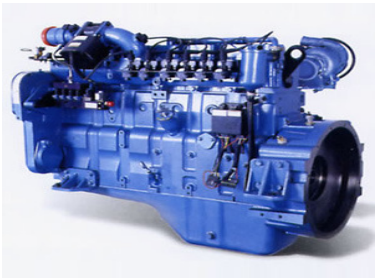
DETAILED PROJECT REPORT
ON
GAS ENGINE BASED
CO-GENERATION TECHNOLOGY
(MORBI CERAMIC CLUSTER)











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GAS ENGINE BASED
CO-GENERATION TECHNOLOGY

MORBI CERAMIC CLUSTER

BEE, 2010
Detailed Project Report on Gas Engine Based Co-generation Technology (2.72 MW)
Ceramic SME Cluster, Morbi, Gujarat (India)
New Delhi: Bureau of Energy Efficiency;
Detail Project Report No.: **MRV/CRM/GEG/08**

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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.

Contents

List of Annexure

List of Table

List of Figures

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
MW	Mega Watt
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 Engine based co-generation technology for power generation and utilization of waste heat from Engine in spray dryer. Gas Engine based co-generation technology, generates electrical energy and thermal energy at the same time by using Natural gas as a fuel. Exhaust heat from Gas Engine is released in two ways first through engine exhaust at temperature of 350 to 400^{O}C and second through engine cooling heat exchanger at a temperature of 75 to 80^{O}C. Hence in order to fully utilize of waste heat, hot water from engine cooling can be used as preheating of engine combustion air which will further increase the efficiency of Gas Engine and exhaust gas of engine can be used as a heat source for 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

S.No	Particular	Unit	Value
5	Simple payback period	years	3.6
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.

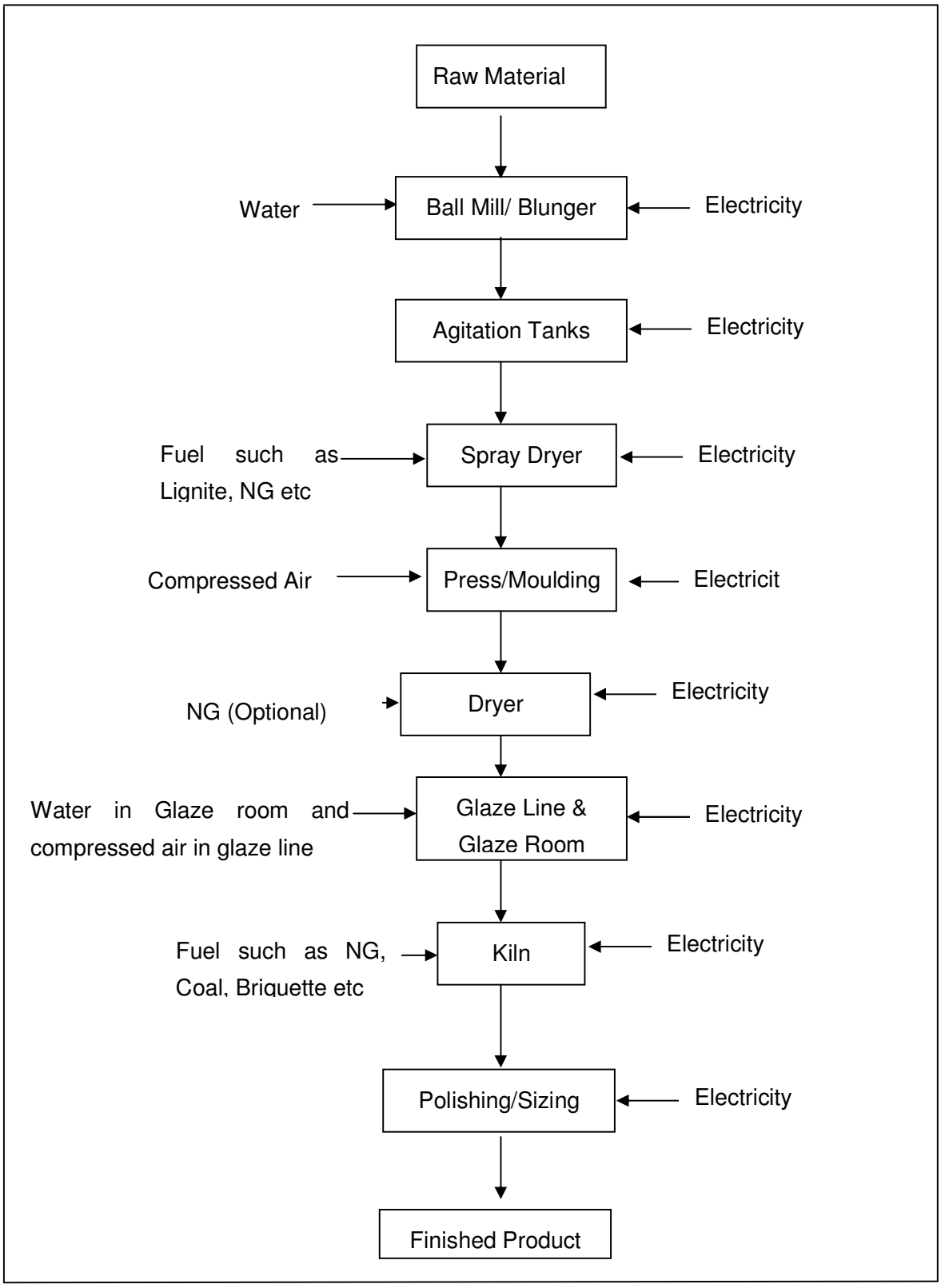

Figure 1.1Process flow diagram

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 1.6 below:

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.
Material of		SS304, SS316, SS316, SS410, SS310,

Components	Different parts	Detail
construction		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

Sr. 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	10667340	33512625
2	Natural Gas	SCM/year	3100385	7602808

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 Engine 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 Engine for power generation and utilization of waste heat of turbine in spray dryer reduces total energy cost of plant. In Gujarat use of Natural gas based engine has spread very fast for co-generation. In case of Natural gas based Gas Engine waste heat is released in two ways first through engine exhaust at temperature of 350 to 400^{O}C and second through engine cooling heat exchanger at a temperature of 75 to 80^{O}C. Hence in order to fully utilize of waste heat, hot water from engine cooling can be used as preheating of engine combustion air which will further increase the efficiency of Gas Engine and exhaust gas of engine can be used as a heat source for spray dryer.

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 vitrified unit is 2.109 MW hence two number of Gas Engine each of capacity of about 1.36 MW will be required to install. Detail technical specification of Gas turnbine are furnished in Annexure 8.

Details of piping and ducting system for waste heat recovery are shown in Table 2.1below:

Table 2.1 Detail design of piping and ducting system

S. No.	Parameter	Detail
1	Duct Material	MS
2	Diameter of duct	610 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 and remaining energy (81%) goes in flue gas which is supplied to the spray dryer as its complete source of energy.

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 price of Natural gas at Morbi on decreasing trends and electricity price on increasing trends, hence revenue generation will increase 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. These 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

MWM/Green Power shall at its own expense and at the sole option of the MWM/Green Power, exchange, replace or repair such part of the Gen sets which have failed or which have essential impact on their usability during a period of 12 months after the date of commissioning of the Gen sets or 18 months after the transfer of risks to you, whichever period expires first, solely as a result of a substantial efficiency which was inherent in Gen sets or the part thereof before transfer of risks and due to faulty design, faulty material or bad workmanship

Promoters will have to promptly notify the MWM/Green Power in writing of obvious defects or deficiencies after detection thereof. Replaced parts shall become the property of the MWM/Green Power upon request of the MWM/Green Power

The MWM/Green Power 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 MWM/Green Power: Improper, unsuitable or negligent use, handling and/or operation of the Gen sets by promoters or by third parties; use of spare parts other than Genuine MWM/Green Power 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. Client has to agree to indemnify the MWM/Green Power from all claims (including claims of third parties) in connection with or resulting from the above mentioned defects.

MWM/Green Power shall bear – insofar as the compliant is legitimate – out of all costs directly arising from repair or replacement only the costs for the spare part including the

delivery costs and the reasonable costs for removal and mounting, as well, if this can be fairly required in the individual case, costs for eventual necessary mechanics and back staff of MWM/Green Power. Other costs shall be borne by client.

Further details of terms and condition are also 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 air preheating system 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 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.
- 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 1.6 million SCM Natural gas per year but required about 4.08 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 16.70 GWh of electricity per year while total electricity requirement in a typical vitrified unit is about 16.70 GWh per year hence electricity not to be imported from grid. 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 4.08 million SCM per year while Natural gas saving due to utilization of waste heat from turbine is about 1.6 million SCM per year and also displaces total electricity consumption of a typical unit which is about 16.70 GWh per year. Hence total monetary benefit due to implementation of this project will be about ₹ 326.64 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	16.70
2	Cost of electricity consumption	₹ in lakh/year	692.85
3	Natural gas saving due to waste heat recovery	million SCM/year	1.60
4	Cost of Natural gas saving	₹ in lakh/year	246
3	Natural gas consumption in Gas turbine	million SCM/year	4.08
5	Cost of Natural gas consumption in Gas turbine	₹ in lakh/year	612.13
6	Total monetary benefit	₹ in lakh/year	326.64

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 7405 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 2.72 MW is ₹ 494 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 ₹ 14.00 lakh, civil works which is ₹ 50.00 lakh, interest during implementation which is ₹ 15.95 lakh, Custom Clearance and Transportation Charges which is ₹ 4.94 lakh, import duty which is ₹ 105.22 lakh and other misc. cost of ₹ 25.00 lakh. The total cost of implementation of the gas turbine based captive power plant is estimated at ₹ 899.11 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)	494
2	Cost of Waste Heat Recovery ducting & diverter damper	₹ (in lakh)	80
3	Erection & Commissioning cost	₹ (in lakh)	14
4	Interest during implementation	₹ (in lakh)	15.95
5	Cost of civil work	₹ (in lakh)	50
5	Custom Clearance and Transportation Charges	₹ (in lakh)	4.94
6	Import duty	₹ (in lakh)	105.22
4	Other misc. cost	₹ (in lakh)	25
5	Total cost	₹ (in lakh)	899.11

4.2 Arrangements of funds

4.2.1 Entrepreneur's contribution

Entrepreneur will contribute 25% of the total project cost which is ₹ 224.78 lakh in case of charcoal fuel project and ₹ 674.33 lakh for Natural gas fuel project.

4.2.2 Loan amount.

The term loan is 75% of the total project cost, which is ₹ 674.33 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 ` 224.78 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 6 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 7 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 ₹ 326.64 lakh per.

- The Operation and Maintenance cost is estimated at 10% 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 ₹ 115.35 lakh in the first year operation and gradually increases to ₹ 455.76 lakh at the end of eighth year.

4.3.2 Simple payback period

The total project cost of the proposed technology is ₹ 899.11 lakh and monetary saving is ₹ 326.64 lakh hence, the simple payback period works out to be 2.75 years.

4.3.3 Net Present Value (NPV)

The Net present value of the investment at 10% works out to be ₹ 75.65 lakh.

4.3.4 Internal rate of return (IRR)

The after tax IRR of the project works out to be 12.62%. Thus the project is financially viable for both types of fuels.

4.3.5 Return on investment (ROI)

The average return on investment of the project activity works out at 24.95%.

Financial indicator of proposed technology is furnished 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	33
2	IRR	%age	12.62
3	NPV	lakh	75.65
4	ROI	%age	24.75
5	DSCR	Ratio	1.49

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

Scenario	DSCR	IRR	ROI	NPV
Normal	1.49	12.62	24.95	75.65
5% increase in fuel saving	1.57	14.39	25.68	128.14
5% decrease in fuel saving	1.41	10.81	24.13	23.17

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 & electrical panel fitting												
4	Testing and trial												
5	On site operator training												

Annexure

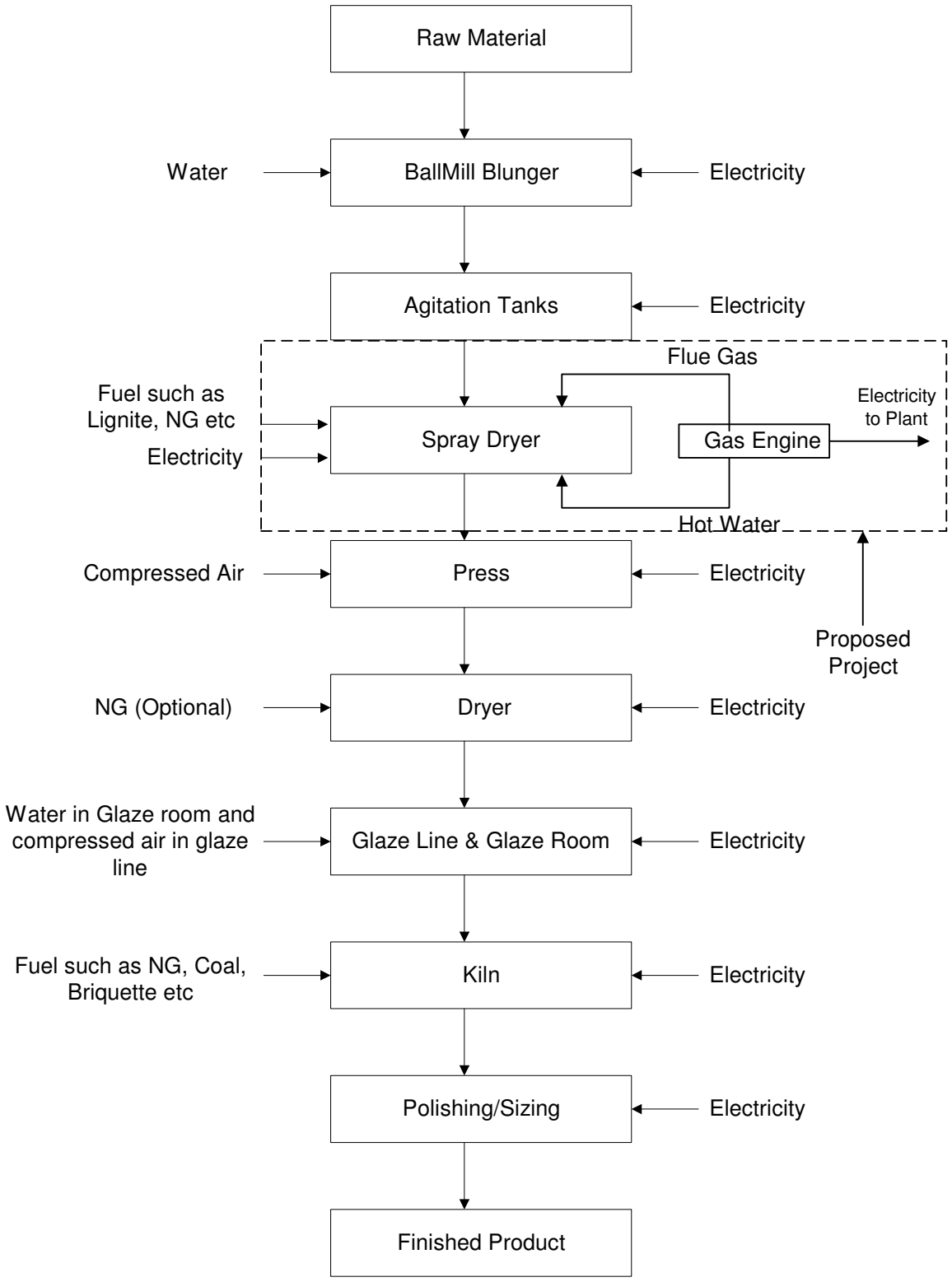
Annexure -1: Energy audit data used for baseline establishment

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	27156
5	SFD flow rate	m^3/day	12643
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

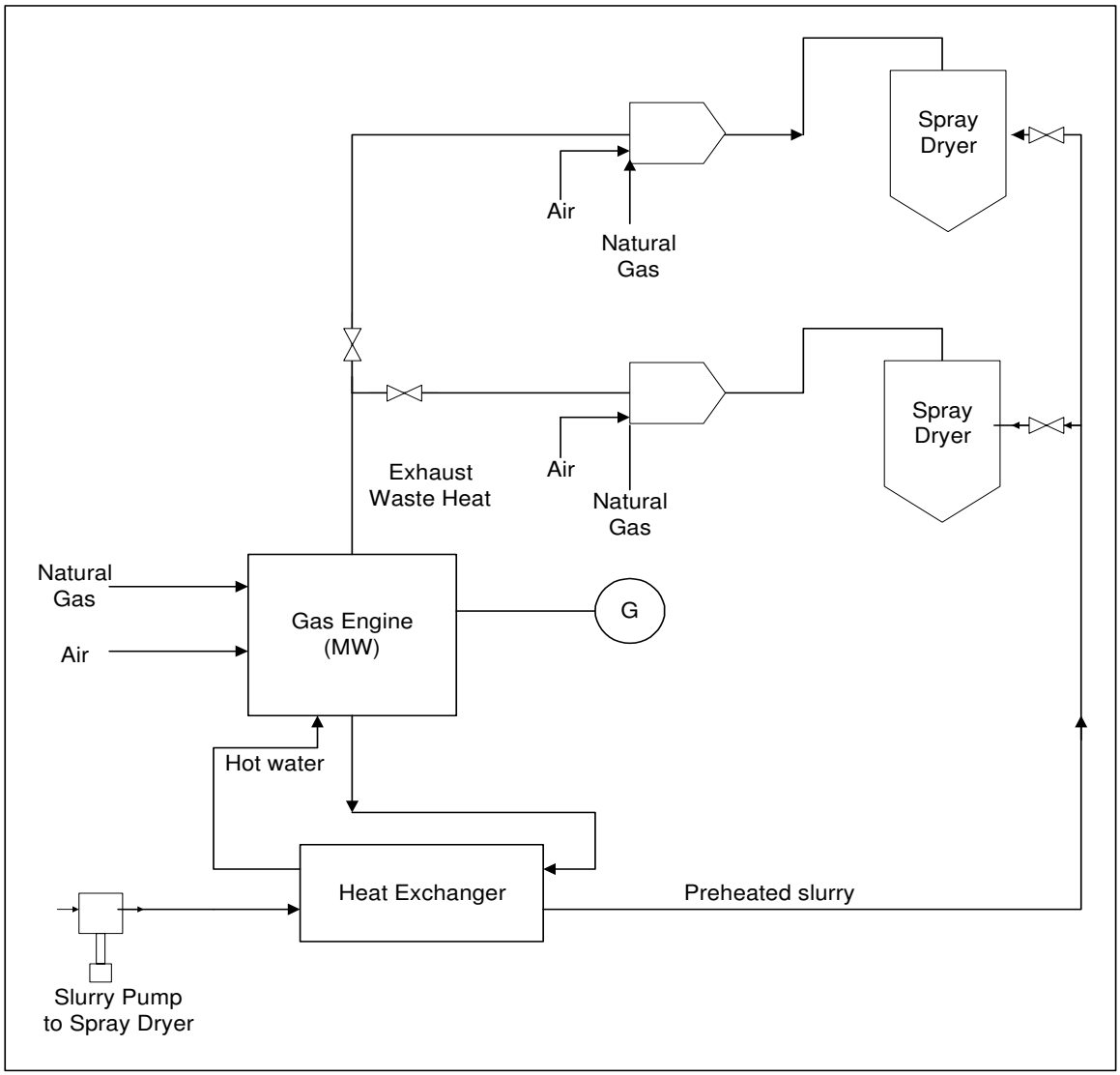
Annexure -2: Process flow diagram after project implementation



Annexure -3: Detailed technology assessment report

S.No.	Parameter	Unit	Value
1	Power Generation efficiency of Gas Engine	%age	40
2	Heat loss due to jacket cooling	%age	20
3	Heat goes to spray dryer	%age	30
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	2109
8	Auxiliary Consumption of Gas Engine required	%age	3
9	Engine load factor	%age	77.50
10	Total Electricity generated by Gas Engine	kWh	2109
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 Engine for power Generation	SCM/hr	515
14	Total Exhaust heat from Gas Engine available	kCal/hr	1360305
15	Equivalent Natural gas saving in spray dryer due to use of waste of gas Engine	SCM/hr	155
16	Heat loss due to jacket cooling can be recovered for preheating air(only 10% can be recovered)	kCal/hr	4,53,419
17	Equivalent natural gas saving due to air preheating by hot water	SCM/hr	52
16	Natural gas consumption in Gas Engine	SCM/year	4,080,914
17	Cost of Natural gas consumed in Gas Engine	₹ in lakh/year	612.13
18	Electricity Generation from gas Engine	kWh/year	16,695,360
19	Equivalent cost of electricity	₹ in lakh/year	692.85
20	Natural gas saving in spray dryer due to use of waste heat	SCM/year	1639440
21	Equivalent saving in cost of Natural gas due to use of waste heat	₹ in lakh/year	246
22	Total saving in due to implementation of this project	₹ in lakh/year	326.64
23	Cost of the project implementation	₹ in lakh	899.11

Annexure -4 Drawings for proposed electrical & civil works



Annexure -5: Detailed financial analysis

Assumption

Name of the Technology	*GAS ENGINE BASED CAPTIVE POWER PLANT*		
Rated Capacity	*2.72 MW*		
Details	*Unit*	*Value*	*Basis*
Installed Capacity	MW	2.72	Feasibility Study
No of working days	Days	330	Feasibility Study
No of Shifts per day	Shifts	3	Feasibility Study
Capacity Utilization Factor	%	82.3	Feasibility Study
Proposed Investment			
Plant & Machinery	₹ (in lakh)	494	Feasibility Study
Cost of Waste Heat Recovery ducting & diverter damper	₹ (in lakh)	80	Feasibility Study
Erection & Commissioning	₹ (in lakh)	14	Feasibility Study
Cost of Civil work	₹ (in lakh)	50	Feasibility Study
Investment without IDC	₹ (in lakh)	638	Feasibility Study
Interest During Implementation	₹ (in lakh)	15.95	Feasibility Study
Custom Clearance and Transportation Charges	₹ (in lakh)	4.94	Feasibility Study
Import duty	₹ (in lakh)	105.22	Feasibility Study
Other charges(Contingency)	₹ (in lakh)	25	Feasibility Study
Total Investment	₹ (in lakh)	899.11	Feasibility Study
Financing pattern			
Own Funds (Equity)	₹ (in lakh)	224.78	Feasibility Study
Loan Funds (Term Loan)	₹ (in lakh)	674.33	Feasibility Study
Loan Tenure	years	6	Assumed
Moratorium Period	Months	6	Assumed
Repayment Period	Months	78	Assumed
Interest Rate	%	10.00	SIDBI Lending rate
Estimation of Costs			
O & M Costs	% on Plant & Equip	10.00	Feasibility Study
Annual Escalation	%	5.00	Feasibility Study
Estimation of Revenue			
Electricity saving	kWh/year	16695360	
Fuel saving due waste heat utilization	SCM/year	1639440	
Fuel consumption in Gas turbine	SCM/year	4080914	
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	674.33	42.00	632.33	61.02
2	632.33	96.00	536.33	58.86
3	536.33	102.00	434.33	48.99
4	434.33	108.00	326.33	38.51
5	326.33	120.00	206.33	27.23
6	206.33	132.50	73.83	14.62
7	73.83	73.83	0.00	2.17
		674.33		

WDV Depreciation

Particulars / years	1	2	3	4	5	6	7
Plant and Machinery							
Cost	899.11	825.03	757.04	694.66	637.42	584.90	536.70
Depreciation	74.09	67.98	62.38	57.24	52.52	48.20	44.22
WDV	825.03	757.04	694.66	637.42	584.90	536.70	492.48

Projected Profitability

Particulars / Years	1	2	3	4	5	6	7
Revenue through Savings							
Fuel savings	326.64	326.64	326.64	326.64	326.64	326.64	326.64
Total Revenue (A)	326.64	326.64	326.64	326.64	326.64	326.64	326.64
Expenses							
O & M Expenses	65.40	68.66	72.10	75.70	79.49	83.46	87.64
Total Expenses (B)	65.40	68.66	72.10	75.70	79.49	83.46	87.64
PBDIT (A)-(B)	261.24	257.97	254.54	250.93	247.15	243.17	239.00
Interest	61.02	58.86	48.99	38.51	27.23	14.62	2.17
PBDT	200.22	199.11	205.55	212.42	219.92	228.55	236.83
Depreciation	34.53	34.53	34.53	34.53	34.53	34.53	34.53
PBT	165.69	164.58	171.02	177.89	185.39	194.02	202.30
Income tax	42.87	44.57	48.66	52.75	56.90	61.30	65.47
Profit after tax (PAT)	122.82	120.01	122.36	125.15	128.49	132.72	136.84

Computation of Tax ***₹(in lakh)***

Particulars / Years	1	2	3	4	5	6	7
Profit before tax	165.69	164.58	171.02	177.89	185.39	194.02	202.30
Add: Book depreciation	34.53	34.53	34.53	34.53	34.53	34.53	34.53
Less: WDV depreciation	74.09	67.98	62.38	57.24	52.52	48.20	44.22
Taxable profit	126.13	131.13	143.17	155.18	167.40	180.36	192.61
Income Tax	42.87	44.57	48.66	52.75	56.90	61.30	65.47

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

Particulars / Years	1	2	3	4	5	6	7
Liabilities							
Share Capital (D)	224.78	224.78	224.78	224.78	224.78	224.78	224.78
Reserves & Surplus (E)	122.82	242.83	365.19	490.33	618.83	751.55	888.39
Term Loans (F)	632.33	536.33	434.33	326.33	206.33	73.83	0.00
Total Liabilities D)+(E)+(F)	979.93	1003.94	1024.30	1041.45	1049.94	1050.16	1113.17

Assets							
Gross Fixed Assets	899.11	899.11	899.11	899.11	899.11	899.11	899.11
Less: Accm. Depreciation	34.53	69.06	103.59	138.11	172.64	207.17	241.70
Net Fixed Assets	864.58	830.05	795.53	761.00	726.47	691.94	657.41
Cash & Bank Balance	115.35	173.89	228.77	280.45	323.47	358.22	455.76
TOTAL ASSETS	979.93	1003.94	1024.30	1041.45	1049.94	1050.16	1113.17
Net Worth	347.60	467.61	589.97	715.11	843.61	976.33	1113.16
Dept equity ratio	1.82	1.15	0.74	0.46	0.24	0.08	0.00

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

Particulars / Years	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***
Sources								
Share Capital	224.78	-	-	-	-	-	-	-
Term Loan	674.33							
Profit After tax		122.82	120.01	122.36	125.15	128.49	132.72	136.84
Depreciation		34.53	34.53	34.53	34.53	34.53	34.53	34.53
Total Sources	899.11	157.35	154.54	156.89	159.67	163.02	167.25	171.36
Application								
Capital Expenditure	899.11							
Repayment of Loan	-	42.00	96.00	102.00	108.00	120.00	132.50	73.83
Total Application	899.11	42.00	96.00	102.00	108.00	120.00	132.50	73.83
Net Surplus	-	115.35	58.54	54.89	51.67	43.02	34.75	97.53
Add: Opening Balance	-	-	115.35	173.89	228.77	280.45	323.47	358.22
Closing Balance	-	115.35	173.89	228.77	280.45	323.47	358.22	455.76

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

Particulars / months	***0***	***1***	***2***	***3***	***4***	***5***	***6***	***7***
Profit after Tax		122.82	120.01	122.36	125.15	128.49	132.72	136.84
Depreciation		34.53	34.53	34.53	34.53	34.53	34.53	34.53
Interest on Term Loan		61.02	58.86	48.99	38.51	27.23	14.62	2.17
Salvage/Realizable value	-	-	-	-	-	-	-	
Cash outflow	(899.11)	-	-	-	-	-	-	-
Net Cash flow	(899.11)	218.37	213.40	205.87	198.19	190.25	181.87	173.53
IRR	12.62%							

NPV	75.65

Break Even Point *₹ (in lakh)*

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***
Variable Expenses							
Oper. & Maintenance Exp (75%)	49.05	51.50	54.07	56.78	59.62	62.60	65.73
Sub Total (G)	49.05	51.50	54.07	56.78	59.62	62.60	65.73
Fixed Expenses							
Oper. & Maintenance Exp (25%)	16.35	17.17	18.02	18.93	19.87	20.87	21.91
Interest on Term Loan	61.02	58.86	48.99	38.51	27.23	14.62	2.17

Depreciation *(H)*	34.53	34.53	34.53	34.53	34.53	34.53	34.53
Sub Total (I)	111.90	110.56	101.54	91.97	81.63	70.02	58.61
Sales (J)	326.64	326.64	326.64	326.64	326.64	326.64	326.64
Contribution (K)	277.59	275.14	272.56	269.86	267.02	264.04	260.91
Break Even Point (L= G/I)	40.31%	40.18%	37.25%	34.08%	30.57%	26.52%	22.46%
Cash Break Even {(I)-(H)}	27.87%	27.63%	24.59%	21.29%	17.64%	13.44%	9.23%
Break Even Sales (J)*(L)	131.67	131.25	121.69	111.32	99.85	86.61	73.37

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

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***Total***
Net Profit Before Taxes	165.69	164.58	171.02	177.89	185.39	194.02	202.30	1260.91
Net Worth	347.60	467.61	589.97	715.11	843.61	976.33	1113.16	5053.38
								24.95%

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

Particulars / Years	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***Total***
Cash Inflow								
Profit after Tax	122.82	120.01	122.36	125.15	128.49	132.72	136.84	888.39
Depreciation	34.53	34.53	34.53	34.53	34.53	34.53	34.53	241.70
Interest on Term Loan	61.02	58.86	48.99	38.51	27.23	14.62	2.17	251.40
Total (M)	218.37	213.40	205.87	198.19	190.25	181.87	173.53	1381.49

Debt

Interest on Term Loan	61.02	58.86	48.99	38.51	27.23	14.62	2.17	251.40
Repayment of Term Loan	42.00	96.00	102.00	108.00	120.00	132.50	73.83	674.33
Total (N)	103.02	154.86	150.99	146.51	147.23	147.12	76.00	925.73
Average DSCR (M/N)	1.49							

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	Green Power International Pvt. Ltd., Wartsila India Ltd. Cummins	E – 12/A, Sector – 63, Noida – 201 301 (U.P.), India	Mr. Ashish Trikha - 0120-4655 460 / 4655 455 / 458, 09717790676

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

MWM
Energy. Efficiency. Environment.

GREEN POWER INTERNATIONAL (P) LTD

Proposal for Natural Gas Genset based Captive Power Generation Plant

PROPOSAL NO:
DATE:

TO:

PROJECT: 1 No. X TCG 2020 V16K (1 X 1364 KWe) @415V Natural Gas Based CPP

Submitted by:
Green Power International (P) Ltd.
E – 12/A, Sector – 63,
Noida – 201 301 (U.P.),
India

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Kind Attention ***Mr.***

Dear Sir,

This has reference to the above-referred subject and discussion had with **Mr. Ashish Trikha** for your requirement of Natural Gas Based Gensets. At the outset we wish to thank you for giving us an opportunity to quote for the said project. As desired, we are enclosing herewith our complete proposal in accordance with your specified requirements.

The Company:

Green Power International Pvt. Ltd. was established in early 2002 in close cooperation with MWM GmbH (formerly Deutz Power System GmbH). The combination of the technical competence of MWM GmbH with the market know-how of the Indian partner company Green Power International has proven to be highly successful.

The core competencies of GPIPL include the design of plants, engineering, plant construction, operation, and maintenance of the complete plants.
As a well-established company with extensive experience in machine and plant engineering, GPIPL offers each customer an innovative solution concept that is tailored to the customer's individual requirements.
We have already commissioned our Natural Gas Based Gensets all over India with complete turnkey projects for most of them, at many places, which are performing satisfactorily. Now we are serving our valuable customers round the clock with a strong team of over 400+ Technical and Service Engineers, specialized in Power Generation Industry and thru complete O & M Contracts of the power plant.

Majority of these projects are Cogeneration Based Captive Power Plants with Chilling / Air-Conditioning / Hot Water Recovery from Engine Jacket Water Heat and Steam from the heat of Engine Exhaust Gases. At present we are having 150+ installations all over India with a capacity of more than 250 MWs. (Please refer our reference list enclosed along with the offer).

MWM GmbH (formerly Deutz Power Systems):

MWM GmbH (formerly DEUTZ Power Systems) in Mannheim, Germany, has been one of the world's leading system providers of highly efficient and environmentally-friendly complete
plants for decentralized energy supply with gas and diesel engines. The company stands for the reliable, uninterrupted provision of electricity, heat, and cooling at all times and at any location.

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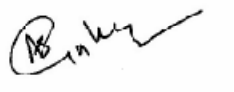
Our Power solution:

We are please to offer you One unit of gas engine of 1364 KWe .The machine offered to you is a **state-of-art**, **fuel-efficient** gas engine with **German technology** and shall lead to a much **faster payback** compared to other competitors. In case you go for **Waste Heat Recovery from Exhaust Gas and Jacket Water the overall system efficiency is more than 86%.**

We hope the above is in line with your requirement. We are eager to work with your esteemed organization and remain at your disposal for any further information.

Thanking you and assuring you of our best services at all times.
Yours faithfully

For *Green Power International Pvt. Ltd.*



Ashu Jain

Email ID: ashu.jain@greenpowerintl.com

For further details contact:

Ashish Trikha

Mobile: 9717099428

Email Id: cbm@greenpowerintl.com

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Terms & Conditions for Sale

1. Scope

"The design and manufacturer of power plant equipment supplied under this offer are as per the enclosed scope document (Scope of Supply/Services). Any detailed quality plan, audit of procedures, inspection and test would be in addition to contract value.

2. Order Confirmation

All orders placed on us directly or through our Regional Offices will be binding on us only after our Head Office in Noida has issued an order confirmation.

3. Specifications etc.

Specifications, dimensions, description, shade of paints, etc. are not binding on us in minute details and are subject to reasonable alterations without notice.

4. Basis of Offer

i. The prices offered for indigenous scope are based on our Std. Power House Layout. The auxiliary equipment offered are standard in nature and do not cater to any specific requirements except otherwise mentioned in the specifications.
ii. It is assumed that the contract will be split in to 3 parts namely
    1. CFR Offshore Supply for Genset portion only
    2. Local Supply for the balance of the plant/accessories of the genset.
    3. On shore services for design and engineering and supervision of erection and commissioning
iii. Customs Duty and Port Clearance / Custom Clearance Charges on Offshore supplies are not included and shall be paid, as applicable, by client at actuals directly to the concerned authorities.
iv. ED (where applicable), CST @ 2% against C-Form (Sales Tax as applicable), on Indian Supplies shall be charged extra at actuals. Any other taxes and duties that may become applicable are to the Client's account.
v. Service tax as applicable shall be charged extra on the Services.
vi. Nhava Sheva (Mumbai) is considered as the destination Port for shipping the genset.
vii. Price for Imported Scope has been offered in Euros. However, all the payments to be made for this shall be in Indian Rupees (INR) only, the exchange rates for the payments shall be made on prevailing exchange rates on the date of final payment/transfer.
viii. Prevailing Exchange Rates would be forward cover rate at the time of maturity of L.C. Buyer would give his consent about the rate before opening the LC in writing to us.

5. Sales Tax Registration Details

PAN No.: AABCG8829R
TIN No.: 07790260143
Sales Tax No.: AABCG8829RST001

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9. Validity

Unless confirmed in writing for further extension, our offer shall remain valid for the period of 1 month from the date of offer.

10. General Lien

We shall be entitled to general lien on goods in our possession or dispatched for all money due to us by the purchaser, both under this contract or any other account and we shall also be entitled to apply any money in our hands under any contract due to us under any other contract or contracts.

11. Execution of High Sea Sales Agreement

As per the Indian Sales Tax Act / Regulation, the High Sea Sales Agreement (format attached) needs to be executed between the parties on a date when the consignment is on high sea i.e. after the date of dispatch from European port & before the date of arrival in Indian port. The Contractor shall contact Owner and on a suitable agreed date the Agreement needs to be signed by both Owner and Contractor. The Original executed High Sea sales Agreement will then be retained by the contractor who, along with other documents (mentioned under payment terms) will forward it to the owner as one of the LC documents. Triplicate Bill of entry would be made available to Green Power within seven days of releasing shipment.

12. Delivery:

Delivery of Imported Genset shall be between 16 – 18 weeks, Ex-works Germany.
Delivery of indigenous supplies shall be within 4-5 months ex- Green power/ vendor basis. The above deliveries are from the date of full advance payment along with technically & commercially clear Purchase order. The above delivery is subject to timely opening of L/C as mentioned in our offshore payment terms. The delivery schedule is subject to "Force Majeure" conditions also.

13. Erection and Commissioning:

We have allowed for times for Supervision of Commissioning according to our estimates. Purchaser shall provide local travel facilities to our Supervisor(s). Also should any additional time be required for Erection, for reasons not attributable to MWM / GREEN POWER, this would be charged at prevailing daily rates.

14. Warranty:

14.1 MWM/Green Power shall at its on expense and at the sole option of the MWM/Green Power, exchange, replace or repair such part of the Gensets which have failed or which have essential impact on their usability during a period of 12 months after the date of commissioning of the Gensets or 18 months after the transfer of risks to you., whichever period expires first, solely as a result of a substantial deficiency which was inherent in Gensets or the part thereof before transfer of risks and due to faulty design, faulty material or bad workmanship

14.2 You will promptly notify the MWM/Green Power in writing of obvious defects or deficiencies after detection thereof. Replaced parts shall become the property of the MWM/Green Power upon request of the MWM/Green Power

14.3 The MWM/Green Power 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 MWM/Green Power: Improper, unsuitable or negligent use, handling and/or operation of the Gensets by you. or third parties; use of spare parts other than Genuine MWM/Green Power 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. You have to agree to indemnify the MWM/Green Power from all claims (including claims of third parties) in connection with or resulting from the above mentioned defects.

14.4 MWM/Green Power shall bear – insofar as the compliant is legitimate – out of all costs directly arising from repair or replacement only the costs for the spare part including the delivery costs and the reasonable costs for removal and mounting. as well, if this can be fairly required in the individual case, costs for eventual necessary mechanics and back staff of MWM/Green Power. Other costs shall be borne by you.

15. Confidentiality:

Except with the consent in writing of MWM / GREEN POWER, the Purchaser shall not disclose technical specification, layout drawings, process details or any other proprietary information supplied along with this offer and subsequently.

16. Effective Date:

Effective date of PO/Contract shall take place upon fulfillment of the following conditions precedent:

1. PO/Contract is signed.
2. Advance payment as stipulated is received by Supplier.
3. Irrevocable L/C at sight as stated has been established by the Purchaser within the specified period and has been accepted by us.

17. Transfer of Title:

Transfer of title shall take place after signing of the High Seas Sales agreement between both the parties.

18. Cancellation

Order received and acknowledged by us shall not be subject to cancellation, either wholly or partly for any reason whatsoever without our consent.

19. Force Majeure:

A "Force Majeure Event" shall mean any unforeseeable act or event that prevents the affected party from performing its obligations under this agreement or complying with any conditions required by the other party under this agreement if such act or event is beyond the reasonable control of and not the fault of the affected party and such party has been unable to avoid such act

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or event by the exercise of prudent foresight and due diligence such as a) war and other hostilities (whether war be declared or not), invasion, act of foreign enemies, mobilisation, requisition or embargo; (b) ionising radiation or contamination of nuclear fuel, radioactive toxic explosives, or other hazardous properties of any explosive nuclear assembly or nuclear components thereof; (c) rebellion, revolution, insurrection, military or usurped power and civil war; (d) riot, civil commotion, terrorism or public disorder except where solely restricted to employees of Supplier or any subcontractor (e) flood, lightning, cyclone, typhoon, earthquake, fire, explosion, shipwrecks, transportation accident or other accidents or act of God; (f) discovery of historically significant artifacts on the facility site.

20. Arbitration

20.1 This Order is to be construed and shall be governed by and interpreted in accordance with the laws of India

20.2 All disputes and differences which may arise out of or in connection with the present Agreement, or the breach thereof, which cannot be settled amicably between Customer and Green Power / MWM shall be finally settled excluding any other jurisdiction but for enforcement of the arbitral award, by arbitration under the Rules of Arbitration of the Indo-German Chamber of Commerce then in force. The Indian Arbitration & Conciliation Act, 1996 and the rules made there under shall be used

20.3 The award of the arbitrator shall be final and binding on the parties hereto

20.4 The language of Arbitration shall be the English language

20.5 The arbitration award shall be final and binding on Customer and Green Power / MWM and subject to no appeal and shall deal with the question of the costs of arbitration and all matters relating thereto.

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SCOPE OF SUPPLY FOR GAS GENSET		
Imported Scope from MWM GmbH (CFR)		
S.No.	Description of Supplies	Remarks
1	BASIC GENERATING SET COMPRISING OF THE FOLLOWING	
a	Natural Gas Engine With Accessories (Skid Mounted)	MWM Germany Make
b	Alternator - Marelli or equivalent, Brushless, double bearing, 415V, 50HZ, Unity PF, 1500rpm	Duly coupled with engine. One for each Engine
c	Standard Engine Maintenance tools	One set only
d	Steel Plate fabricated base frame,	One for each Engine
e	Anti-Vibration Isolators & Flexible Couplings	One for each Engine
f	Insulating mat	One for each Engine
2	AIR INTAKE & EXHAUST SYSTEM FOR ENGINE	
a	Intake air filter, Dry Type with restriction indicator	One for each Engine
b	Dry exhaust manifolds	One for each Engine
c	SS Compensator	One for each Engine
d	Back Pressure Switch	One Set for each engine
e	Exhaust Temperature Sensor	Engine mounted, One for each Engine
f	Turbocharger	One for each Engine
3	COOLING SYSTEM	
a	Jacket water pre-heater	Loose supply, One for each Engine
b	Jacket water thermostatic control valve (HT 3-way valve)	Loose supply, One for each Engine
c	Intercooler water thermostatic control valve (LT 3-way valve)	Loose supply, One for each Engine
d	HT level monitor with level switch and pressure relief valve	Loose supply, One for each Engine
e	LT level monitor with level switch and pressure relief valve	Loose supply, One for each Engine
f	Differential pressure switch for HT circuit	Loose supply, One for each Engine
g	Differential pressure switch for LT circuit	Loose supply, One for each Engine
h	Expansion water tank (HT + LT)	Loose supply, One for each Engine
i	Rubber compensator at HT & LT inlet/outlet	Loose supply, One set for each Engine
4	LUBE OIL SYSTEM	
a	L.O.priming pump, Engine mounted	One for each Engine
b	Lube oil cooler (Plate heat exchanger)	Engine Mounted, One for each Engine
c	Lube Oil Filter (wire edge filter combined with fine paper micro filter), Engine Mounted	One for each Engine
d	Two solenoid valves for automatic oil top-up	Loose supply, One set for each Engine
e	Flexible hose with fittings	One for each Engine
5	STARTING SYSTEM	
a	Engine Electric Starting Motor, Engine mounted	One for each Engine
6	FUEL GAS SYSTEM	
a	Gas Pressure control unit (inlet press 80mbar)	Loose supply, One for each Engine
b	Pre-pressure regulator unit	Loose supply, One for each Engine
c	Flexible gas pipe	Loose supply, One for each Engine
7	ELECTRICAL POWER & CONTROL SYSTEM	
a	TEM EVO (Total Electronic Management) Control and Supervision al reevant functions of gas engine	One for each Engine
b	Operating Terminal (TEM Screen)	One set Common for all Engines
c	Cable and interfaces between Engine & TEM panel, TEM & TEM I/O Panel, Communication interfaces and cables etc	One set for each Engine
8	DOCUMENTATION, INSTRUCTION MANUALS, DRAWINGS	One set for each Engine
9	FREIGHT UPTO NHAVA SEVA PORT FOR IMPORTED EQUIMENT	One for each Engine

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INDIGENOUS SCOPE OF SUPPLY BY GREEN POWER		
S.No.	Description of Supplies	Remarks
1	EXHAUST / VENTILLATION SYSTEM FOR ENGINE	
a	Exhaust silencer, Industrial Type	Loose supply. One for each Engine
b	Flexible bellows	Loose supply. One set for each Engine
c	Exhaust Piping duly insulated along with structural supports from the Genset manifold tc the out of Genset Room	10 Running meters considered for each engine.
d	Ventilation System for Combustion air and room air flow out of the Power house as per MWM requirement	To be designed suitably to operate all the installed engines
2	COOLING SYSTEM	
a	Electric Motor Driven H.T. Pump	One for each engine
b	Electric Motor Driven L.T. Pump	One for each engine
c	Radiator with interconnecting pipes for HT circuit	One for each engine
d	PHE with interconnecting pipes (primary) for LT circuit	One for each engine
e	Raw Water pumps & cooling tower with interconnecting pipes for LT circuit.	Common system for the supplied genset(s).
3	LUBE OIL SYSTEM	
a	Lube Oil Top - up Tank with motorised gear pump.	Common system for all supplied genset
b	Associated pipe work, valves and fittings to interconnect all lube oil system equipment	One for each Engine. Each set of piping shall be of 15 Meters
4	FUEL GAS SYSTEM	
a	Fuel Gas pipe work along with necessary supports, from the main gas valve within the Power house building.	One for each Engine. Each set of piping shall be of 10 Meters
5	ELECTRICAL POWER & CONTROL SYSTEM	
a	Batteries and cables with clamps for Starter of Engine	One set for each engine
b	24V battery bank with charging system for TEM Panel	One set for each engine
c	Generator Incomer Power Panel with outgoing Facility from Rear Side. (415V, 3-Pole, ACB, EDO)	One breaker for each Genset in common enclosure
d	MCC Panel for Genset auxiliaries only	Common Panel for all Genset
e	TEM I/O panel	One set for each Genset
f	Earthing Strips (Cu + G.I) from Genset to the Earthing Grid near the Plant room	One set of 20 RMT for each Genset.
6	ELECTRICAL INSTALLATION MATERIAL	
a	Power Cables from Alternator to the Genset Power Panel	Single Core. One set of 15 Meters for each engine
b	Control and instrument cables with termination kits, lugs, cable trays / racks etc. as required for interconnecting the system within the GE House between the Genset and the Genset panel supplied by MWM Green Power	The specs as per the Packager. One set of 15 Meters for each engine
7	ENGINEERING & OTHER SERVICES	
a	Engineering of Power plant	
b	Documentation, Instruction manuals, drawings	For all the indigenous supplies
c	Erection, Installation, Testing & Commissioning of all Power plant equipment .	For Imported Scope & Indigenous scope of the Packager
d	Inland transportation of local equipment from works to site	For all the Indigenous scope of Packager
e	Unloading and shifting of imported and indigenous materials.	Customer shall provide facility to unload and store materials within 30 mtr of genset foundation.

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SCOPE OF CUSTOMER / PURCHASER		
S.No.	Description of Supplies	Remarks
1	POWER GENERATION RELATED	
a	DM / Soft Water Make up as required for Cooling Tower, Engine cooling circuit etc.	Water Quality to be maintained as recommended
b	Main Gas Valve & Metering near the Genset room within 1 meter. Of Power House Building	By Customer
c	Gas Flow meter with temp. & pressure compensator	By Customer
d	Emergency Power at MCC Panel	By Customer
e	Power Evacuation from the generator breaker to the user end	By Customer
f	Power Cables from Generator panel to the Distribution Panel	By Customer
g	Cable Racks, trays and supports from Power Evacuation point up to the Substation panels	By Customer
h	Chimney / Stack of 30 Meters , as required	By Customer
2	HEAT RECOVERY SYSTEM	
a	Waste Heat Recovery Boiler/ Thermic Fluid Generator/ Chiller with Diverter Damper, Accessories and Mountings & it BOP (if required)	By Customer
b	Jacket Water VAM with Accessories & BOP	By Customer
3	GENERAL	
a	All Civil works (Major or Minor) required for setting up the Power House plant including the insert plates as required	By Customer
b	Cable Trenches, trench covers and any other civil works required for the complete Power house	By Customer
c	Earthing pits/stations along with electrodes as required and connection to grid near plant room	By Customer
d	Chain Pulley Block / EOT Crane	By Customer
e	Fire fighting system & Air conditioners for Control room	By Customer
f	Power House lighting, wiring , distribution boards for power house lighting	By Customer
g	First fill of Lube Oil, Chemicals, Coolant, Gas & other consumables for commissioning and thereafter for regular operation	By Customer
h	Free Construction water and Power at site as required	By Customer
i	Civil Design and Engineering	By Customer
4	OTHERS	
a	Custom Clearance & Port Handling including its charges and Custom Duty payment at actual	By Customer
b	Excise Duty (where applicable) & 2 % CST against C-Form extra as applicable	By Customer
c	Any other local taxes, duties, levies, etc.	By Customer
d	Inland transportation of Imported equipment from port to site	By Customer
e	All primary and secondary statutory / non-statutory clearances for the installation / operation of Power Plant including CPCB, SPCB, SEB, CEIG, MOEF etc.	By Customer
f	Site clearances / permits related with Instalation of equipment i.e.CEIG (Electrical Inspector), TAC (fire fighting)	By Customer
g	Comprehensive Insurance including inland transit, storage cum erection & all risk and Third party liability	By Customer
h	Safe Storage Space within / near the Power House Building	By Customer
i	All Workmen compensation policy	By Customer
j	Free Canteen, Accommodation (Guest House) and local Transportation Facility	By Customer

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SPECIFICATIONS / MAKES OF MAJOR INDEGENOUS ITEMS			
S.NO.	**DESCRIPTION**	**SPECIFICATION**	**MAKE**
1	EXHAUST SYSTEM		
a.	EXHAUST DUCT	ERW / SPIRAL WELD PIPE, CONFORMING TO IS	JINDAL/RATNAMANI / SAIL / MUKAT / EQVT
c.	EXHAUST INSULATION & ALUMINIUM CLADDING	ROCKWOOL LRB MATRESS, of REQD. THICKNESS & DENSITY CONFORMING TO IS:8183-1976 AND CLADDED WITH 24 SWG THICK ALUMINIUM SHEET	LLOYD INSULATION / ROCKWOOL INDIA / MIN WOOL
d.	EXHAUST SILENCER	FABRICATED FROM IS:2062 SHEETS & PAINTED WITH HEAT RESISTANT ALUMINIUM PAINT OF SUITABLE GRADE	RUSKPOWER / ACOUSTIC / DECIMIN/NELSON / EQVT.
e.	EXHAUST FLEXIBLE BELLOWS	SS-304, METALLIC BELLOWS, SINGLE PLY, SUITABLE FOR AN OPERATING TEMPERATURE OF 600 DEG C.	ALFA FLEXITUBE / KANWAL / PRECISE / EQVT.
f.	SUPPORTS	IS 2062	REPUTED MAKE
2	COOLING SYSTEM		
a.	HT / LT PUMPSETS	VERTICAL IN-LINE, CLOSE COUPLED, SINGLE STAGE CENTRIFUGAL PUMP WITH MOTOR, MECHANICAL SEAL ETC.	ITT - LOWARA, ITALY / WILO, GERMANY / NOCHI, ITALY / EQVT.
b.	COOLING TOWER	INDUCED DRAFT TYPE FRP COOLING TOWER OF SUITABLE SIZE	MIHIR / ADVANCE / BELLS / EQVT.
c.	COOLING WATER PUMP	BACK PULLOUT TYPE / HORIZONTAL CENTRIFUGAL PUMP WITH MECHANICAL SEAL, BASE FRAME COUPLING, ETC.	KSB / KBL / M&P / EQVT.
d.	MOTOR FOR COOLING WATER PUMP	HORIZONTAL FOOT MOUNTED TYPE SQ. CAGE INDUCTION MOTOR, TEFC, 3 PHASE, 415 V, 50 Hz, 2900 RPM	ABB / SIEMENS / CROMPTON / EQVT.
e.	MONOBLOCK PUMP WITH MOTOR	BACKPULL OUT PUMP WITH SQ. CAGE INDUCTION MOTOR, TEFC, 3 PHASE, 415 V, 50 Hz, 2900 RPM	KSB / KBL / M&P / CGL / EQVT.
f.	RADIATOR FOR HT CKT	REMOTE TYPE AIR COOLED FLUIR COOLER.	COIL CO. / STAR COOLERS / GEM / EQVT.
g.	PLATE HEAT EXCHANGER	SS PLATE HEAT EXCHANGER	GEA ECOFLEX INDIA / TRANTER INDIA / EQVT.
h.	WATER PIPES	MS ERW PIPES OF SUITABLE SIZES, THICKNESS - CLASS C CONFORING TO IS:1239 / IS:3589	JINDAL / TATA / RATNAMANI/ MUKAT/ SAIL / EQVT.
i.	BUTTERFLY / CHECK VALVES	CI BUTTERFLY VALVES OF SUITABLE SIZES	INTER VALVE/ STAFFORD INDIA / ADVANCE / EQVT.

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j.	BALL VALVES	CS BODY BALL VALVES OF SUITABLE SIZES WITH SOCKET WELD ENDS	AUDCO / INTERVALVE / VIRGO / EQVT.
k.	PRESSURE GAUGES	GLYCERIN FILLED SS BOURDEN TYPE PRESSURE GAUGES, 4" DIAL SIZE	MASS / GIC / FORBES MARSHALL / WAREE / WIKA / EQVT.
l.	TEMPERATURE GAUGES	RIGID STEM & MERCURY TYPE SS DIAL THERMOMETER (GLYCERIN FILLED) DIAL ,4" SIZE & SS THERMOWEL	MASS / GIC / FORBES MARSHALL / WAREE / WIKA / EQVT.
m.	SUPPORTS	IS 2062	REPUTED MAKE
3	**LUBE OIL SYSTEM**		
a.	LUBE OIL PIPES	MS ERW PIPES OF SUITABLE SIZES, THICKNESS - CLASS C CONFORMING TO IS:1239	JINDAL / TATA / RATNAMANI/ MUKAT/ SAIL / EQVT.
b.	LUBE OIL TOP UP TANK	FABRICATED FROM 3 MM THICK MS SHEET CONFORMING TO IS:2062 GRADE A / B	FABRICATED
c.	LUBE OIL TRANSFER PUMP	GEAR PUMP COUPLED WITH MOTOR ON COMMON BASE FRAME	PEC / ROTO DEL MAKE PUMP WITH ABB / SIEMENS MAKE MOTOR
d.	BALL VALVES	CS BODY BALL VALVES OF SUITABLE SIZES WITH SOCKET WELD ENDS	AUDCO / INTERVALVE / VIRGO
4	**FUEL GAS SYSTEM**		
a.	GAS PIPE LINE	MS SEAMLESS PIPES OF SUITABLE SIZES, THICKNESS SCHEDULE-40.	MSL / ISL / EQVT.
5	**ELECTRICAL CONTROLS & POWER SYSTEM**		
a.	GENERATOR INCOMER BREAKERS	415 V, 3 POLE, ACB, EDO	L & T / EQVT.
d.	BATTERY BANK	24 VOLT	EXIDE / EQVT.
e.	BATTER CHARGER		PHOENIX / EQVT.
6	**ELECTRICAL INSTALLATION MATERIAL**		
a.	POWER CABLE - 1 CORE, 400 SQMM	ALUMINIUM CONDUCTOR, XLPE UNARMOURED CABLE	GLOSTER / KEI / POLYCAB / EQVT.
b.	LT AUXILIARY POWER CABLE FOR GENSET AUXILIARIES	PVC ARMOURED ALUMINIUM CABLE OF SUITABLE SIZES	GLOSTER / KEI /POLYCAB / EQVT.
c.	CONTROL CABLE	PVC ARMOURED / UNARMOURED COPPER CABLE OF SUITABLE SIZES	GLOSTER / KEI /POLYCAB / EQVT.
d.	INSTRUMENT CABLE	SCREEN & HOFR COPPER FLEXIBLE CABLE OF SUITABLE SIZES	FUSION POLYMER / KEI / EQVT.

Bureau of Energy Efficiency (BEE)
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