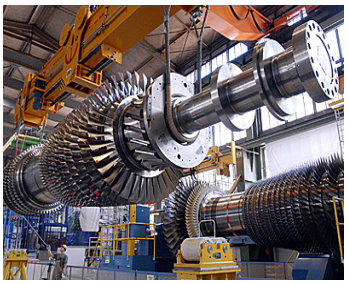
DETAILED PROJECT REPORT
ON
GAS TURBINE BASED
CO-GENERATION TECHNOLOGY
(MORBI CERAMIC CLUSTER)











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GAS TURBINE BASED CO-GENERATION TECHNOLOGY

MORBI CERAMIC CLUSTER

BEE, 2010

Detailed Project Report on Gas Turbine Based Co-generation Technology (3.5 MW)

Ceramic SME Cluster, Morbi, Gujarat (India)

New Delhi: Bureau of Energy Efficiency;

Detail Project Report No.: **MRV/CRM/GTG/09**

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Acknowledgement

We sincerely appreciate the efforts of industry, energy auditors, equipment manufacturers, technology providers, consultants and other experts in the area of energy conservation for joining hands with Bureau of Energy Efficiency (BEE), Ministry of Power, and Government of India for preparing the Detailed Project Report (DPR) under BEE SME Program in SMEs clusters. We appreciate the support of suppliers/vendors for providing the adoptable energy efficient equipments/technical details to the SMEs.

We have received very encouraging feedback for the BEE SME Program in various SME Clusters. Therefore, it was decided to bring out the DPR for the benefits of SMEs. We sincerely thank the officials of BEE, Executing Agencies and ISTSL for all the support and cooperation extended for preparation of the DPR. We gracefully acknowledge the diligent efforts and commitments of all those who have contributed in preparation of the DPR.

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List of Abbreviation

BEE	Bureau of Energy Efficiency
SME	Small and Medium Enterprises
DPR	Detailed Project Report
GHG	Green House Gases
CDM	Clean Development Mechanism
DSCR	Debt Service Coverage Ratio
NPV	Net Present Value
IRR	Internal Rate of Return
ROI	Return on Investment
WHR	Waste Heat Recovery
SCM	Standard Cubic Meter
GT	Gas Turbine
MW	Mega Watt
GWh	Giga Watt Hours
SIDBI	Small Industrial Development Bank of India
MT	Million Tonne

EXECUTIVE SUMMARY

SEE-Tech Solution Pvt. Ltd. is executing BEE-SME program in Morbi Ceramic Cluster, supported by Bureau of Energy Efficiency (BEE) with an overall objective of improving the energy efficiency in cluster units.

Morbi cluster is one of the largest ceramic 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 ceramic clusters in India. The main energy forms used in the cluster units are grid electricity, Natural gas, charcoal, lignite and small quantity of diesel oil.

In ceramic industry 50% of total energy is consumed in spray dryer. Spray dryer is used to remove the moisture present in the raw material which is added during the grinding process. Slurry containing 35-37% moisture and remaining 63-65% clay is dried to about 4-5% moisture in a spray dryer. Majority of the ceramic units of the cluster uses solid fuel in spray dryer whereas very few units use Natural gas.

This DPR highlights the energy, environment, economic and social benefits of use of Gas turbine based co-generation technology for power generation and utilization of waste heat from turbine in spray dryer. Gas turbine based co-generation technology, generates electrical energy and thermal energy at the same time by using Natural gas as a fuel. Further this thermal energy used in spray dryer for removing moisture present in raw material. For implementing this technology vitrified tiles unit has been selected, where the Natural gas is used as a fuel in spray dryer. Exhaust of gas turbine will be available at a temperature of about 500 to 550 ^{o}C which will fulfill the heat requirement of spray dryer.

Total investment required and financial indicators calculated such as debt equity ratio, monetary saving, IRR, NPV, DSCR and ROI etc for proposed technology is furnished in Table below:

S.No	*Particular*	*Unit*	*Value*
1	Project cost	₹(in Lakh)	1904
2	Fuel Saving due to utilization of waste heat	SCM/year	9,015,551
3	Electricity generated by Gas turbine	GWh/year	23.06
4	Natural gas consumption in Gas Turbine	SCM/year	11,880,000
3	Monetary benefit	₹(in Lakh)	527.45
4	Debit equity ratio	Ratio	3:1
5	Simple payback period	year	3.6

S.No	Particular	Unit	Value
6	NPV	₹(in Lakh)	351.67
7	IRR	%age	16.70
8	ROI	%age	20.76
9	DSCR	Ratio	1.36
10	Process down time	Days	10

The projected profitability and cash flow statements indicate that the project implementation i.e. installation of Gas turbine based cogeneration technology will be financially viable and technically feasible solution for ceramic 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. Morbi Ceramic 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*:**

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.

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

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.

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 Brief Introduction about cluster

Morbi SME Cluster is one of the largest ceramic clusters in India and mainly famous for manufacturing of ceramic tiles. Over 70% of total ceramic tiles product comes from Morbi cluster. This cluster is spread over a stretch of about 10km on the Morbi–Dhuva Highway.

There are approximately 479 ceramic units in this cluster which are engaged in manufacturing of wall tiles, vitrified tiles, floor tiles, sanitary wares, roofing tiles and others product. There are around 50 more ceramic units coming up in Morbi cluster.

Primary raw materials required for manufacturing of tiles are various types of clay, quartz, calcite/wool astonite, frits & Glazes. Most of the raw materials are easily available in Gujarat and in the neighboring state of Rajasthan. Some of the units use raw material produced at another plant. The main reason for growth of ceramic cluster in Morbi is easy availability of raw material viz; clay suitable for ceramic tiles.

The main form of energy used by the cluster units are grid electricity, Natural Gas, charcoal, lignite, and diesel oil. Major consumptions of energy are in the form of Natural Gas and lignite. Details of total energy consumption at Morbi ceramic cluster are furnished in Table 1.1 below:

Table 1.1 Details of annual energy consumption

S. No	Type of Fuel	Unit	Value	% contribution
1	Electricity	GWh/year	1,200	8.23
2	Natural Gas	SCM/year	660,000,000	46.32
3	Charcoal	tonne/year	165,000	8.55
4	Lignite	tonne/year	1,320,000	36.84
5	Diesel	litre/year	800,000	0.06

Classification of Units

The ceramic units can be broadly categorized into four types based on product manufactured

- Floor tiles unit
- Sanitary ware unit
- Vitrified tiles unit
- Wall tiles unit

Further the ceramic cluster is classified into three type based on capacity of unit viz small scale, medium scale and large scale unit.

Products Manufactured

There are many types of ceramic product manufactured from four different types of units. Details of product manufactured and number of units engaged in manufacturing of such products are given in Table 1.2 below:

Table 1.2 Details of types of product manufactured

S. No	Type of Product	No. of unit	%age share
1	Wall Tiles	178	37
2	Vitrified Tiles	36	8
3	Floor Tiles	52	11
4	Sanitary Wares	43	9
5	Spray dryer Mud manufacturing	40	8
6	Roofing Tiles (seasonal operation)	120	25
7	Third firing manufacturing (Producing pictures on tiles)	10	2
8	Total	479	

Capacity wise production

Capacity wise production breakup is furnished in Table 1.3 below:

Table 1.3 Production wise unit breakups

Type of product	No. of Units.				Production (m^2/day or MT[a]/day)			
Scale of Unit	Small	Medium	Large	Total	Small	Medium	Large	Total
Wall Tiles	43	100	35	178	2,500	3,500	7,500	13,500
Floor Tiles	8	38	6	52	3,000	4,000	7,000	14,000
Vitrified Tiles	NA	22	4	26[b]	NA	5,760	11,520	17,280
Sanitary Wares	10	24	9	43	4	8	14	26

[a]- In case of sanitary wares, production is measured in MT,.[b]- During audit no SSI vitrified tiles units were covered, therefore production data are not available for these units.

Energy usages pattern

Average monthly electricity consumption in ceramic unit ranges from 1 lakh to 2 lakh kWh depending on the size of the unit. In thermal energy, solid fuel such as lignite, charcoal, Indonesian coal, briquette, etc are used in spray dryer and natural Gas is used in kiln in all almost all units. Solid fuel consumption in spray dryer ranges from 80 to 160 kg/MT and. natural Gas consumption in kiln varies from 1.01 to 1.4 SCM/m^2 of tiles produced.

General production process for ceramic cluster

The units of Morbi ceramic cluster are involved in the manufacturing of 4 different types of products such as floor tiles, wall tiles, vitrified tiles and sanitary wares. Production process for manufacture of wall, floor and vitrified tiles is nearly the same except some differences in process parameters while the manufacturing process of sanitary wares inter alia involves manual moulding whereas in case of tiles, press is used to form the biscuits. General production processes for manufacturing of ceramic products is are following:

Wet Grinding

The raw material such as clay, feldspar, quartz, calcite etc. are mixed with water in a proper proportion and grind in a ball mill to make homogeneous mixture. Ball Mill is a batch type of process. After completion of one batch of ball mill, slurry is sent to the underground tanks containing the agitator motor in each tank to maintain the uniformity of mixture. Mainly blungers are used for mixing and grinding in case of wall and floor tiles, while ball mills are used for grinding in case of vitrified tiles.

Spray Drying

After preparation of slurry of required density it is stored in the underground tanks in which it is agitated to maintain uniformity of slurry. The slurry is then pumped through a hydraulic pump into the spray dryer where it is sprayed through nozzles. The material is dried in spray dryer to remove the moisture added during the grinding process in a ball mill. The moisture in the raw material is brought down to about 5–6 % from 35-40%. The product from spray dryer is stored in silos. Hot flue gases at a temperature of about 550 – 600 ^{o}C is used as the heating source which is generated by combustion of lignite, Indonesian coal, saw dust, briquette, natural gas etc.

Pressing/Moulding

The product from spray dryer is then sent to the press section which is pneumatically operated where the required sizes of biscuit tiles are formed. In case of sanitary ware manual moulding is carried out by hand held hose.

Drying

After pressing/moulding products containing about 5–6% moisture is dried to about 2–3% moisture in a dryer. In some units, hot air from kiln cooling zone exhaust is used in dryers and additional fuel firing is provided if required whereas in case of wall and floor tiles, fuel firing is done continuously.

Glazing

After drying, biscuit tiles are send for glazing on a glaze line. Glaze is prepared in ball mills. Glazing is required for designing on tiles. In case of sanitary ware the dried wares are glazed in several spray glazing booths, where compressed air is used.

Firing and Baking

After glazing product are then sent for final firing in kiln where temperature of 1100-1150 ^{o}C is maintained in the kiln. Natural gas is used for combustion in kiln. In some units hot air from gasifier is utilized for combustion.

Sizing

Tiles coming out of kiln are sent for sizing and calibration in case of wall and floor tiles. The tiles are cut in proper sizes so that all tiles have similar dimensions. After sizing the finished product is ready for dispatch.

Polishing

Polishing is required for vitrified tiles. It utilizes 40-45% of total electricity consumption of plant. After kiln the vitrified tiles are passed through polishing line. Polishing line consist of sizing, calibration and polishing machines.

General production process flow diagram for manufacturing of ceramic product is shown in Figure 1.1.

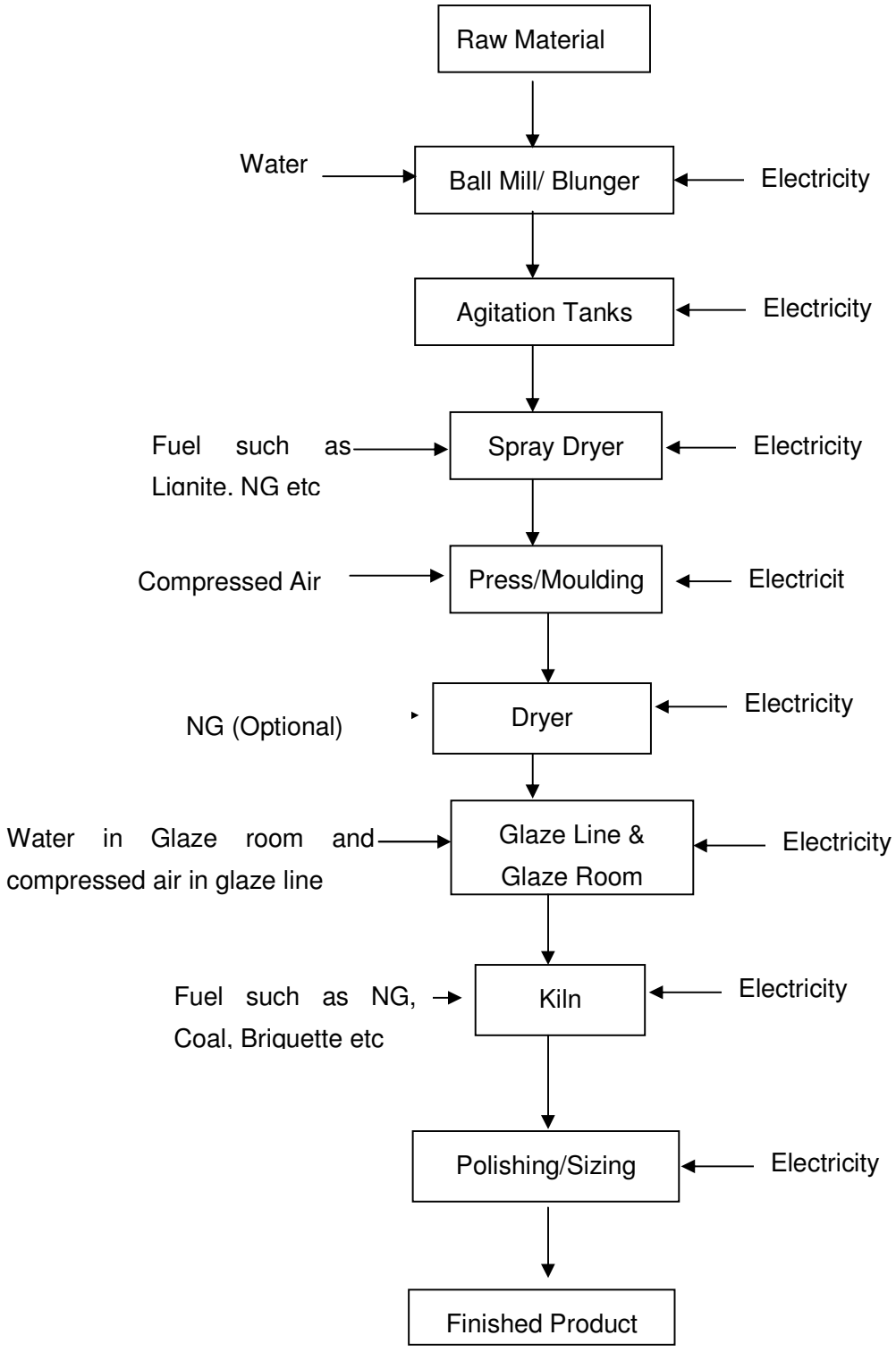

Figure 1.1 Process flow diagram

1.2 Energy performance in existing system

1.2.1 Fuel consumption

Average fuel and electricity consumption in a typical ceramic unit is given in Table 1.4 below:

Table 1.4 Average fuel and electricity consumption

Energy	*Electricity (MWh per year)*			*Natural gas (SCM per year)*			*Solid Fuel [lignite] (Tonne per year)*		
Scale of Unit	*Small*	*Medium*	*Large*	*Small*	*Medium*	*Large*	*Small*	*Medium*	*Large*
Wall Tiles	900	1500	2400	750,000	1,050,000	2,250,000	2,400	2,880	3,600
Floor Tiles	900	1500	2400	900,000	1,200,000	2,100,000	3,600	4,200	4,800
Vitrified Tiles	NA	6000	12000	NA	2,700,000	6,000,000	NA	6,000	9,000
Sanitary Wares	2400	450	900	120,000	240,000	420,000	NA	NA	NA

1.2.2 Average annual production

Annual production in terms of m^2/year is taken in case of tiles and in terms of MT/year in case of sanitary wares is given in the following Table 1.5 below:

Table 1.5 Average annual production

S. No.	*Type of Industry*	*Production (m^2/year) or MT/year*		
		Small scale	*Medium scale*	*Large scale*
1	Vitrified Tiles	750,000	1,050,000	2,250,000
2	Wall Tiles	900,000	1,200,000	2,100,000
3	Floor Tiles	NA	1,728,000	3,456,000
4	Sanitary Wares	1200	2400	4200

1.2.3 Specific energy consumption

Specific energy consumption both electrical and thermal energy per m^2 or MT of production for different type of ceramic products are furnished in Table 1.6below:

Table 1.6 Specific energy consumption

S. No.	Type of Industry	kWh/m^2 or kWh/piece	SCM/m^2 or SCM/piece
1	Vitrified Tiles	3.71 - 5.01	1.51 - 3.11
2	Wall Tiles	0.61 - 2.47	0.68 - 1.65
3	Floor Tiles	1.51 - 1.92	1.28 - 1.8
4	Sanitary Wares	0.78 - 1.73	1.10 - 1.49

Equipment wise specific energy consumption

The specific energy consumption of the equipments used in the ceramic industry is given in Table 1.7 below wherever possible.

Table 1.7 Equipment wise specific energy consumption

S.No	Equipment	Electrical energy		Thermal energy	
		Unit	Vale	Unit	value
1	Ball Mill/Blunger	kWh/MT	4 -12		-
2	Agitation process	kWh/m^3/hr	0.2 - 0.8		-
3	Spray Dryer	-	-	kg/MT	80 - 160
4	Press	kWh/m^2	0.22- 0.4		-
5	Dryer	kWh/m^2	0.011	SCM/m^2	0 - 0.63
6	Glaze line + Glaze ball mill	kWh/MT	2 - 9		-
7	Kiln	kWh/m^2	0.36 - 1.26	SCM/m^2	1.01 -1.4
8	Polishing line/sizing	kWh/m^2	1.74 - 2.35		-

[C] *In sanitary ware production is measured in term of pieces only.*

1.3 Existing technology/equipment

1.3.1 Description of existing technology

In ceramic plant, electricity cost is about 25 to 30% of total cost and the natural gas consumption cost in spray dryer is about 35 to 40% of total energy consumption cost in a unit. Hence, about 60 to 70% of total energy cost in ceramic plant is in the spray dryer only.

Spray dryer is used to remove the moisture present in raw material which was added during the grinding process. Flue gas generated after combustion of natural gas is cooled upto a temperature of about 55^{O}C with the addition of air by another blower and then sent to the spray dryer as a heat source to evaporate the moisture present in the raw material. It is a direct contact type of drying where the flue gas is in direct contact with the raw material.

Existing Spray Dryer Specification is shown in Table 1.8 below.

Table 1.8 Spray dryer specifications

Components	*Different parts*	*Detail*
Burners		Natural gas fired
Atomizer	Rotary disc	Wheel dia:100mm to 350mm
		Wheel type: with parts in SS and ceramic
	Pressure nozzle	Low, high pressure
	Two fluid nozzle	Air atomizing
Chambers	Flat roof	With and without bustle
	Tall from	With and without bustle
	Tall from	With second stage fluid bed
Product separation	Cyclone bag filter	Single point, two points or multi point
		Low and high pressure drop reserve jet
	Bag filter self cleaning	Reserve pulse jet
Controls safety		DCS, PLC, MICRO-PROCESSOR
		Explosion vents, pressure release flaps, fire quenching nozzles.
Capacities	Feed	Clear solution with slurries with 67% solid concentration
	Feed rate	24 MT/hr
	Product	Powder, granules.

Components	Different parts	Detail
Material of construction		SS304, SS316, SS316, SS410, SS310, SS430, SS410.
Fabrication		Shop as well as site fabrication.

At Morbi, electricity connection is taken from Paschim Gujarat Vitaran Company Limited at the following tariff rates

Energy charges

Table 1.9 Energy charges

S. No.	Contract Demand, KVA	Energy Charges, Rs/KWh
1	Upto 1000	3.85
2	From 1001 to 2500	4.05
3	Above 2500	4.15

Demand Charges

Table 1.10 Demand charge

S. No.	Billing Demand, KVA	Demand Charges, Rs/KVA
1	For first 500	98
2	For next 500	139
3	For next 1500	208
4	Billing demand in Excess of 2500	237
5	Billing Demand Excess of contract demand	369

Therefore, total electricity Charges (including the maximum demand charges & other taxes) is Rs. 6.5 per kWh.

1.3.2 Role in process

Basic purpose of spray dryer is to evaporate the water present in slurry. In ceramic industry, water is added in the raw material during the grinding process in Ball Mill / Blunger for proper mixing and grinding process in order to increase the fineness of the material.

Cogeneration technology in ceramic plant will cater for electricity supply of plant utilities and thermal energy for spray dryer. Thus reducing the plant energy consumption cost.

1.4 Baseline establishment for existing technology

1.4.1 Design and operating parameters

Natural gas consumption in spray dryer depends on the following parameters

- Slurry flow rate to spray dryer
- Moisture content in slurry
- Temperature of slurry
- Calorific value of fuel
- Combustion air flow rate
- Temperature of combustion air

Electricity requirement in the ceramic plant depends on the production. Detail of Natural gas consumption in spray dryer and electricity comsumption in vitrified tites unit is given in Table 1.11below:

Table 1.11 Natural gas and electricity consumption

S. No.	*Energy Type*	*Unit*	*Value*	
			Min	*Max*
1	Electricity	kWh/year	1,066,7340	33,512,625
2	Natural Gas	SCM/year	3,100,385	7,602,808

1.4.2 Operating efficiency analysis

Operating efficiency of the spray dryer is found to be in the range of 75 % to 83% for different types of fuels. Specific energy consumption in the spray dryer for different types of fuels is given in Table 1.12 below:

Table 1.12 Operating efficiency analysis for different fuel

S. No.	Type of Fuel	Unit	Specific Fuel Consumption	
			Min	Max
1	Natural Gas	SCM/MT	32	36
2	Charcoal	kg/MT	57	60
3	Saw Dust	kg/MT	83	111
4	Lignite	kg/MT	109	122

The operating efficiency of spray dryer is determined by indirect method. It includes the quantification of different types of losses occurred in spray dryer.

Detailed parameters and calculations used for operating efficiency evaluation of spray dryer efficiency are given in the Annexure 1.

1.5 Barriers in adoption of proposed equipment

1.5.1 Technological barrier

In Morbi cluster, overall technical understanding on ceramic manufacturing is good and rapidly increasing. Important equipments like kiln, polishing machine etc are bought from Italy (Sacmi) and China (Modena), which are leading suppliers of these equipments world wide. Many of the unit owners are frequently visiting international ceramic fairs and ceramic process equipment suppliers, thus keeping them informed. It has been observed that at cluster level there is committed interested for leadership and following up is quick. In general, there is readiness to adopt provided delivery, outcome and results are demonstrated.

However the first change is still a challenge, upon success, later on duplication and adaptation is extremely prevalent in the cluster. The technologies need to be demonstrated within the cluster. While carrying out the audits and presenting the Energy audit reports to the units, in the discussion with the plant owners & other personnel, many of them agreed with many of the

identified energy saving measures and technologies but they demanded demonstration of the energy saving technologies in any plant and thereafter they have readiness to follow.

1.5.2 Financial barrier

Availing finance is not the major issue. Among the SMEs, the larger units, if convinced are capable of either financing it themselves or get the finance from their banks. The smaller units will require competitive loan and other support to raise the loan. However as most of them have been able to expand their setup and grow, there is readiness to spend for energy efficiency technologies which have good returns. Energy Efficiency Financing Schemes such as SIDBI's, if focused on the cluster, will play a catalytic role in implementation of identified energy conservation projects & technologies.

The cluster has significant potential of co-generation through gas turbine. However though there are good returns, this project is highly capital intensive and requires support of policy as well as innovative financial mechanisms. CDM needs to be duly applied to generate additional cash flow to further improve the returns from the project.

1.5.3 Skilled manpower

In Morbi ceramic cluster, the availability of skilled manpower is one of the problems due to more number of units. One local technical persons available at Morbi takes care of about 5-10 ceramic units. Maintenance or repair work of major equipments of ceramic units like kiln, polishing machine etc, are generally taken care by the equipment suppliers itself as they station one of their experienced technical representative at Morbi for the maintenance work.

Specialized and focused training of the local service providers on better operation and maintenance of the equipments, importance of the energy and its use and energy conservation measures will improve awareness among the unit owners and workforce. Original equipment suppliers should also participate in these programs.

1.5.4 Other barrier (If any)

Many of the new technology provider's (especially some foreign technology leaders) have not shown keen interest in implementation of their new innovative technologies. This appears to be because of fear of duplication.

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2. PROPOSED EQUIPMENT FOR ENERGY EFFICENCY IMPROVEMENT

2.1 Description of proposed equipment

2.1.1 Detailed of proposed equipment

Gas turbine based co-generation technology, generates electrical energy and thermal energy at the same time by using Natural gas as a fuel. Further this thermal energy used in spray dryer for removing moisture present in raw material. For implementing this technology vitrified tiles unit has been selected, where the Natural gas is used as a fuel in spray dryer. This is because of the following reasons.

- Natural gas price is high as compared to the solid fuel.
- In spray dryer, requirement of flue gas temperature is about 550 ^{o}C
- Cogeneration technology helps to reduce the plant energy operating cost in terms of ₹ per kCal in comparison with the present cost.

Use of Gas Turbine for power generation and utilization of waste heat of turbine in spray dryer reduces total energy cost of plant. Exhaust of gas turbine is available at a temperature of about 500 to 550 ^{o}C which can fulfill the heat requirement of spray dryer. If the requirement of spray dryer does not meet completely then the additional Natural gas firing is also there. In this project, the existing system does not get disturbed and keep it up as a back up for any emergency.

For implementation of the proposed technology, separate system is provided without destroying the existing firing system of spray dryer and retrofits the same with the existing firing system.

2.1.2 Equipment/technology specification

Scince total electrical load of a typical vertifed unit is 2.8 MW hence a Gas turbine of capacity of about 3.5 MW will be required to install. Implementation of this project will include the following components like Gas turbine, sound enclosure, air supply system, control system and electrical system. Detail technical specification of Gas turnbine are furnished in Table 2.1 below:

Table 2.1 Technical specification of Gas turbine

S. No.	*Parameter*	*Detail*
1	Manufacturer	SOLAR
2	Model	Centaur 40 (T-4701)

S. No.	Parameter	Detail
3	Operation	continuous
4	Turbine design	open cycle, single shaft, cold-end drive
5	Compressor	11 stages, axial
6	Combustion chamber	annular with 10 injectors
7	Turbine	3 stage, axial-reaction
8	Turbine speed	14 951 rpm
9	Nominal shaft power rating	3 712 kW
10	Heat input	12 611 kJ/s
11	Weight approx.	3 200 kg

Further detail techinacal and other specification of Gas turbine are shown in Annexure 8.

Details of piping and ducting system for waste heat recovery are shown in Table 2.2 below:

Table 2.2 Detail design of piping and ducting system

S. No.	Parameter	Detail
1	Duct Material	MS
2	Diameter of duct	762 mm
3	Insulation Material	Glass Wool
4	Insulation thickness	75 mm
5	Aluminum cladding	22 g
6	Length of pipe	Decided on the basis of site and location

2.1.3 Integration with existing equipment

Gas Turbine based cogeneration technology generates electricity for the plant where as the hot exhaust of the gas turbine is used in spray dryer. Mostly there is no supplementary fuel

requirement in the spray dryer. This saves total spray dryer fuel cost. Over all energy cost of plant in co-generation mode is lower than the present scenario. From total natural gas input to the gas turbine 19 % of the energy in Natural gas is converted to electricity, 5% of the energy considered as heat loss and remaining energy i.e.76% goes in flue gas which is supplied to the spray dryer through piping and ducting system.

The following are the reasons for selection of this technology

- Spray dryer is one of the major thermal energy consumers in ceramic industry
- It will reduce the total operating energy cost of the plant.
- It reduces the GHG emissions
- This project is also applicable for getting the carbon credit benefits.
- It is a clean technology.

2.1.4 Superiority over existing system

Use of this technology reduces the overall plant energy cost. It also eliminates the dependency for electricity on the state electricity grid. As the Natural gas price at Morbi on decreasing trends and electricity prices on increasing trends, hence revenue generation will increases after implementation of this project and makes this project more financially feasible.

2.1.5 Source of equipment

This technology is already implemented and in operation in most of the ceramic units in India. This are running successfully and the unit owners had observed the savings in terms of rupees due to availability of natural gas at low cost.

2.1.6 Availability of technology/equipment

Suppliers of this technology are available at local level as well as at international level very easily. Even most of the suppliers took initiative and interacting with the ceramic unit owners for creating the awareness of use of this technology at ceramic industries.

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

Warranty of twelve months from issue of "Provisional Acceptance Certificate" (PAC) but not later than 18 months from "Notification of Readiness for Dispatch", if shipment, erection or Provisional Acceptance is delayed by causes beyond TURBOMACH's reasonable control. This

is provided that the installation is operated in accordance with the TURBOMACH guidelines and instructions and maintenance is performed by TURBOMACH. Further details of terms and condition are shown in Annexure 8.

2.1.9 Process down time

Process down time of spray dryer of about 10 days will be required for the installation of ducting system for waste heat recovery and 1 day full plant shutdown time will be required for electrical connections.

2.2 Life cycle assessment and risks analysis

Life of the equipment is about 20 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.
- Availability of natural gas at the required pressure

2.3 Suitable unit for Implementation of proposed technology

Suitable unit for implementation of this tehnology are vitrified unit having the production capacity of about 11,106 m^2 per day and having total electrical load of about 2.8 MW.

3. ECONOMIC BENEFITS FROM PROPOSED TECHNOLOGY

3.1 Technical benefit

3.1.1 Fuel saving

Natural gas consumption in the ceramic unit will increase after implementation of this project but it will reduce the overall plant energy consumption cost due to use of cogeneration technology. Project implementation will lead to save about 9.01 million SCM Natural gas per year but required about 11.88 million SCM Natural gas per year by Gas turbine.

3.1.2 Electricity saving

After implementation of project, unit will not require to take the electricity from the state electricity grid because Gas turbine will generate about 23.06 GWh of electricity per year while total electricity requirement in a typical vitrified unit is about 22.17 GWh per year. The electricity consumption pattern is same as in present consumption pattern but project implementation will reduce the overall energy consumption cost.

3.1.3 Improvement in product quality

Product quality achieved would be same as in the present quality. It does not have any impact on the improvement in the quality of the product.

3.1.4 Increase in production

Production will be the same as in present. Plant owner may have to increase the production in case of ceramic units using Natural gas as a fuel in spray dryer and having only one spray dryer at their plant. In ceramic unit, 2 days in a week have to shut down the spray dryer for its cleaning. But after implementation of the proposed project, this is not possible i.e. shutdown of turbine for 2 days in week because electricity are not taken from grid. Therefore, they have to install one more spray dryer as a backup in case of shutdown period for cleaning of first spray dryer. Hence indirectly increases the plant production capacity.

3.1.5 Reduction in raw material

Raw material consumption is same even after the implementation of proposed technology.

3.1.6 Reduction in other losses

There is no other reduction losses

3.2 Monetary benefits

Natural gas consumption in Gas turbine is about 11.88 million SCM per year while Natural gas saving due to utilization of waste heat from turbine is about 9.01 million SCM per year and also displaces total electricity consumption of a typical unit which is about 22.17 GWh per year. Hence total monetary benefit due to implementation of this project will be about ` 527 lakh per year. Details of energy and monetary benefit due to implementation of project are furnished in Table 3.1 below:

Table 3.1 Energy and monetary benefit

S.No	*Parameter*	*Unit*	*Value*
1	Present electricity consumption in a unit	GWh/year	22.17
2	Cost of electricity consumption	₹in lakh/year	957
3	Natural gas saving due to waste heat recovery	million SCM/year	9.01
4	Cost of Natural gas saving	₹ in lakh/year	1352
3	Natural gas consumption in Gas turbine	million SCM/year	11.88
5	Cost of Natural gas consumption in Gas turbine	₹ in lakh/year	1782
6	Total monetary benefit	₹ in lakh/year	527.45

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

3.3 Social benefits

3.3.1 Improvement in working environment

Use of cogeneration technology in ceramic industry reduces the overall emission of pollutant due to better utilization of waste heat from turbine hence improve the working environment in and near to the plant.

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 significant 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 utilization of waste heat from turbine exhaust and displacement of electricity consumption in a unit. This project results in reduction of about 14331 tCO_2 per year for a single ceramic unit. This project is also applicable to avail the carbon credit benefits through CDM project and generates the extra income.

3.4.3 Reduction in other emissions like SO_X

Significant amount of SO_X will be reducing due to generation of electricity from Natural gas based Gas turbine instead of taking electricity from coal based power plant.

4 INSTALLATION OF PROPOSED EQUIPMENT

4.1 Cost of project

4.1.1 Equipment cost

Cost of Gas turbine of capacity about 3.5 MW is ₹1325 lakh.

4.1.2 Erection, commissioning and other misc. cost

Other cost includes cost of Waste Heat Recovery ducting & diverter damper which is ₹ 80.00 lakh, erection & commissioning cost which is ₹ 50.00 lakh, civil works which is ₹ 50.00 lakh, interest during implementation which is ₹ 37.63 lakh, Custom Clearance and Transportation Charges which is ₹ 13.25 lakh, import duty which is ₹ 282.23 lakh and other misc. cost of ₹ 66.00 lakh. The total cost of implementation of the gas turbine based captive power plant is estimated at ₹ 1904.10 lakh and furnished in Table Details of total project cost requires for implementation of proposed technology are furnished in Table 4.1 below:

Table 4.1 Details of proposed technology project cost

S.No	*Particular*	*Unit*	*Value*
1	Cost of system	₹ (in lakh)	1325
2	Cost of Waste Heat Recovery ducting & diverter damper	₹ (in lakh)	80
3	Erection & Commissioning cost	₹ (in lakh)	50
4	Cost of Civil work	₹ (in lakh)	50
4	Interest during implementation	₹ (in lakh)	37.63
5	Custom Clearance and Transportation Charges	₹ (in lakh)	13.25
6	Import duty	₹ (in lakh)	282.23
4	Other misc. cost	₹ (in lakh)	66
5	Total cost	₹ (in lakh)	1904.10

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

The total cost of the proposed technology is estimated at ₹ 1904.10 lakh. The entrepreneur's contribution is 25% of total project cost, which is ₹ 476.03 lakh.

4.2.2 Loan amount.

The term loan is 75% of the total project cost, which is ₹ 1428.08 lakh.

4.2.3 Subsidy by Government

As the overall energy efficiency in the project is more than 15% it qualifies for subsidy of 25 % of the project cost as per the NMCP scheme of Ministry of MSME, GoI. 25 % of the project cost in this case works out to ₹ 476.03 lakh. As the subsidy is normally available after implementation of the project the same has not been taken in the project cost and means of finance. On receipt of subsidy from Ministry of MSME, GoI through the nodal agency the amount of subsidy is generally set off [reduced] from the loan outstanding by the lender bank. Availability of this subsidy will make the project economically more attractive.

4.2.4 Terms & conditions of loan

The interest rate is considered at 10% which is SIDBI's rate of interest for energy efficient projects. The loan tenure is 8 years excluding initial moratorium period is 6 months from the date of first disbursement of loan.

4.3 Financial indicators

4.3.1 Cash flow analysis

Profitability and cash flow statements have been worked out for a period of 9 years. The financials have been worked out on the basis of certain reasonable assumptions, which are outlined below.

The project is expected to achieve monetary savings of ₹ 326.72 lakh per.

- The Operation and Maintenance cost is estimated at 5% of cost of total project with 5% increase in every year as escalations.
- Interest on term loan is estimated at 10%.
- Depreciation is provided as per the rates provided in the companies act.

Considering the above mentioned assumptions, the net cash accruals starting with ₹ 193.05 lakh in the first year operation and gradually increases to ₹ 1051.66 lakh at the end of ninth year.

4.3.2 Simple payback period

The total project cost of the proposed technology is ₹ 1904.10 lakh and monetary savings is ₹ 527.45 lakh hence the simple payback period works out to be 3.6 years.

4.3.3 Net Present Value (NPV)

The Net present value of the investment at 10% works out to be ₹ 153.59 lakh.

4.3.4 Internal rate of return (IRR)

The after tax internal rate of return of the project works out to be 12.10%. Thus the project is financially viable.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 19.60%.

Details of financial indicator are shown in Table 4.2 below:

Table 4.2 Financial indicators of proposed technology/equipment

S.No	Particulars	Unit	Value
1	Simple Pay Back period	Month	43
2	IRR	%age	12.10
3	NPV	lakh	153.59
4	ROI	%age	19.60
5	DSCR	Ratio	1.50

4.4 Sensitivity analysis

A sensitivity analysis has been carried out to ascertain how the project financials would behave in different situations like when there is an increase in fuel savings or decrease in fuel savings. For the purpose of sensitive analysis, two following scenarios has been considered

- Optimistic scenario (Increase in fuel savings by 5%)
- Pessimistic scenario (Decrease in fuel savings by 5%)

In each scenario, other inputs are assumed as a constant. The financial indicators in each of the above situation are indicated along with standard indicators.

Details of sensitivity analysis at different scenarios are shown in Table 4.3 below:

Table 4.3 Sensitivity analysis at different scenarios

Particulars	*DSCR*	*IRR*	*ROI*	*NPV*
Normal	1.50	12.10%	19.60%	159.59
Particulars	*DSCR*	*IRR*	*ROI*	*NPV*
5% increase in fuel savings	1.58	13.43%	20.22%	253.84
5% decrease in fuel savings	1.43	10.74%	18.89%	53.33

4.5 Procurement and implementation schedule

Procurement and implementation schedule for proposed project are shown in Table 4.4 below and further details of process break down are shown in Annexure 6.

Table 4.4 Procurement and implementation schedule

S. No.	*Activities*	*Weeks*											
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
1	Foundation & civil work												
2	Erection & commissioning of the turbine set												
3	Cabling & elec-trical panel fitting												
4	Testing and trial												
5	On site operator training												

Annexure

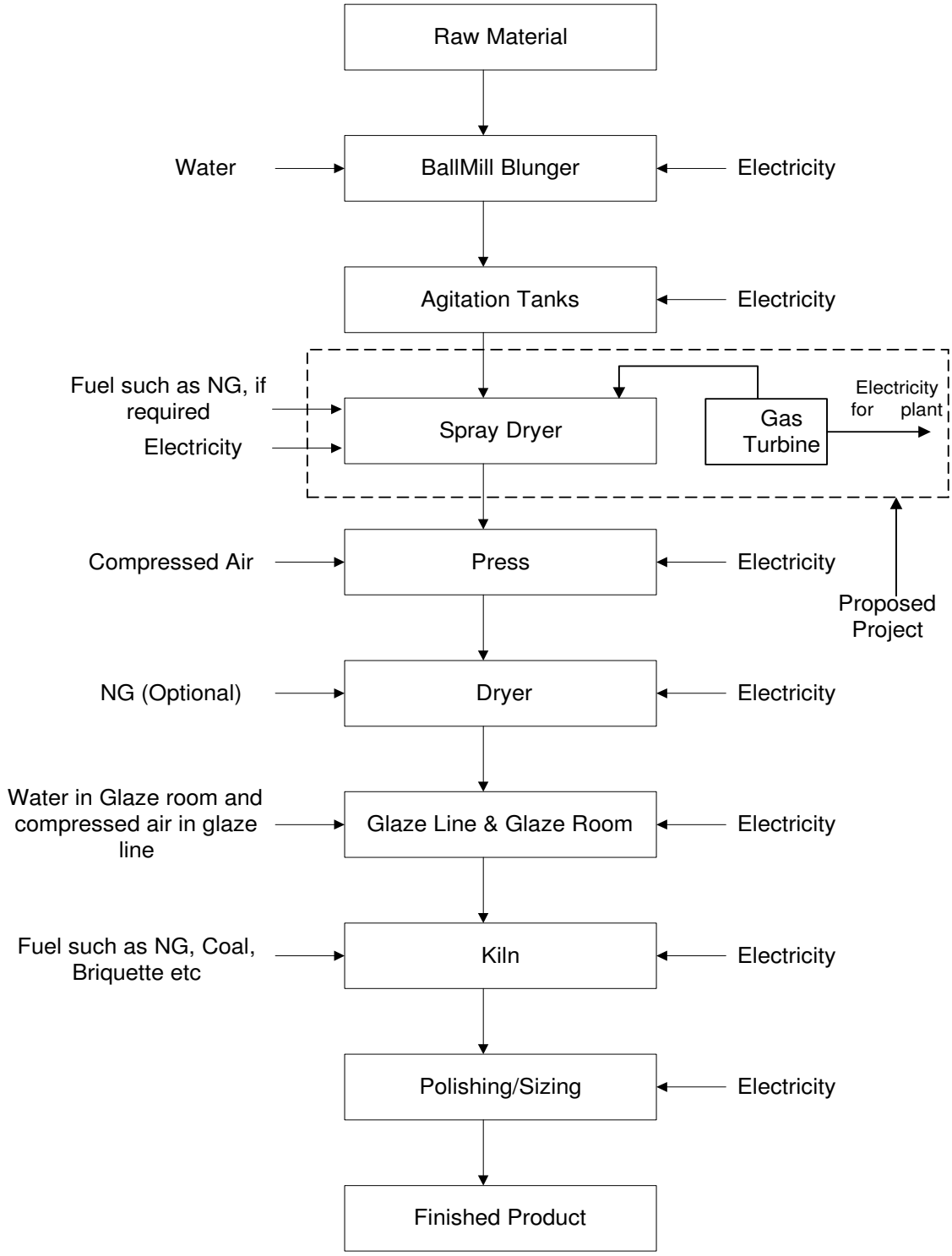
Annexure -1: Energy audit data used for baseline establishment

S. No.	Parameter	Unit	Value
1	Spray dryer Production	MT/day	420
2	Type of fuel used	-	Natural gas
3	Fuel flow rate	SCM/hr	625
4	FD flow rate	m^3/hr	27,156
5	SFD flow rate	m^3/hr	12,643
6	Density of air	kg/m^3	0.9
7	Density of Natural gas	kg/SCM	0.6
8	Moisture in slurry	%age	36.35
9	Slurry inlet temperature	^oC	35
10	Ambient temperature	^oC	40
11	Flue gas outlet temperature	^oC	90
12	Area of cylindrical part	m^2	630
13	Temperature of cylindrical part of spray dryer	^oC	73
14	Area of conical part	m^2	106
15	Temperature of conical part of spray dryer	^oC	41
16	Moisture present in fuel	%age	5
17	Hydrogen present in fuel	%age	5
18	Product temperature	^oC	54
19	Specific heat capacity of flue gas	kCal/kg ^oC	0.23
20	Specific heat capacity of product	kCal/kg ^oC	0.19

Indirect efficiency of spray dryer

S. No.	Particular	Unit	Value	%age
1	Heat loss due to dry flue gas	kCal/hr	868,657	6.5
2	Heat due to hydrogen present in fuel	kCal/hr	409,200	3.1
3	Heat loss due to radiation	kCal/hr	277,200	2.1
4	Heat loss due to moisture present in fuel	kCal/hr	454,874	0.34
5	Heat loss due to heat carried away by product	kCal/hr	62040	0.47
6	Total heat loss	kCal/hr	1,651,320	12.51
7	Efficiency of spray dryer	%age	-	87.50

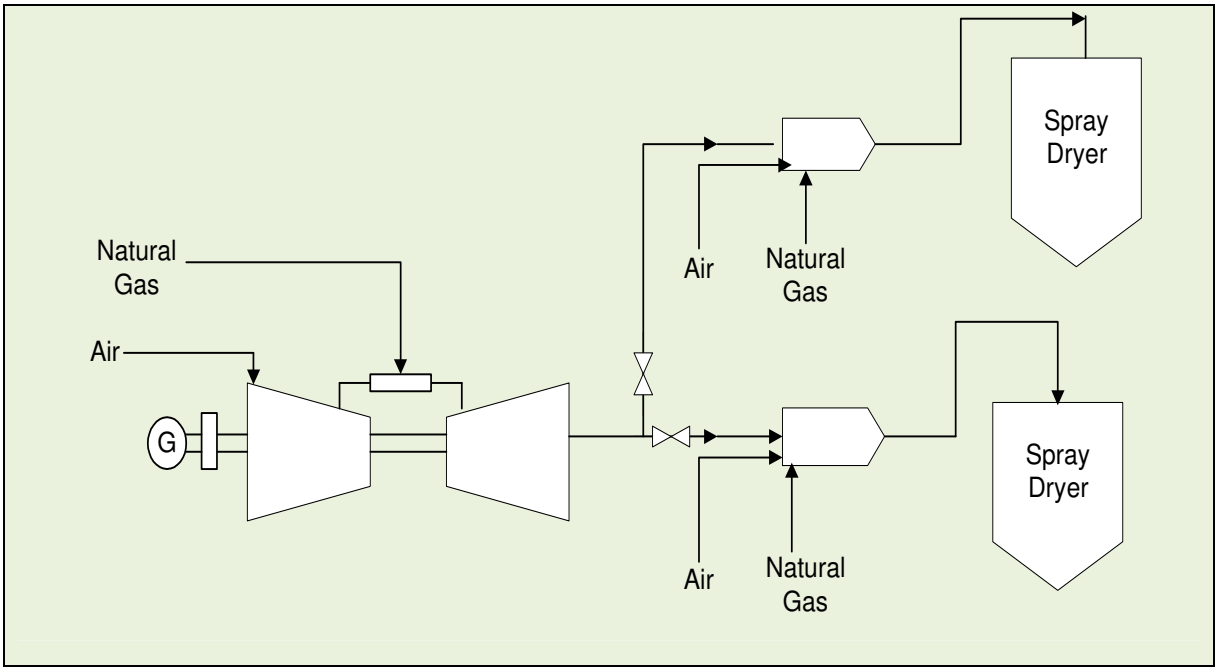
Annexure -2: Process flow diagram after project implementation



Annexure -3: Detailed technology assessment report

S.No.	Parameter	Unit	Value
1	Power Generation efficiency of Gas Turbine	%age	19
2	Heat loss efficiency	%age	5
3	Heat goes to spray dryer	%age	76
4	Calorific Value of Natural gas	kCal/SCM	8800
5	Cost of Natural Gas	₹ /SCM	15
6	Cost of Electricity	₹ /kWh	4.15
7	Plant electricity load	kW	2800
8	Auxiliary Consumption of Gas Turbine required	%age	4
9	Turbine load factor	%age	83.2
10	Total Electricity generated by Gas Turbine	kWh	2912
11	Working hours of spray dryer	hr	24
12	Working days of spray dryer in a year	days	330
13	Natural Gas required in Gas turbine for power Generation	SCM/hr	1500
14	Total Exhaust heat from Gas turbine available	kCal/hr	10,017,280
15	Equivalent natural gas saving in spray dryer due to use of exhaust of gas turbine	SCM/hr	1138
16	Natural gas consumption in Gas Turbine	SCM/year	11,880,000
17	Cost of Natural gas consumed in Gas turbine	₹ in lakh/year	1782
18	Electricity Generation from gas turbine	kWh/year	2,30,63,040
19	Equivalent cost of electricity	₹ in lakh/year	957
20	Natural gas saving in spray dryer due to use of exhaust heat	SCM/year	9,012,960
21	Equivalent saving in cost of Natural gas due to use of exhaust heat	₹ in lakh/year	1352
22	Total Saving in Rs. due to implementation of this project	₹ in lakh/year	527
23	Cost of the project implementation	₹ in lakh	1904

Annexure -4 Drawings for proposed electrical & civil works



Annexure -5: Detailed financial analysis

Assumption

Name of the Technology	***GAS TURBINE BASED COGENERATION TECHNOLOGY***		
Rated Capacity	***3.5 MW***		
Details	***Unit***	***Value***	***Basis***
Installed Capacity	MW	3.50	Feasibility Study
No of working days	Days	330	Feasibility Study
No of Shifts per day	Shifts	3	Feasibility Study
Capacity Utilization Factor	%age	82.3	Feasibility Study
Proposed Investment			
Plant & Machinery	₹ (in lakh)	1325	Feasibility Study
Cost of Waste Heat Recovery ducting & diverter damper	₹ (in lakh)	80	Feasibility Study
Erection & Commissioning	₹ (in lakh)	50	Feasibility Study
Cost of Civil work	₹ (in lakh)	50	Feasibility Study
Investment without IDC	₹ (in lakh)	1505	Feasibility Study
Interest During Implementation	₹ (in lakh)	37.63	Feasibility Study
Custom Clearance and Transportation Charges	₹ (in lakh)	13.25	Feasibility Study
Import duty	₹ (in lakh)	282.23	Feasibility Study
Other charges(Contingency)	₹ (in lakh)	66	Feasibility Study
Total Investment	₹ (in lakh)	1904.10	Feasibility Study
Financing pattern			
Own Funds (Equity)	₹ (in lakh)	476.03	Feasibility Study
Loan Funds (Term Loan)	₹ (in lakh)	1428.08	Feasibility Study
Loan Tenure	Year	8	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	102	Assumed
Interest Rate	%age	10.00	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	5.00	Feasibility Study
Annual Escalation	%age	5.00	Feasibility Study
Estimation of Revenue			
Electricity saving	kWh/year	23063040	
Fuel saving due waste heat utilization	SCM/year	9015551	
Fuel consumption in Gas turbine	SCM/year	11880000	
Cost of electricity	₹ / kWh	4.15	
Cost of Natural gas	₹ / SCM	15	
St. line Depn.	%age	5.28	Indian Companies Act
IT Depreciation	%age	8.24	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	1428.08	72.00	1356.08	129.58
2	1356.08	156.00	1200.08	128.50
3	1200.08	168.00	1032.08	112.36
4	1032.08	174.00	858.08	95.28
5	858.08	180.00	678.08	77.80
6	678.08	186.00	492.08	59.34
7	492.08	192.00	300.08	40.93
8	300.08	198.00	102.08	21.33
9	102.08	102.08	0.00	3.09
		1428.08		

WDV Depreciation

Particulars / years	1	2	3	4	5	6	7	8	9
Plant and Machinery									
Cost	1,904.10	1,747.20	1,603.23	1,471.13	1,349.91	1,238.67	1,136.61	1,042.95	957.01
Depreciation	156.90	143.97	132.11	121.22	111.23	102.07	93.66	85.94	78.86
WDV	1,747.20	1,603.23	1,471.13	1,349.91	1,238.67	1,136.61	1,042.95	957.01	878.15

Projected Profitability

Particulars / Years	1	2	3	4	5	6	7	8	9
Revenue through Savings									
Fuel savings	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45
Total Revenue (A)	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45
Expenses									
O & M Expenses	77.13	80.99	85.04	89.29	93.75	98.44	103.36	108.53	113.96
Total Expenses (B)	77.13	80.99	85.04	89.29	93.75	98.44	103.36	108.53	113.96
PBDIT (A)-(B)	450.32	446.46	442.41	438.16	433.70	429.01	424.09	418.92	413.49
Interest	129.58	128.50	112.36	95.28	77.80	59.34	40.93	21.33	3.09
PBDT	320.74	317.96	330.06	342.88	355.90	369.67	383.16	397.58	410.40
Depreciation	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45
PBT	239.29	236.51	248.61	261.43	274.45	288.22	301.70	316.13	328.95
Income tax	55.69	59.14	67.28	75.34	83.16	90.96	98.40	105.93	112.69
Profit after tax (PAT)	183.60	177.37	181.32	186.09	191.28	197.26	203.30	210.20	216.26

Computation of Tax ***₹ (in lakh)***

Particulars / Years	1	2	3	4	5	6	7	8	9
Profit before tax	239.29	236.51	248.61	261.43	274.45	288.22	301.70	316.13	328.95
Add: Book depreciation	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45
Less: WDV depreciation	156.90	143.97	132.11	121.22	111.23	102.07	93.66	85.94	78.86
Taxable profit	163.84	173.99	197.95	221.66	244.66	267.61	289.50	311.64	331.54
Income Tax	55.69	59.14	67.28	75.34	83.16	90.96	98.40	105.93	112.69

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

Particulars / Years	1	2	3	4	5	6	7	8	9
Liabilities									
Share Capital (D)	476.03	476.03	476.03	476.03	476.03	476.03	476.03	476.03	476.03
Reserves & Surplus (E)	183.60	360.97	542.29	728.38	919.66	1,116.92	1,320.23	1,530.43	1,746.69
Term Loans (F)	1356.08	1200.08	1032.08	858.08	678.08	492.08	300.08	102.08	0.00
Total Liabilities D)+(E)+(F)	2015.70	2037.07	2050.39	2062.48	2073.76	2085.02	2096.33	2108.53	2222.71
Assets									
Gross Fixed Assets	1904.10	1904.10	1904.10	1904.10	1904.10	1904.10	1904.10	1904.10	1904.10
Less: Accm. Depreciation	81.45	162.90	244.35	325.80	407.25	488.70	570.15	651.60	733.06
Net Fixed Assets	1822.65	1741.20	1659.75	1578.30	1496.85	1415.40	1333.95	1252.50	1171.04
Cash & Bank Balance	193.05	295.87	390.64	484.18	576.91	669.63	762.38	856.04	1051.66
TOTAL ASSETS	2015.70	2037.07	2050.39	2062.48	2073.76	2085.02	2096.33	2108.53	2222.71
Net Worth	659.62	836.99	1018.31	1204.40	1395.68	1592.95	1796.25	2006.46	2222.71
Dept equity ratio	2.06	1.43	1.01	0.71	0.49	0.31	0.17	0.05	0.00

Projected Cash Flow: ***₹ (in lakh)***

Particulars / Years	0	1	2	3	4	5	6	7	8	9
Sources										
Share Capital	476.03	-	-	-	-	-	-	-	-	-
Term Loan	1428.08									
Profit After tax		183.60	177.37	181.32	186.09	191.28	197.26	203.30	210.20	216.26
Depreciation		81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45
Total Sources	1904.10	265.05	258.82	262.77	267.54	272.74	278.71	284.75	291.66	297.71
Application										
Capital Expenditure	1904.10									
Repayment of Loan	-	72.00	156.00	168.00	174.00	180.00	186.00	192.00	198.00	102.08
Total Application	1904.10	72.00	156.00	168.00	174.00	180.00	186.00	192.00	198.00	102.08
Net Surplus	-	193.05	102.82	94.77	93.54	92.74	92.71	92.75	93.66	195.63
Add: Opening Balance	-	-	193.05	295.87	390.64	484.18	576.91	669.63	762.38	856.04
Closing Balance	-	193.05	295.87	390.64	484.18	576.91	669.63	762.38	856.04	1051.66

Calculation of Internal Rate of Return ***₹ (in lakh)***

Particulars / months	0	1	2	3	4	5	6	7	8	9
Profit after Tax		183.60	177.37	181.32	186.09	191.28	197.26	203.30	210.20	216.26
Depreciation		81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45
Interest on Term Loan		129.58	128.50	112.36	95.28	77.80	59.34	40.93	21.33	3.09
Salvage/Realizabl										

e value										
Cash outflow	(1,904.10)	-	-	-	-	-	-	-	-	-
Net Cash flow	(1,904.10)	394.63	387.32	375.13	362.82	350.53	338.05	325.68	312.99	300.80
IRR	12.10%									
NPV	153.59									

Break Even Point ***₹ (in lakh)***

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***
Variable Expenses									
Oper. & Maintenance Exp (75%)	57.85	60.74	63.78	66.97	70.32	73.83	77.52	81.40	85.47
Sub Total (G)	57.85	60.74	63.78	66.97	70.32	73.83	77.52	81.40	85.47
Fixed Expenses									
Oper. & Maintenance Exp (25%)	19.28	20.25	21.26	22.32	23.44	24.61	25.84	27.13	28.49
Interest on Term Loan	129.58	128.50	112.36	95.28	77.80	59.34	40.93	21.33	3.09
Depreciation *(H)*	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45
Sub Total (I)	230.31	230.20	215.07	199.06	182.69	165.40	148.22	129.92	113.03
Sales (J)	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45	527.45
Contribution (K)	469.60	466.71	463.67	460.48	457.13	453.62	449.93	446.05	441.98
Break Even Point (L= G/I)	49.04%	49.32%	46.38%	43.23%	39.96%	36.46%	32.94%	29.13%	25.57%
Cash Break Even {(I)-(H)}	31.70%	31.87%	28.82%	25.54%	22.15%	18.51%	14.84%	10.87%	7.15%
Break Even Sales (J)*(L)	258.69	260.16	244.65	228.00	210.79	192.32	173.76	153.63	134.89

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

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***Total***
Net Profit Before Taxes	239.29	236.51	248.61	261.43	274.45	288.22	301.70	316.13	328.95	2495.28
Net Worth	659.62	836.99	1018.31	1204.40	1395.68	1592.95	1796.25	2006.46	2222.71	2733.38
										19.60

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

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***Total***
Cash Inflow										
Profit after Tax	183.60	177.37	181.32	186.09	191.28	197.26	203.30	210.20	216.26	1746.69
Depreciation	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	81.45	733.06
Interest on Term Loan	129.58	128.50	112.36	95.28	77.80	59.34	40.93	21.33	3.09	668.21
TOTAL (M)	394.63	387.32	375.13	362.82	350.53	338.05	325.68	312.99	300.80	3147.95

Debt

Interest on Term Loan	129.58	128.50	112.36	95.28	77.80	59.34	40.93	21.33	3.09	668.21
Repayment of Term Loan	72.00	156.00	168.00	174.00	180.00	186.00	192.00	198.00	102.08	1428.08
TOTAL (N)	201.58	284.50	280.36	269.28	257.80	245.34	232.93	219.33	105.17	2096.29
Average DSCR (M/N)	1.50									

Annexure:-6 Procurement and implementation schedule

Break up of shutdown period of plant required for Operation of turbine

S.No	Activity	Day
		1
1	Electrical connections to the plant from turbine	

Day wise break up of shut down period of Spray dryer

S.No	Activity	Day									
		1	2	3	4	5	6	7	8	9	10
1	Cooling of spray dryer										
2	Dismantling of existing pipeline										
3	New ducting & piping arrangement for spray dryer										
4	Connection & fitting										
5	Pipe & Duct Insulation										
6	Instrumentations and trial										

Annexure -7: Details of technology service providers

S.No.	Name of Service Provider	Address	Contact Person and No.
1	Triveni Engineering & Industries Ltd	12-A Peenya Industrial Area, Peenya, Banglore-560058	Mr. Arun Mote 080-22164000 / 28391624 / 28394721 mktg@tbg.trivenigroup.com
2	Shri vishwkarama engineering	Plot no. 69, G block gali no.08, faridabad-121008, Haryana	Mr. s vishwkarama +91-0129-2229705 vishwkarma_sen@yahoo.co.in
3	Turbo tech precision engineering Ltd.	Survey no. 8/2 Honnasandra village, Kasaba Hobli, Nelamangala Tuluk Bangalore -560044	Mr. Aradhya Nanjundaiah - 080-27723097

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

Turbomach
A Caterpillar Company

Website : www.turbomach.com
e-mail : pradeep_yadav@turbomach.com

TURBOMACH INDIA PVT. LTD.
5 & 6 Papa Industrial Estate
Suren Road, Andheri East,
Mumbai 400 093.
Telephone no.: 022 40 425 431 (D)
: 022 40 425 425
Fax no. : 022 40 425 400

Ref.: 10/SEE-Tech/90.410

Date : 08 April, 2010.

SEE-Tech Solutions Pvt. Ltd.
11/5, Lets Conserve, MIDC InfoTech Park,
Near VRCE Telephone Exchange,
South Ambazari Road,
Nagpur-440 022 (India)

Kind Attn.: **Ms. Monika Chaudhari - Manager :Projects**

Sub.: Gas Turbine based Co-Gen Captive Power Plant – 3.5 MW (ISO)

Ref : Morbi Project.

Dear Madam,

This is with reference to your valuable enquiry. Based on the discussions and in line to the details furnished to us, we are pleased to submit our techno-commercial proposal for Gas turbine based captive power plant for 3.5 MW (ISO)

We, TURBOMACH is a well established name in the world power market since last 25 years. **TURBOMACH is a Swiss company founded in 1979 and group company of CATERPILLAR, USA.** We have our expertise in technical design, applications engineering, manufacturing power plants based on advanced technology, Gas and Steam turbines. **We undertake complete turnkey jobs from design to operation and maintenance, providing power, heating systems & air-conditioning systems.**

We firmly believe in providing the latest technology for producing ecofriendly energy, more reliably and efficiently. The Gas turbine package is integrated seamlessly with utilization of exhaust heat for further power generation or meeting other heating or chilling load requirements. This ensures a total co-generation efficiency of upto 85%.

Turbomach

A Caterpillar Company

In India, since 1998, we have our well equipped engineering, project management, after sales support and sales team. **We have executed around 28 nos turnkey projects** and they are operating successfully giving constant quality power alongwith waste heat utilization, ensuring thermal efficiency of upto 85%.

Our reputed turnkey job customer's in India are Maruti Udyog, Garden Silk Mills, JBF, Welspun, Alok Textiles, S Kumars, Colourtex, GFL, Century, HR Johnson, Nitco Tiles and many more.

In India, more than 135 nos Gas turbine (Solar) working successfully in various sectors including Oil & Gas. World-wide more than 13,500 nos of turbines in operation.

Hope the enclosed proposal is in line to your requirement and will meet your approval. Should require any further details, please write to or call the undersigned.

Looking forward to associate ourself in meeting your uninterrupted power needs. Please confirm your availability for further discussion on this proposal and to take it further.

Thanking you and assuring you of our best attention always, we are

Yours truly,
For **TURBOMACH INDIA PVT. LIMITED**

Pradeep Yadav
Sales Manager, India

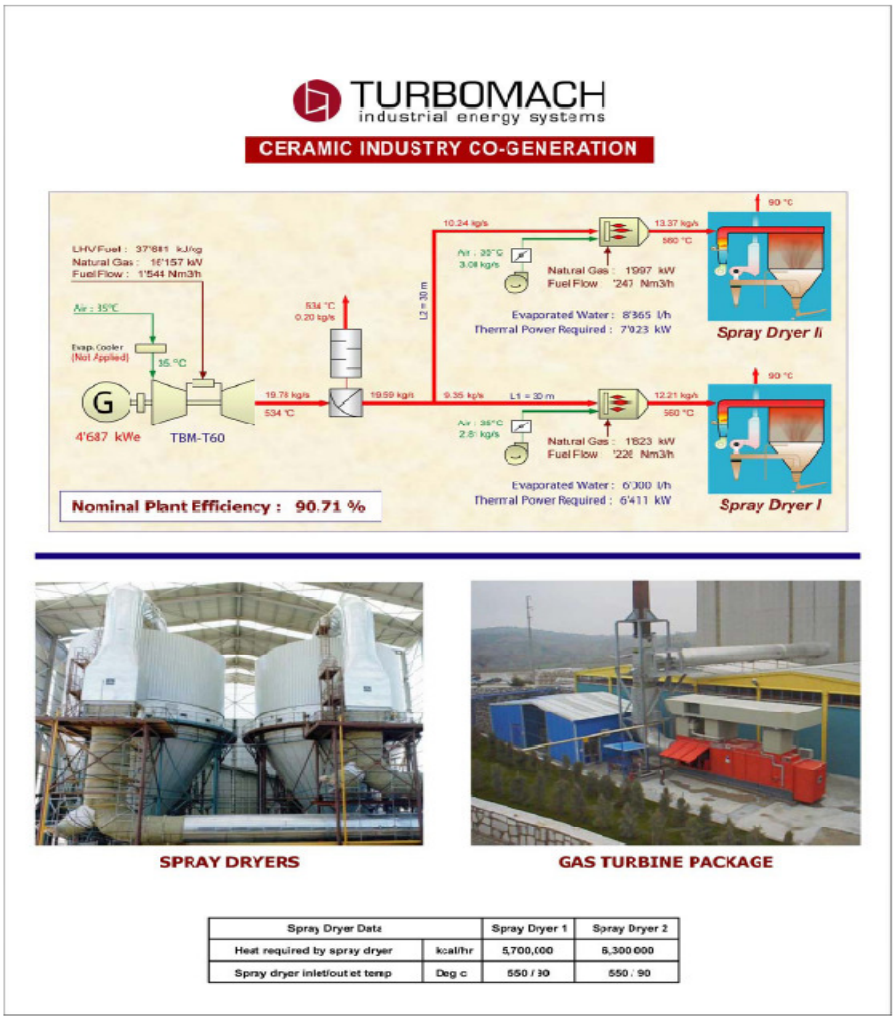
Mobile no.: **9833491235**
e-mail : pradeep_yadav@turbomach.com

ENCLS :

1. **Techno-commercial offer with terms and conditions.**

GAS TURBINE CO-GENERATION SYSTEMS FOR CERAMIC INDUSTRY

TURBOMACH HAS INSTALLED GAS TURBINE CO-GENERATION SYSTEMS AT MORE THAN 60 CERAMIC INDUSTRIES . ONE SUCH SCHEME AS FOLLOWS :



SPRAY DRYERS

GAS TURBINE PACKAGE

Spray Dryer Data		Spray Dryer 1	Spray Dryer 2
Heat required by spray dryer	kcal/hr	5,700,000	5,300 000
Spray dryer inlet/out et temp	Deg c	550 / 30	550 / 90

Project : SEE-Tech Solutions Pvt. Ltd.
Type : TBM-C40
Offer No. : 90.410 Rev. No. :
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Project	:	SEE-Tech Solutions Pvt. Ltd.		
Type	:	TBM C40		
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Date	:	06.04.10	Rev. Date	:

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SCOPE OF SUPPLY

The equipment, works and services listed below are included in our scope of supply. They are further described under the corresponding item number.

Item	Quantity	Description
1	1	3.5 MW Gas Turbine Generator Set
2	1	Sound Enclosure
3	1	Air Supply System
4	1	Control System
5	1	Electrical System
6	1	Fire Detection and Extinguishing Equipment
7		Services

Note: The gas turbine generator set is completely factory assembled, wired, pre-tested and delivered to site as one transport unit, excluding the air supply system, which is delivered pre-assembled as a separate transport unit.

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BUDGET PRICE

Our Budget Price as stated below, is based on the Scope of Supply, the Terms and Conditions, the Limits of Supply and the Exclusions as specified in the present budget offer, and amounts to:

PRICE

SUPPLY **– GAS TURBINE (1 no.) MODEL C40, GAS FIRED**	**US$**	**2,650,000-**
SERVICES	**US$**	**1,00,000-**

TURBOMACH S.A. **Riazzino, 08.04.2010**

Area Sales Manager

Project	:	SEE-Tech Solutions Pvt. Ltd.		
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TERMS AND CONDITIONS

General	Arrangements, dimensions and drawings appearing in our budget offer are to be understood as preliminary only and might be modified during the detail engineering phase, in order to optimise our design. We reserve the right to select our nominated sub-suppliers.
Warranty Period	Twelve months from issue of "Provisional Acceptance Certificate" (PAC) but not later than 18 months from "Notification of Readiness for Dispatch", if shipment, erection or Provisional Acceptance is delayed by causes beyond TURBOMACH's reasonable control. This is provided that the installation is operated in accordance with the TURBOMACH guidelines and instructions and maintenance is performed by TURBOMACH.
Prices	The offered price has to be understood as budget price in US Dollar (USD) The Price is subject to change up to contract signature, based on the exchange rate of the offered currencies to US Dollar (USD), Swiss Franc (CHF) and Euro (EUR). Any and all taxes, duties and fees, levied in the country of installation, are excluded.
Delivery Time	10 months Ex-Works after Effective Date of the contract and clarification of all technical and commercial details.

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Offer Validity

This budget offer is valid for 01 month, counted from issuing date.

Terms of Payment

20 % of the Contract price as advance payment not later than 30 days after Contract signature against signed commercial invoice and Advance Payment Bank Guarantee of same amount as per Attachment 1.3. This guarantee having a validity until "Ex works delivery", however, not later than the delivery of the major components plus 1 (one) month and becomes valid upon receipt of the down payment.

80 % out of a Letter of Credit (L/C) that must be irrevocable, confirmed, in accordance with the UPC 500 terms, allowing partial shipments, and acceptable to the supplier.
The L/C must be opened via a first class Indian bank to a Supplier's named bank. The L/C must be available and payable at sight at the confirming bank, and must have a validity of 1 month after the contractual date for last payment.
The costs of the opening bank, and the cost for the confirmation of the L/C shall be borne by the Buyer, whereas all other L/C cost of the Supplier's bank will be borne by Supplier.
The L/C shall be opened at the latest within 30 days after contract signature, and its wording must be agreed between Buyer and Supplier before opening.
Should the L/C not be opened within the time frame above mentioned, the Supplier reserves the right to delay its activities, to charge default interest and/or to terminate the Contract in accordance with the relevant provisions of the Contract.
If any L/C amendment is required, the cost of such amendment shall be borne by the Buyer.

TURBOMACH S.A. **Riazzino, 08.04.2010**

Area Sales Manager

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TECHNICAL DESCRIPTION

3.5 MW GAS TURBINE GENERATOR SET
TBM-C40

consisting of:

1 GAS TURBINE GENERATOR SET

1.1 Industrial Gas Turbine

for gas fuel and liquid fuel operation, with electronic governor.

• manufacturer	SOLAR
• model	Centaur 40 (T-4701)
• operation	continuous
• turbine design	open cycle, single shaft, cold-end drive
• compressor	11 stages, axial
• combustion chamber	annular with 10 injectors
• turbine	3 stage, axial-reaction
• turbine speed	14 951 rpm
• nominal shaft power rating	3 712 kW
• heat input	12 611 kJ/s
• Weight approx.	3 200 kg

All performance data at ISO conditions

1.2 Reduction Gear

The reduction gear box transmits the power from the gas turbine to the electrical generator. It is directly flanged to the gas turbine.

• design	epicyclic, 2 stage
• rated output speed	1 500 rpm
• Weight approx.	1 400 kg

1.3 Coupling

The coupling connects the gearbox output shaft with the generator. Mechanical fuses protect the gas turbine and the reduction gear from torque overload e.g. from mal-syncronisation.

• type	curved tooth coupling
• mechanical fuse	shearing pins
• Weight approx.	200 kg

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1.4 Synchronous Generator

• type	brushless
• voltage	11 kV ± 5%
• power rating	4 500 kVA
• efficiency at full load p.f.= 0.8	96.3 %
• insulation class	H
• temperature rise class	F
• protection class	IP 21
• cooling	air self-ventilated
• Weight approx.	9.5 t

1.5 Starting System

For starting the gas turbine an electro-hydraulic start system is provided

• prime mover	AC electric motor
• nominal power	90 kW
• nominal voltage	400 V
• hydraulic pump	variable displacement, high pressure
• hydraulic starting motor	variable displacement, high pressure
• high pressure piping	

1.5.1 Gas Fuel System

The gas fuel system is designed to operate on Natural Gas and comprises mainly:

- Fuel gas protection filter
- Main gas fuel control valve
- Gas pressure switches
- Main gas manifold
- Vent valve , switches and gauges
- Gas leakage detection

The required gas pressure at gas filter inlet is between 1 350 and 2 000 kPa(g)

1.6 Lubrication System

The lubrication system supplies clean and filtered oil at required temperature and pressure to the turbine, reduction gear and the generator. It consists of:

- 1 000 litre capacity oil tank, integrated into the skid base
- Duplex cartridge filter, valves and indicators
- engine driven main lube oil pump
- DC pre-post lube-oil pump
- Electrostatic lube oil mist separator
- Oil tank ventilation

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1.7 Water Wash System

For turbine compressor cleaning on crank or on-line operation, based on direct injection into the air inlet manifold of a water-detergent mixture.
It consists mainly of:

- Distribution piping with spray-nozzles for on line operation
- portable hand lance with spray-nozzle for crank washing
- Portable water tank
- Portable water pump

1.8 Base Frame

The above mentioned components are mounted on the base frame, made of welded steel profiles, completely hermetic, with integrated lube oil tank.
Flanges and nozzles for the customer's connection are grouped together at the front end of the base frame.

1.9 Spring Dampers

Six disk spring dampers are placed between the base frame and the flat concrete foundation, in order to:

- Isolate the gas turbine package from the foundation avoiding vibration transfer
- Allow simple foundation construction
- Allow levelling of the gas turbine package in case of slightly uneven foundation.

2 SOUND ENCLOSURE

The turbine and driven equipment, with the control system, are housed in a insulated and sound attenuated enclosure suitable for indoor installation.The sound attenuating equipment is designed for a residual sound pressure level of 85 dB (A) at 1 m, under free-field conditions, including:

- Sound proofing enclosure
- Internal sound attenuating wall to separate the gas turbine generator set compartment from the control system compartment
- Side doors for easy maintenance

Overall dimensions of sound attenuating enclosure:	L	= 10 000	mm
	H	= 3 390	mm
	W	= 2 200	mm
Total weight of genset approx.:		32	t

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3 AIR FILTRATION SYSTEM

The standard gas turbine generator air filtration system is designed wheatherproof and is located on top of the sound attenuating enclosure.

The air filter module is divided into two sections; one supplying combustion air to the gas turbine air intake manifold, the other one supplying cooling air to the sound attenuating enclosure.

The filter housing is made of welded metal sheets, reinforced by steel structure, and thus forming a rigid and self-supporting structure, internally cladded with mineral wool, and divided into two separate compartments. Normally it is bolted directly to the top of the sound proofing enclosure.

The filtration system consists of :

- Combustion air filtration system
- Enclosure ventilation air filtration system
- Combustion air intake system with silencers
- Generator and enclosure ventilation air inlet and outlet with silencers and louvers
- Compressed air filter cleaning system
- Lube-oil cooling system, as described with the lubrication system

3.1 Combustion Air Filtration System

The combustion air filtration system is a two stage filter, with a pre filter installed in front of the main filters. The pre-filter with a quick exchange system allows the exchange of the pre-filter while the engine is running.

- Pre-filter fleece
- Cassette type main filters

3.2 Ventilation Air Filtration System

The installed filters are of pocket type, depth loading filter elements. They are of synthetic fibres, processed to wedge-shaped filter bags, securely mounted to U-shaped profile frames. Spacers ensure depth utilisation of the bags for good dust-holding capacity. The filtration degree corresponds to G3.

3.3 Combustion Air Intake System

The combustion air intake equipment is installed between the air combustion filtration system and the enclosure.

- Turbine air intake duct
- Turbine air intake silencer

3.4 Enclosure Ventilation System

The enclosure ventilation system provides for cooling and safe operation of the components.

- Ventilation air intake duct with silencer and fans
- Ventilation air outlet duct with silencer and extraction fans
- Air shutters to sealing the enclosure against ambient air

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4 CONTROL SYSTEM

The turbine control system is installed in a control panel located at the generator end of the package in a compartment completely separated (sealed gas tight) from the gas turbine. All cables between the control panel and the field instruments are pulled, connected and tested in our workshop.

4.1 "TUMATRONIC S3" Turbine Control System

The control system is operating with: Backup failsafe PLC, PC "Real Time", PC HMI with touch screen TFT and Profibus acquisition modules.

The following components are installed in the two PC racks:

- Pentium CPU with CD ROM, floppy and hard disk drive as operator interface
- Pentium CPU with floppy and compact flash memory as control PC
- Ethernet communication between these CPUs
- Ethernet communication with desktop PC
- Driver card for TFT touch screen display

4.2 Generator Control, Synchronising & Auxiliary System

The generator control system is installed in the same panel as the turbine control system. This enables a fast and safe communication between these two systems.

The generator and protection panel includes:

- Generator measure transmitter
- Generator protections
- SPM synchroniser
- Generator voltage regulation (AVR)
- Vibration monitor
- Gas leakage monitor
- Cos-phi card

4.3 Control System Interface

The signal exchange between the TURBOMACH control system and other components of the plant (i.e. waste heat recovery boiler, medium voltage substation etc.) is provided using potential free contacts.

The standard connection with high-level supervisory control systems (DCS, SCADA, ecc.), is provided using Modbus over serial (hardware interface RS 232 or 485) or Ethernet and OPC over Ethernet. All available data will be transmitted as raw data, the data processing are excluded.

The system includes:

- Desktop remote PC
  The PC supplied is usually installed in the customer control room and communicates with the gas turbine control system through Ethernet (TCP/IP).
- Client Supervision Control System Interface

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4.4 Remote Monitoring & Diagnostic System RM&DS
(Active only during warranty period)

The system includes:

- IIM: (Insight Interface Module) A communication box located on site and passively connected to the package for data acquisition via OPC.
- Remote Monitoring Server: Server PC, passively connected to the site's IIM, installed In TBM head quarter that is the primary system for configuration, management and acquisition.
- TSAT: (Turbomach Satellite Network), fully private communication network, based on satellite technology, used to interconnect Turbomach's Remote Service centre network to plants' local networks.

4.5 Control Cabling

The control cables are designed for 60°C max. ambient temperature. Control cabling outside the enclosure to the remote control PC is limited to 15 m length.

5 ELECTRICAL SYSTEM

The AC and DC supply systems are installed in a compartment within the package, separated (gas tight) from the turbine area with a sound-absorbing panel, together with the control cubicles.

5.1 Power Supply

The Power Supply includes mainly:

- AC supply system 400 / 230 V
- 24V/DC supply system with batteries and battery charger

5.2 Electrical Cabling

All cables between the power supply panel and the electrical consumers in the package are pulled, connected and tested in our workshop.

The electrical cables installed inside of the sound attenuating enclosure are self extinguishing in case of fire and do not produce hazardous gases or smoke.

6 FIRE DETECTION AND EXTINGUISHING SYSTEM

The fire detection and extinguishing equipment is installed to protect equipment against fires inside the gas turbine enclosure. The CO2 extinguishing system is released automatically by the fire detection system or manually by a push-button installed outside of the enclosure. The fire detection system includes a battery and is thus independent of the AC power supply. Battery and control unit are installed in the control cubicle .

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7 SERVICES

The following services are included in our supply:

- Gas turbine generator set test
- Technical documentation
- On-site operator training
- Supervision of erection
- Commissioning

* Unloading of the gas turbine generator set and setting onto the foundation is excluded.

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8 ON-SITE NOMINAL PERFORMANCES

Site conditions

- Altitude 20 m. a. s. l.
- Inlet duct pressure loss 75 mm H_2O
- Exhaust duct pressure loss 250 mm H_2O
- Relative humidity 60 %

Fuel

- Type natural gas
- Lower heating value 47 940 kJ/kg

The fuel must fulfil the requirements of Solar fuel specification "Fuel, Air and Water (or steam) for Solar Gas Turbine Engines", ES 9-98, whereby the Gas temperature at least 28°C above the dew point of the gas at the GT package inlet flange.

Nominal Performance

Load	%	100
Engine inlet temperature	°C	35
Generator output power	kW	2895
Heat rate	kJ/kWh	14012
Exhaust gas flow	kg/s	17.34
Exhaust gas temperature	°C	459

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LIMIT OF SUPPLY

TURBOMACH's supply is limited to the following terminal points:

MECHANICAL EQUIPMENT

Gas fuel	Gas fuel inlet flange on gas turbine base skid Gas vent line outlet on gas turbine base skid
Combustion air	Air filter system inlet
Cooling air	Cooling air filter system inlet Cooling air outlet
Cooling water	Inlet/outlet flanges at lube oil coolers Inlet/outlet flanges on generator coolers
Lubricating oil	Oil tank filling plug
Wash water	Water tank filling plug
Instrument air	Inlet flange on gas turbine base skid Inlet flange on self-cleaning air filter system
Exhaust gas	Outlet flange of Gas Turbine
Waste water	Outlet flanges on gas turbine base skid

ELECTRICAL EQUIPMENT

MV Power	Generator terminals
400 V Power	Inlet terminals of AC/DC supply panel
Control Cables	Terminal boards of TBM control cubicles plus 15 m control cable to remote PC

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EXCLUSIONS

TURBOMACH's supply does not include the following equipment, works and services:

- Any and all civil works, above and below ground
- External cabling up to/from specified limits of supply
- External piping up to/from limits of supply
- Fuel regulating and metering station
- Mechanical erection, local connections and interconnecting piping (supervision will be provided by Turbomach)
- Electrical erection, local connections and external electrical wiring (supervision will be provided by Turbomach)
- Cranes, hoists and scaffoldings for erection and installation
- Unloading at site and setting on foundations
- Fuels, electricity, water and other utilities for erection, commissioning and tests
- Welding and welding consumables on site
- Site facilities, i.e., office/sanitary/storage rooms etc.
- Potable water supply, drainage or sewage systems
- External lighting, lightning and earthing
- Site preparation, waste removal, preparation of access roads etc.
- Spare parts and consumables
- First lube oil filling
- All taxes, duties and fees, levied in the country of installation, custom clearance
- Local permits and authorities approvals
- Deviations from our codes and standards

Others marked as option or not listed and/or described in the scope of supply.

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Websites: www.bee-india.nic.in, www.energymanagertraining.com

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Website: www.letsconserve.org

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