance the enthalpy of the atmospheric air to such a level that only the moisture from the fermented leaves are removed and no burning of the fermented leaves occurs. For this reason the coal fired heaters are designed to raise the temperature of the atmospheric air to a temperature range of 900 C to 1400 C, depending on the type of dryer, so that the moisture content in the tea leaves is reduced from 70 – 72 % to 2.5 – 3%.

1.4 Baseline establishment for existing technology

Coal under the existing condition is being used only to meet the thermal energy requirement during the drying process of tea manufacturing. As the present efficiency of utilization of coal in the tea factories is low and also the coal being used in the tea factories contains high percentage of volatile matter, this DPR is prepared with the objective to work out the feasibility of optimum utilization of coal through gasification. The baseline for implementation of this technology is as tabulated below;

Table 6: Baseline energy consumption data by coal heater

S. No.	Particulars	Unit	Value
1	Capacity of the Driers	Kg of made tea/ Hour	280
2	Coal Consumed	Kg of coal/ Hour	238
3	Calorific value of coal	Kcal/ kg of coal	4500
4	heat required per kg of made tea for moisture reduction	Kcal/ kg of made tea	950
5	overall efficiency of the system	%	24.84
6	Hours of operation of the drier per day	Hours/ day	12
7	Number of days of operation of the coal heater	Days/ Year	300
8	Hours of operation per year	Hours/ Year	3600
9	Yearly consumption of coal by driers	tonne of coal/ Year	856.8

1.4.1 Operating parameters

As coal is presently being used only for thermal application during the drying process of tea manufacturing, so the operating parameter reflecting the utilization of this resource is determined by the efficiency of the presently installed indirect fired air heater using coal as fuel.

1.4.2 Operating efficiency determining the thermal utilization of coal

The operating efficiency for thermal utilization of coal is determined in the process of drying during tea manufacturing. The process of drying involves moisture removal from the fermented tea leaves by means of hot atmospheric air. The enthalpy of the atmospheric air is raised by means of the heat of combustion by burning coal in the indirect fired coal heater attached with the drier. The heat generated in the combustion chamber of the indirect fired heater is passed on to the atmospheric air so that the temperature of the atmospheric air is raised to about 140^0 C, which is then utilized for drying of the fermented tea leaves spread over the drier.

The operating efficiency determining the thermal utilization of coal is evaluated by the actual heat utilized to raise the enthalpy of the atmospheric air to the quantity of heat generated from the combustion of coal.

During the energy audit phase it was revealed that as per the industry standard 1.45 kg of moisture is required to be removed from the fermented leaves to get 1 kg of made tea. Considering the ambient temperature as 30^{0}C and latent heat of evaporation of water as 540 kcal, the heat that is actually required to evaporate 1 kg of water thus is 610.21 kcal.

As 1.45 kg of moisture is required to be removed to produce 1 kg of made tea, so the heat required for producing 1 kg of made tea is 884.80 kcal. This amount of heat required can be conservatively considered as 950 kcal per kg of made tea as the moisture particles are not evenly distributed within the fermented tea leaves. Thus the actual thermal energy required during drying process to get 1 kg of made tea is 950 kcal. The evaluation of the operating efficiency is as tabulated below;

Table 7: Operating parameters

S. No.	Particulars	Value
1	Coal required during drying to get 1 kg of made tea	0.85 kg of coal
2	Average calorific value of coal	4500 kcal per kg of coa
3	Actual heat generated through in coal heater for 1 kg of coal	3825 kcal
4	Actual heat required to remove moisture during drying for 1 kg of made tea	950 kcal
5	Actual heat required by the drier having capacity to produce 440 kg of made tea	418 000 kcal
6	Operating efficiency under existing condition	24.84 %
7	Operating loss under existing condition	75.16 %

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 thermal energy equipment are not followed.
- 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 no process down time is required for implementation of the technology, yet the implementation time is high due to some civil construction.
- Proper training to staff is required to operate the technology.

2. PROPOSED EQUIPMENT FOR ENERGY EFFICENCY IMPROVEMENT

2.1 Description of proposed technology

Unlike the existing condition, this proposed technology involves optimum utilization of the coal through the process of gasification for meeting the thermal energy and also partial electrical energy requirement. The basic reason for adoption of this proposed technology is due to the fact that the coal that is being used in the tea factories of Jorhat Cluster contains high volatile matter within the range of 45% – 49%. The three broad divisions of this proposed technology are;

- Gasification of coal resulting in the production of Producer Gas, comprising mainly of the volatile matter content in the coal. The residue resulting due to the gasification of the coal is coke, which is rich in fixed carbon.
- Modification of the existing 63 kVA diesel generator set to dual fuel mode, so that the Producer Gas after necessary filtration could be used as a fuel to generate power towards partial fulfillment of the electrical energy requirement.
- Preheating of the atmospheric air through waste heat recovery from the dual fuel mode generator set and use of coke as a fuel in the indirect fired heater to generate hot process air required for drying.

Coal Gasification is a thermo – chemical process of converting coal to gaseous fuel with coke, a carbon rich solid as residue. It is not simply pyrolysis; pyrolysis is only one of the steps in the conversion process. The other steps are combustion with air and reduction of the product of combustion, (water vapor and carbon dioxide) into combustible gases, (carbon monoxide, hydrogen, methane, some higher hydrocarbons) and inert, (carbon dioxide and nitrogen). The gaseous fuel produced during the process known as Producer Gas have some fine dust and condensable compounds termed tar. By bringing down the tar content in the Producer Gas to less than 100 ppm through filtration process, the Producer gas is suitable to operate a diesel engine on dual fuel mode.

The detailed chemical reaction during the process of coal gasification is as below;

1) Combustion (Oxidation)

$C + O_2 \rightarrow CO_2 + \text{Heat}$

$H_2O + C \rightarrow CO + H_2 - \text{Heat}$

2) ***Reaction (Reduction)***

$CO_2 + \text{Heat} \rightarrow 2CO - \text{Heat}$

$H_2O + CO + \text{Heat} \leftrightarrow CO_2 + H_2 + \text{Heat}$

$2H_2 + C \rightarrow CH_4 + \text{Heat}$

$CO + 3H_2 \rightarrow H_2O + \text{Heat}$

3) Pyrolysis (Carbonization)

$CH_{0.8} S_{0.2} O_{0.1} N_{0.01}$ (Coal Molecule) → $CH_4 + H_2 + CO + H_20 + NH_3$ + Heat (Hot Gas released from Oxidation and Reduction zone) + Tar (Viscous hydrocarbon $C_6 H_6$, $C_{10}H_8$)

4) Drying of Fuel

The moisture content in the introduced coal is removed in the Drying zone.

2.1.1 Details of proposed equipment

This technology is recommended to be implemented in the tea factories using coal as the source of thermal energy because;

- Coal under the existing condition is used only for thermal energy requirement at a very low efficiency.
- The coal that is being used in the tea factories have high amount of volatile matter, in the range of 45% - 49%, for which the opportunity of gasification of coal is very good

The equipments required for the implementation of this proposed technology primarily includes the coal gasification plant. For generating the thermal energy required to produce hot air for the drying process during tea manufacturing and 63 kVA of electrical energy, coal gasifier of 100 kWe capacity having a coal intake of 200 kg per hour, requires to be installed. The existing 63 kVA Diesel generator that is being installed in the typical tea factory to provide back – up power during off – grid period has to be modified to dual fuel mode along with provision for waste heat recovery from the exhaust gas to pre – heat the atmospheric air required for drying.

2.1.2 Equipment/Technology Specification

Gasifier

Figure 1: Coal Gasification Plant

Table 8: Equipment specification

S. No.	Details	Specification
1.	Capacity	100 kWe
2.	Coal Requirement per hour	200 kg per hour
3.	Size of Platform	15' X 30'
4.	Size of Underground Tank	10' (Length) X 10' (Breadth) X 5' (Depth)
5.	Size of Gasifier	5' (Diameter) X 16' (Height)
6.	Type of Coal Feeding	Stoker feeder

Diesel Generator with dual fuel mode:

The generalized technical specification required for the Diesel Generator set with dual fuel mode is as tabulated below;

Table 9: Equipment specification (Dual Fuel generating set)

S. No.	Details	Specification
Generator Specification		
1.	Capacity	63 kVA
2.	RPM	1500 RPM
3.	Phase	3 phase
4.	Number of Pole	04
5.	Output Voltage	415 V
6.	Frequency	50 Hz
7.	Power Factor	0.80
Engine Specification		
1.	Fuel	Diesel and Producer Gas
2.	Cooling System	Water Cooled
3.	BHP	83
4.	Starting mode	Electrical starting through 12 V DC battery
5.	RPM	1500

2.1.3 Integration with Existing Equipment

The energy conservation proposal is for optimum utilization of coal through modification in the existing system of operation. The proposed technology will produce electrical power in addition to the thermal energy required for generating hot air required for drying, so this proposed technology can be integrated with the existing system. Both thermal energy requirement for drying process and partial electrical energy requirement will be met through implementation of this technology, so this technology is suited for tea factories using coal as the source of thermal energy.

2.1.4 Superiority over existing system

The proposed coal gasification technology utilizes coal for both thermal and electrical energy requirement unlike the existing system where coal is used only for thermal energy requirement. This makes this proposed technology is more energy efficient than the existing one and is also 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. The financial calculation is carried out on the basis of a single coal gasification plant of 100 kWe capacity that will generate Producer gas for captive power generation by modifying the existing 63 kVA Diesel generator set to dual fuel mode generator set. Also coke, which is the carbon rich residue in gasification plant will be used as fuel in the indirect heater attached with the drier for generating hot air for the drying process.

2.1.5 Source of equipment

The recommended technology is proven one and is recommended for optimum utilization coal, which is a scarce natural resource. This technology is being implemented in industries where both electrical and thermal energy is required for the process. These are running successfully and the unit owners had observed the savings in terms of energy.

2.1.6 Availability of technology/equipment

Coal gasification plants having cogeneration facility are being made available by different manufacturers in the country. Some of these manufacturers are recognized by the Ministry of New and Renewable Energy with an objective of certifying the quality of the equipments. With an objective of targeting the tea factories to help them utilize the coal in a more efficient fashion, these manufacturers have also tied up with local firms.

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

The installation and commissioning of the coal gasification plant will require 15 days and this can be installed without disturbing the tea manufacturing process. Thus installation and commissioning of this technology can be done at any time of the year and there is no process down time during implementation

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 both thermal and electrical energy efficiency. This measure is suitable for implementation in the tea factories of this cluster that uses coal as the thermal energy source.

3. ECONOMIC BENEFITS FROM PROPOSED TECHNOLOGY

3.1 Technical benefit

3.1.1 Fuel saving

This proposed technology uses coke, the carbon rich residue after gasification instead of coal as fuel in the indirect fired air heater in drying process. Savings in coal will be bought about through preheating of process air for drying by waste heat recovery from the 63 kVA dual fuel mode generator set. The saving in coal is as tabulated below;

Table 10: Coal savings

Coal Saving			
S. No.	**Parameters**	**Unit**	**Value**
1	Actual coal consumption by coal heater per hour under existing condition	Kg of coal/ hour	238
2	Expected coal Consumption after implementation of this proposed technology	Kg of coal/ hour	200
3	Coal Saving per hour	Kg of coal/ hour	38
4	Hours of operation of the drier heater per annum	Hours/ year	3600
5	Coal Savings per annum	Kg of coal/ year	136800

3.1.2 Electricity saving thorough captive generation

Table 11: Electricity Savings through captive generation

Electricity Saving through captive generation			
S. No.	**Parameters**	**Unit**	**Value**
1	Installed capacity of the dual fuel mode Generator set	kVA	63
2	Expected generating Power factor	Ratio	0.8
3	Actual kW generation	kW/ Hr	50.4
4	Hours of operation per year	Hours/ Year	3600
5	Expected Electrical energy Saving through captive generation per Annum	kWh/Annum	181440

3.1.3 Diesel Consumption for Captive Power Generation

Table 12: Diesel Consumption for Captive Power Generation

S. No.	Parameters	Unit	Value
1	Diesel Consumption for operating the dual fuel mode Diesel Generator	Liters/ Hour	2.5
2	Hours of operation per Year	Hours/ Year	3600
3	Annual Diesel Consumption for operating the proposed technology	Liters/ Year	9000

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 180000 kWh/Annum through captive generation and 136800 kg of coal/ annum for the unit with only an extra consumption of 9000 liters of Diesel. Please refer following table.

Table 13: Monetary benefit (For One Typical Unit of Jorhat Tea Cluster)

Energy and monetary benefit			
S. No.	**Parameters**	**Unit**	**Value**
Electricity Savings			
1	Cost of Electricity	`/ kWh	7.45
2	Expected Saving through captive generation	kWh /Annum	181440
3	Expected Monetary Saving per Annum	`/Annum	1351728
Coal Savings			
4	Cost of Coal	`/ kg	4.50
5	Expected Annual Savings in Coal	Kg/ Annum	136800
6	Expected Monetary Saving per Annum	`/ Annum	615600
Diesel Consumption for operating the proposed technology			
7	Cost of Diesel	`/ liter	38.00
8	Expected Diesel Consumption for operating the technology	Liters/ Annum	9000
9	Expected Cost of Diesel for Operating the technology	`/ Annum	342000
Net Monetary Benefits from implementation of the proposed technology			
10	Total Monetary Benefits from Coal saving and captive generation	`/ Annum	1967328
11	Cost of Diesel for operating the technology	`/ Annum	342000
12	Net Monetary Benefits from implementation of the proposed technology	`/ Annum	1625328
13	Capital Cost For Implementing the Technology	` (in lacs)	18.72
14	Simple Payback	Years	1.15
		Months	14

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

3.3 Social benefits

3.3.1 Improvement in working environment

Use of coal gasification technology in Tea Industry reduces the consumption of coal in drying section in one hand and generates captive power on the other hand. This not only improves energy efficiency but also reduces plant load factor for the tea factory due to captive generation of electrical power.

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. Reduction in CO_2 emissions will be possible due to efficient utilization of coal. This project results in reduction of peak demand. The CO_2 calculations are tabulated below:

Table 14: CO2 Savings Calculations

S. No.	*Parameters*	*Value*	*CO2 emission Factor*	*CO2 generated/saved (in tonne/annum)*
1	Diesel Consumption (ltr/annum)	9000	2.6	23.4
2	Coal Consumption Reduction (kg/annum)	136800	95.81kgof CO2/KJ	246.9401
3	Electricity generation (kWh/annum)	181440	1.03kg/kWh	186.8832
	Total CO_2 Savings			***410.4233***

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

Cost of Coal gasification plant of 100 kWe capacity, including the accessories is `9.80 Lacs excluding tax and transportation. Considering the tax @5%, the capital cost of coal gasification plant is `10.30 lacs.

4.1.2 Erection, commissioning and other misc. cost

The details of project cost is as given in table 6 given below-

Table 15: Details of proposed technology project cost

Details of Proposed Technology Project Cost			
S. No.	Particulars	Unit	Value
1	Cost of Coal gasification plant	` (in Lacs)	10.30
2	Modification of existing DG set to dual fuel mode with waste heat recovery system of air preheating	` (in Lacs)	1.50
3	Erection & Commissioning cost	` (in Lacs)	0.60
4	Cost of civil work	` (in Lacs)	3.50
5	Transportation Charges	` (in Lacs)	0.80
6	EPC cost	` (in Lacs)	0.84
7	Other charges (Including Contingency @ 10% on 1&2)	` (in Lacs)	1.18
8	Total cost	` (in Lacs)	18.72

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

Entrepreneur will contribute 25% of the total project cost i.e. ` 4.68 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. `14.04 Lakh, with repayment of 5 years excluding moratorium period 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;

- 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

The Cash Flow statement is given in Annexure 5

4.3.2 Simple payback period

The estimated payback period is about 1.15 years or about 14 months.

4.3.3 Net Present Value (NPV)

The Net present value of the investment at 10% works out to be ` 43.54 lakh.

4.3.4 Internal rate of return (IRR)

The after tax IRR of the project works out to be 69.06%.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 28.22 %.

4.4 Sensitivity analysis

Sensitivity analysis to assess the cushioning affect of coal gasification 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 fuel savings, 5% increase in power generation.

b) Pessimistic Scenario: Under this scenario the financial projections are evaluated on the basis of 5% decrease in the net saving, 5% decrease in power generation.

The result of the sensitivity analysis is as given below;

Table 16: Sensitivity Analysis

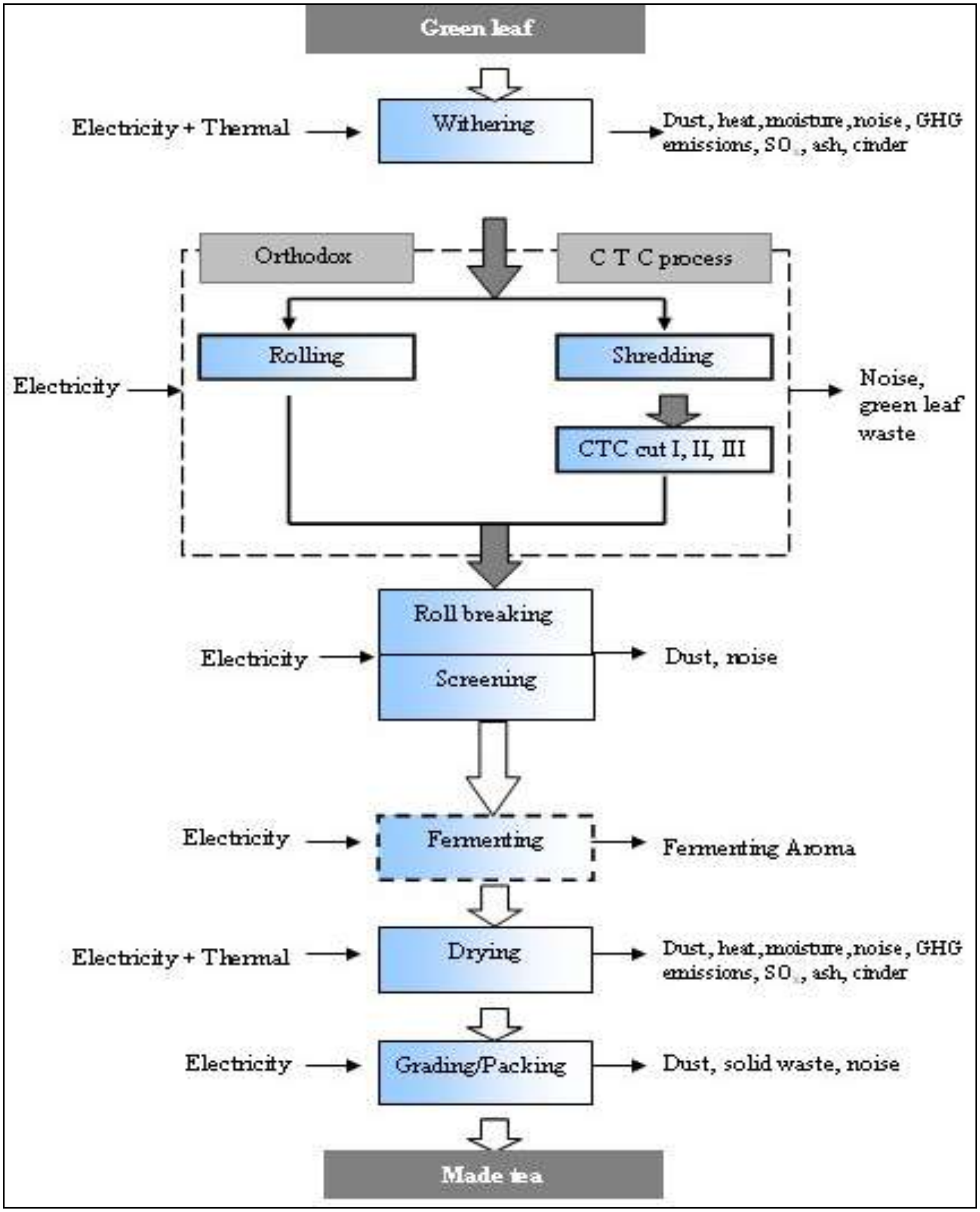
Particulars	IRR	NPV	ROI	DSCR
Normal	69.06%	43.54	28.22%	3.73
5% increase in fuel savings , power generation	73.91 %	47.31	28.34 %	3.95
5% decrease in savings, power generation	64.22 %	39.77	28.08%	3.50

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).

Annexure 1: Process Flow Diagram



Annexure 2: Energy audit data used for baseline establishment

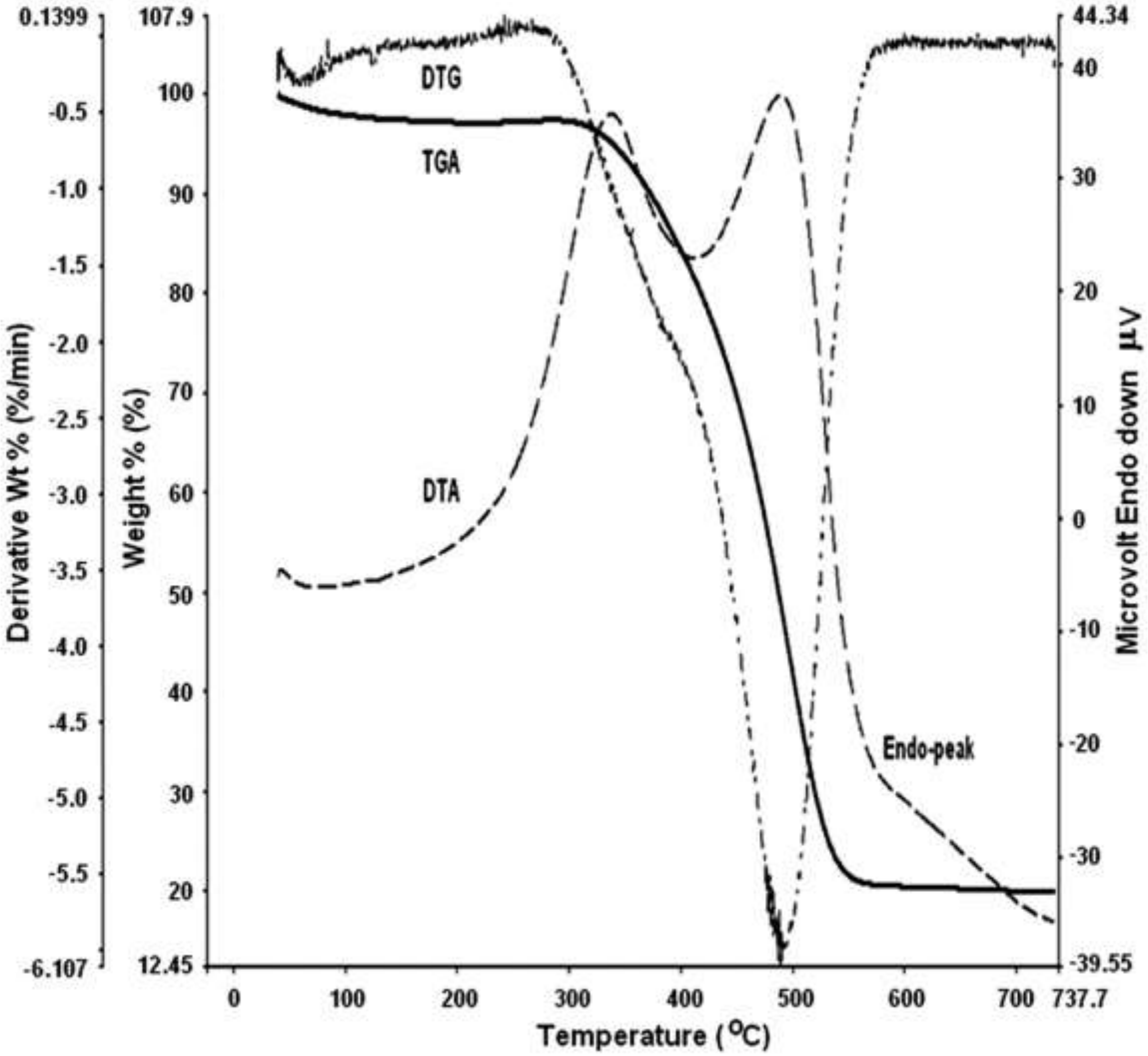
Coal under the existing condition is directly fed to the indirect heater fired by coal to produce hot process air required for drying, which is the considered as the baseline. The details of the drier that is being used in a typical tea factory of the cluster is as tabulated below;

S. No.	Particulars	Unit	Value
1	Capacity of the Driers	Kg of made tea/ Hour	280
2	Coal Consumed	Kg of coal/ Hour	238
3	Calorific value of coal	Kcal/ kg of coal	4500
4	heat required per kg of made tea for moisture reduction	Kcal/ kg of made tea	950
5	overall efficiency of the system	%	24.84
6	Hours of operation of the drier per day	Hours/ day	12
7	Number of days of operation of the coal heater	Days/ Year	300
8	Hours of operation per year	Hours/ Year	3600
9	Yearly consumption of coal by driers	tonne of coal/ Year	856.8

The property of coal that is being presently used in the typical tea factory is as tabulated below;

S. No.	Coal Property	Unit	Value
1	Calorific value of coal	Kcal/ kg of coal	4500
2	Amount of carbon	Percentage	74 % – 81 %
3	Amount of Oxygen	Percentage	9 % – 7.5 %
4	Volatile matter content	Percentage	45 % – 49 %

The TGA and DTA graphs are as depicted in the following figure. This figure also illustrates the Derivative Thermo – gravimetric (DTG) curve



DTG
TGA
DTA
Endo-peak
Derivative Wt % (%/min)
Weight % (%)
Microvolt Endo down µV
Temperature (°C)
0.1399
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5
-5.0
-5.5
-6.107
107.9
100
90
80
70
60
50
40
30
20
12.45
44.34
40
30
20
10
0
-10
-20
-30
-39.55
0
100
200
300
400
500
600
700
737.7

Annexure 3: Detailed technology assessment report

S. No	Parameter	Value
1	Details of the Coal Gasification Plant	100 kWe with a coal intake capacity of 200 kg per hour, The gasification of coal will yield Producer Gas that can be used as fuel in DG sets operating on dual fuel mode. The gasification process will leave carbon rich solid residue known as coke, which can be used as fuel in the indirect fired heater for the drier.
2	Details of the Generator Set	The existing 63 kVA DG set to be modified to dual fuel mode with waste heat recovery system for pre – heating the atmospheric air to be fed to the indirect fired heater for use as process air for drying.
3	Coal consumption by the gasification plant	200 kg of coal/ Hour
4	Mode of coal feeding	Continuous through feeding hopper
5	Start up	Through blower and external power
6	Temperature of the gas coming out of the gasification plant	200^0 C
7	Material of construction	The gasification plant will be made of M. S. / SS/ Ceramic & refractory lining and depending on the process requirement and maintaining a minimum shell life of 15 years.

Savings			
S. No.	Parameters	Unit	Value
1	Actual coal consumption by coal heater per hour under existing condition	Kg of coal/ hour	238
2	Expected coal Consumption after implementation of this proposed technology	Kg of coal/ hour	200
3	Coal Saving per hour	Kg of coal/ hour	38
4	Hours of operation of the drier heater per annum	Hours/ year	3600
5	Coal Savings per annum	Kg of coal/ year	136800
6	Cost of Coal	`/ kg	4.50
7	Expected Monetary Saving per Annum	`/ Annum	615600
Electricity Saving through captive generation			
1	Installed capacity of the dual fuel mode Generator set	kVA	63
2	Expected generating Power factor	Ratio	0.8
3	Actual kW generation	kW/ Hr	50.4

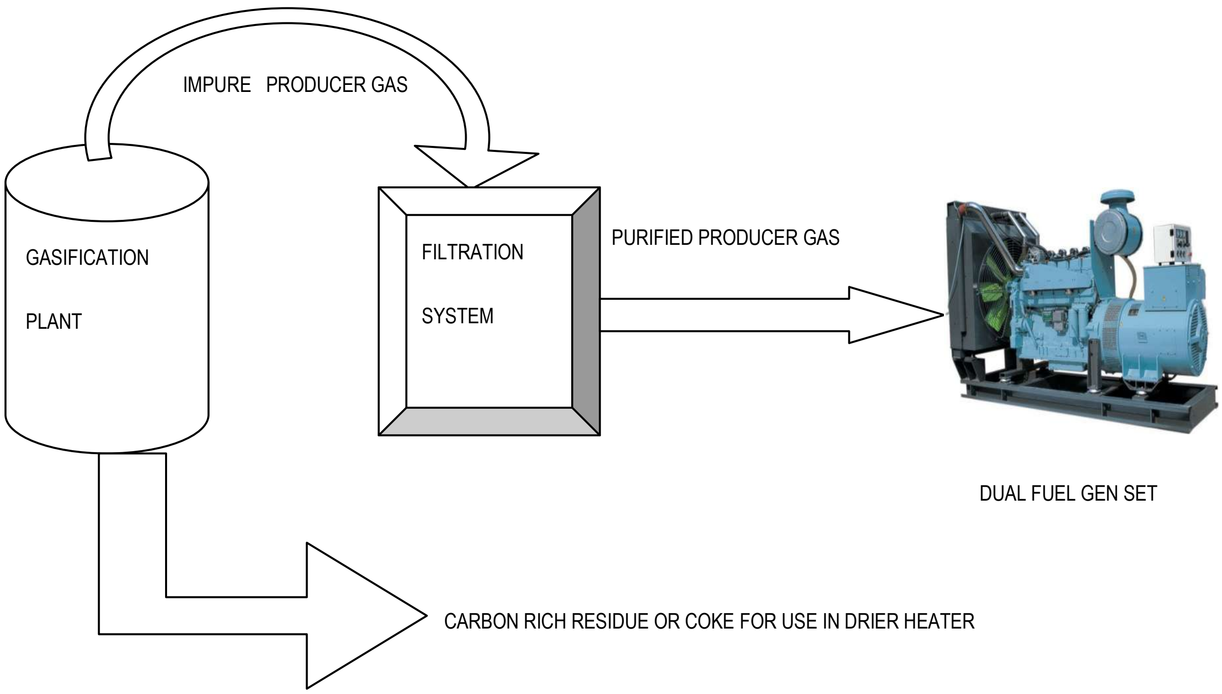
4	Hours of operation per year	Hours/ Year	3600
5	Expected Electrical energy Saving through captive generation per Annum	kWh/Annum	181440
6	Cost of Electricity	`/ kWh	7.45
7	Expected Monetary Saving per Annum	`/Annum	1351728
Additional Diesel Consumption			
1	Diesel Consumption for operating the dual fuel mode Diesel Generator	Liters/ Hour	2.5
2	Hours of operation per Year	Hours/ Year	3600
3	Annual Diesel Consumption for operating the proposed technology	Liters/ Year	9000
4	Cost of Diesel	`/ liter	38.00
5	Expected Cost of Diesel for Operating the technology	`/ Annum	342000
Net Monetary Benefits from implementation of the proposed technology			
1	Total Monetary Benefits from Coal saving and captive generation	`/ Annum	1967328
2	Cost of Diesel for operating the technology	`/ Annum	342000
3	Net Monetary Benefits from implementation of the proposed technology	`/ Annum	1625328
4	Capital Cost For Implementing the Technology	` (in lacs)	18.72
5	Simple Payback	Years	1.15
		Months	14

Annexure 4: Drawings for proposed electrical & civil works

For implementation of this proposed technology minor electrical modification is required for making the identified load points directly connected to the 100 KVA generator set to be operated in the dual fuel mode.

For the purpose of installation of the gasification plant the following Civil Construction will be required;

Particulars	Size
Platform for installation of the gasification Plant	15' X 30'
Underground Water Tank	10' (Length) X 10' (Breadth) X 5' (Depth)



SCHEMATIC LAYOUT OF THE PROPOSED TECHNOLOGY

Annexure 5: Detailed financial analysis

Name of the Technology	COAL GASIFICATION		
Rated Capacity	100 kWe		
Details	**Unit**	**Value**	**Basis**
Installed Capacity	kWe	100	
No of working days	Days	300	Feasibility study
No of Working hours	Hrs./day	12	
Proposed Investment			
Plant & Machinery	` (in lakh)	11.80	As per quotation provided
Civil Work	` (in lakh)	3.50	Assumed
Erection & Commissioning	` (in lakh)	1.40	Assumed
Investment without EPC	` (in lakh)	16.70	
EPC cost	` (in lakh)	0.84	Assumed
Misc. Cost(10% of the plant & Machinery cost)	` (in lakh)	1.18	Assumed
Total Investment	` (in lakh)	18.72	
Financing pattern			
Own Funds (Equity)	` (in lakh)	4.68	Feasibility Study
Loan Funds (Term Loan)	` (in lakh)	14.04	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 EE 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			
Captive Electrical Power Generation	kWh/Year	181440	Feasibility Study
Cost of electricity	`/kWh	7.45	Feasibility Study
Coal Saving	Tonne/ year	136.80	Feasibility Study
Cost of coal	`/ Tonne	4500	Feasibility Study
Diesel requirement	Liters/ Year	9000	Feasibility Study
Cost of Diesel	`/ Liter	38.00	Feasibility Study
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	14.04	1.20	12.84	1.62
2	12.84	2.40	10.44	1.17
3	10.44	2.64	7.80	0.92
4	7.80	2.79	5.01	0.66
5	5.01	3.40	1.61	0.36
6	1.61	1.61	0.00	0.05
		14.04		

WDV Depreciation **`(in lakh)**

Particulars / years	1	2
Plant and Machinery		
Cost	18.72	3.74
Depreciation	14.97	2.99
WDV	3.74	0.75

Projected Profitability **`(in lakh)**

Particulars / Years	1	2	3	4	5	6	7	8
Electricity savings	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
Total Revenue (A)	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
Expenses								
O & M Expenses	0.37	0.39	0.41	0.43	0.45	0.48	0.50	0.53
Total Expenses (B)	0.37	0.39	0.41	0.43	0.45	0.48	0.50	0.53
PBDIT (A)-(B)	15.88	15.86	15.84	15.82	15.80	15.78	15.75	15.73
Interest	1.62	1.17	0.92	0.66	0.36	0.05	0.00	0.00
PBDT	14.26	14.69	14.92	15.16	15.44	15.73	15.75	15.73
Depreciation	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
PBT	13.27	13.70	13.93	14.17	14.45	14.74	14.76	14.74
Income tax	0.00	3.97	5.07	5.15	5.25	5.35	5.35	5.35
Profit after tax (PAT)	13.27	9.72	8.86	9.02	9.20	9.39	9.41	9.39

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

Particulars / Years	1	2	3	4	5	6	7	8
Profit before tax	13.27	13.70	13.93	14.17	14.45	14.74	14.76	14.74
Add: Book depreciation	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Less: WDV depreciation	14.97	2.99	-	-	-	-	-	-
Taxable profit	(0.71)	11.69	14.92	15.16	15.44	15.73	15.75	15.73
Income Tax	-	3.97	5.07	5.15	5.25	5.35	5.35	5.35

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

Particulars / Years	1	2	3	4	5	6	7	8
Share Capital (D)	4.68	4.68	4.68	4.68	4.68	4.68	4.68	4.68
Reserves & Surplus (E)	13.27	23.00	31.86	40.88	50.08	59.47	68.88	78.28
Term Loans (F)	12.84	10.44	7.80	5.01	1.61	0.00	0.00	0.00
Total Liabilities (D)+(E)+(F)	30.79	38.11	44.33	50.56	56.37	64.15	73.56	82.95

Assets	1	2	3	4	5	6	7	8
Gross Fixed Assets	18.72	18.72	18.72	18.72	18.72	18.72	18.72	18.72
Less Accumulated Depreciation	0.99	1.98	2.96	3.95	4.94	5.93	6.92	7.91
Net Fixed Assets	17.73	16.74	15.75	14.76	13.77	12.79	11.80	10.81
Cash & Bank Balance	13.06	21.37	28.58	35.80	42.59	51.36	61.76	72.14
TOTAL ASSETS	30.79	38.11	44.33	50.56	56.37	64.15	73.56	82.95
Net Worth	17.95	27.68	36.53	45.56	54.76	64.15	73.56	82.95
Debt Equity Ratio	2.74	2.23	1.67	1.07	0.34	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	4.68	-	-	-	-	-	-	-	-
Term Loan	14.04								
Profit After tax		13.27	9.72	8.86	9.02	9.20	9.39	9.41	9.39
Depreciation		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Total Sources	18.72	14.26	10.71	9.85	10.01	10.19	10.38	10.40	10.38
Application									
Capital Expenditure	18.72								
Repayment Of Loan	-	1.20	2.40	2.64	2.79	3.40	1.61	0.00	0.00
Total Application	18.72	1.20	2.40	2.64	2.79	3.40	1.61	0.00	0.00
Net Surplus	-	13.06	8.31	7.21	7.22	6.79	8.77	10.40	10.38
Add: Opening Balance	-	-	13.06	21.37	28.58	35.80	42.59	51.36	61.76
Closing Balance	-	13.06	21.37	28.58	35.80	42.59	51.36	61.76	72.14

IRR **`(in lakh)**

Particulars / months	0	1	2	3	4	5	6	7	8
Profit after Tax		13.27	9.72	8.86	9.02	9.20	9.39	9.41	9.39
Depreciation		0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Interest on Term Loan		1.62	1.17	0.92	0.66	0.36	0.05	-	-
Cash outflow	(18.72)	-	-	-	-	-	-	-	-
Net Cash flow	(18.72)	15.88	11.89	10.77	10.67	10.55	10.43	10.40	10.38
IRR	69.06%								
NPV	43.54								

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

Particulars / Years	1	2	3	4	5	6	7	8
Variable Expenses								
O & M Expenses (75%)	0.28	0.29	0.31	0.32	0.34	0.36	0.38	0.40
Sub Total(G)	0.28	0.29	0.31	0.32	0.34	0.36	0.38	0.40
Fixed Expenses								
O & M Expenses (25%)	0.09	0.10	0.10	0.11	0.11	0.12	0.13	0.13
Interest on Term Loan	1.62	1.17	0.92	0.66	0.36	0.05	0.00	0.00
Depreciation (H)	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Sub Total (I)	2.70	2.26	2.01	1.75	1.46	1.16	1.11	1.12
Sales (J)	16.25	16.25	16.25	16.25	16.25	16.25	16.25	16.25
Contribution (K)	15.97	15.96	15.94	15.93	15.91	15.89	15.88	15.86
Break Even Point (L= G/I)%	16.90%	14.17%	12.64%	11.01%	9.19%	7.28%	7.01%	7.06%
Cash Break Even {(I)-(H)}%	10.71%	7.97%	6.44%	4.80%	2.98%	1.06%	0.79%	0.83%
Break Even Sales (J)*(L)	2.75	2.30	2.05	1.79	1.49	1.18	1.14	1.15

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

Particulars / Years	1	2	3	4	5	6	7	8	Total
Net Profit Before Taxes	13.27	13.70	13.93	14.17	14.45	14.74	14.76	14.74	113.77
Net Worth	17.95	27.68	36.53	45.56	54.76	64.15	73.56	82.95	403.14
									28.22%

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

Particulars / Years	1	2	3	4	5	6	7	8	Total
Cash Inflow									
Profit after Tax	13.27	9.72	8.86	9.02	9.20	9.39	9.41	9.39	59.47
Depreciation	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	5.93
Interest on Term Loan	1.62	1.17	0.92	0.66	0.36	0.05	0.00	0.00	4.78
Total (M)	15.88	11.89	10.77	10.67	10.55	10.43	10.40	10.38	70.18
DEBT									
Interest on Term Loan	1.62	1.17	0.92	0.66	0.36	0.05	0.00	0.00	4.78
Repayment of Term Loan	1.20	2.40	2.64	2.79	3.40	1.61	0.00	0.00	14.04
Total (N)	2.82	3.57	3.56	3.45	3.76	1.66	0.00	0.00	18.82
DSCR (M/N)	1.62	1.17	0.92	0.66	0.36	0.05	0.00	0.00	4.78
Average DSCR	3.73								

Annexure 6: Procurement and implementation schedule

Activity No.	Activity Details	Days														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1.	Civil works															
2.	Fitment of Equipments															
3.	Trial Operation															
4.	Training to staff															

The equipment for this technology will be delivered at the site of the tea factory after 3 months of receipt of confirmed order by the tea factory. During the period between placement of order and delivery of the equipments, the necessary site preparation will have to be done by the concerned tea factory. After the arrival of the equipment the installation and commissioning will take 15 days time, the break – up of which is as detailed;

- On the selected site necessary civil foundation and construction work will be carried out by the supplier in co – ordination with the factory personals. This is estimated to take 6 days.
- The fitment of equipments will take 9 days after the partial completion of the civil works.
- After completion of the installation, the equipment supplier will commission the equipment and as per the terms and conditions of MNRE, the equipment supplier will give a trial run for 3 days.
- Training to the staff will be provided simultaneously till completion of the trial run.

Annexure 7: Details of technology service providers

S. No.	Name and address of Service Provider	Name of the Parent Company	Contact Person and No.
1	M/s Radiant Energy Services, 2nd Floor, Lahkar Commercial Complex; A. T. Road, Guwahati – 781001; Assam	M/s Ganesh Engineering Works Poddar House, Jyoti Chowk; Buxar – 802101 Bihar	Mr. D. P. Hazarika 98640 92040
2	M/s B. J. Turnkey Services, Decial, Post Office - Dhulipar Sivasagar – 785640, Assam	M/s Yash Energy (P) Ltd. 408, Haash Business Center Fatehpura, Ahmedabad - 380007	Mr. Jayesh Darji – 99989 84960 Mr. Bishwa Jyoti Bhuyan – 98540 28406

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

Bio Energy

GANESH ENGINEERING WORKS

Engineers,Manufacturer & Supplier

Poddar House, Jyoti Chowk, Buxar - 802101 (Bihar)
Tel. : (06183) 224571 ; Mob. : 9431420171 ; FAX : (06183) 227503
E_mail : podaar_buxar4@yahoo.com

Date: 13 july 201

To,
SRO, i
Petroleum Conservation Research Association
Guwahati

Sub: Detailed Quotation for cogeneration technology to generate 63 kVA of electrical energy and 1, 65, 000 kcal per hour of thermal energy at a temperature of 140^0 C using Gas obtained from Coal Gasifier

ir,

e are an MNRE approved manufacturer of Gasifier. As per your enquiry regarding coal gasification technology to meet both power and thermal energy requirement, we are pleased to serve the tea industry of Assam. For this we have the following enterprise as our channel partner for serving the requirement of customers specially Tea Factories of Assam;

RADIANT ENERGY SERVICES
2ND FLOOR; LAHKAR COMMERCIAL COMPLEX
T. ROAD; GUWAHATI – 781001
Contact Person: Mr. D. P. Hazarika
Contact Number: 098640 92040

As per your requirement, we are pleased to submit our most competitive offer, which is detailed as below;

1. SPECIFICATION OF OUR GASIFIER: MODEL 100 Kwe on Coal
2. COST OF THE GASIFIER : Rs 9,80,000=00 Ex Buxar + tax
3. TERMS AND CONDITION OF SALES 60 days delivery after confirmation of order along with 30 % advance.

4. **Technology** ; Coal gasification is as usual as of Biomass gasification with care to control feed of air and steam to convert the coal in partially to combustible gases , and after purification these gases be use as electrical energy/thermal energy and gas called ~~[illegible]~~ producer gas.

Thanking You

ours faithfully
nesh Engineering Works
Ashok Poddar
Ashok Poddar
9431420171

Manufacturer of Bio-Mass Gasifier & Coal Gasification Plant

Subject to Buxar Jurisdiction

Ganesh Engineering Works

Poddar House, Jyoti Chowk, Buxar-802101 (Bihar)

Phone : 06183-224571, Fax : 06183-227503, Mob : 9431420171

E-mail : poddar_buxar1@yahoo.co.in

Manufacturer & Researchers of BIO-MASS GASIFIERS

Ref .... Date 18/7/2011.

SRO.
Petroleum Conservation Research Association
Guhati

QUOTATION / ORDER

Dear Sir,

We acknowledge with thanks for your enquiry / letter no .... dated .... and in reply we have pleasure to write you as follows :

Sr. No.	Particulars	Amount
01.	COAL Rice Husk / ~~Woody~~ Bio-Mass Gasifier Model No. (Getie suitable for Duel Fuel / ~~100 %~~ mood engine / generating sets along with all standard accessories with motor, pump, blower valves etc. for 65 KVA Power Generation (You shall provide all the pump pipes & fittings, suction pipes, Elec. wire for motor connection, manpower, fooding & lodging travelling exp. of Tech. etc. and civil work of site)	Rs. 9,80,000=00
02.	Erection & Installation Charges	Extra
	Rs. Nine eighty thousand only TOTAL :	9,80,000=00

Terms :
- Price are Ex. Buxar, Tax Extra as applicable.
- Delivery 3 months from the date of order.
- Payment 30 % advance along with order and balance before delivery of goods / machine.
- We take guarantee for one year form the date of supply. Any defects due to workmanship shall be repaired at site or at works depend on the nature of fault, all the transportation of the materials will be arrange & payable by you. All the electrical equipment / spare excluded from guarantee.
- Other as per Annexure 1 enclosed
- During gurantee period visit, you shall provide / bear all the too & fro travelling expenses of each visit with free lodging & fooding.

We trust for your valued order.

Thanking you and assuring you our best workmanship and attention at all the times.

Yours faithfully

For, **Ganesh Engineering Works.**

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