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yard for chemicals and fuel/lubricants will also be provided with fire extinguishers and sand bucket rack.

The general safety features adopted will have provision of fire extinguishers, over pressure relief devices, safe storage of all chemical and fuels, grounding of all electric equipment, safe location of electric gear, proper building and equipment layout, instrumentation alarms, guard railings, security personnel.

Silencers will be provided for safety valves and vents of the plant to ensure noise control in the plant. Safety measures will be taken for handling the chemicals in the water treatment plant.

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9.0 CLEARANCES

9.1 Statutory Clearances

Sr. No	NAME OF CLEARANCES	STATUS
1.	Clearance from Govt./MB	
a)	Land Allocation	Completed
b)	SPV Incorporation	Completed
c)	Concession Agreement	Draft Agreed
[illegible]	[illegible] Clearances	
a)	Authorization (MSW Rules) For Site	Applied
b)	Clearance For Stack Height From Airport Authority Of India	Applied
d)	NOC From Ground Water Authority	Applied
e)	Clearance From GMDA	Applied
f)	Clearance From Town & Country Planning	Applied
g)	Environmental Clearance from MoEF	TOR Finalized and Approved By MoEF- EIA Under Progress

9.2 Non-Statutory Clearances

[illegible]	[illegible]	[illegible]
1.	Construction power	
2.	Power Purchase Agreement (PPA)	
3.	Power evacuation arrangements	Exportable power will be stepped up to 11 kV and to be connected at DTL sub-station at Gorchug located at 2 km from plant site by ~~laying a separate~~ line from power plant switchyard to the sub-station.

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10.0 BENEFITS TO MUNICIPAL BOARD

Major cities of India produce approximately 1.50 Lakhs tonnes of Municipal Waste per day and approximately 70%-80% of which are disposed of by the Urban Local Bodies (ULB) leaving [illegible] on the streets unattended. The ULBs collect, transport and dispose of (open yard dumping) around 1.0 Lakh tonnes of MSW spending around Rs.1,000- Rs.1,500 per MT of MSW (around Rs.12.0 Crores per day). More than 20,000 hectares of costly urban land is used for open yard dumping and the requirement of land increases and once used, these lands are exhausted in every 5-10 years time. In addition, the non-sanitary land filling practice mostly followed has resulted in severe environment deterioration in respect of ground water contamination, air pollution and has been causing diseases due to bacteria and pathogens.

Although all the ULBs were directed by MOEF to set up waste processing disposal facilities by 31.12.2003, not a single ULB could implement the directives because of various constraints. It is reported that most of the ULB are getting summons from the Court of Law for not complying with Supreme Court directives for setting up MSW processing facilities latest by the year 2003 and this has caused an urgency to support the Urban Local Bodies for setting up such facilities.

However, one of the great difficulties is involved in completing the development phase and thus it is squeezed to the minimum possible due to shortage of funds. The development phase includes getting permits and clearances, getting land, tying up MSW/Sewage supply, tying up power sale, tying up water requirements, etc.

The bankable document shall also comprise of technical studies, economic and financial analysis, environmental studies, market demand studies, resource mobilization & development of contractual framework, risk analysis and allocation. However, few of these activities are normally completed due to lack of funds with the municipalities.

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10.1 Cost to the municipalities

The daily solid waste generation in Guwahati is about 321 TPD. The average GMC expenditure towards SWM for year 2004-0[illegible] is Rs. 954 lakhs. This amount includes collection, transportation and disposal (mainly through land-filling). The proposal includes treatment/disposal of 5[illegible]

Guwahati is located on the Brahamputra flood plains. A significant area in and around Guwahati gets occasionally flooded during the monsoon and the water often stands for about 8 months along the low lying tracts. Because of expansion of the city over the years, the entire high-level area within the Guwahati municipal limits has been fully occupied. In view of the above, land area is very precious and it cannot afford it any more to lose it to activities such as land filling that are non-productive and can be avoided/minimized.

With the MSW Handling Rules 2000 coming into force, it has become essential for the municipalities to tackle the Solid wastes in most scientific way with minimum use of land filling option.

10.2 Benefits from the proposed approach

The proposed approach ensures the following benefits to municipalities:

A) Ensure effective utilisation of approved grant by GMC under "Jawahar Lal Nehru National Urban Renewal Mission (JNNURM)" by the Ministry of Urban Development, Govt of India of Rs. 3516.71 Lakhs for the purpose of MSW Management in the city of Guwahati .

B) All the project development expenses are borne by the Guwahati Waste Management Company Private Limited (GWMCL) a SPV incorporated to develop the project and to obtain requisite clearances necessary for implementing an integrated waste management facility

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including an integrated waste processing facility at Boragaon in Guwahati ;

C) GWMCL will bring the latest technology to put up the most efficient plant

D) Since the project is on Build Operate, Transfer (BOT) basis, it will lead to permanent asset for the GMC .

E) The asset would come back to the GMC after the period of Concession and it would be able to re-bid for selecting the operator.

F) The BOT operator will be selected through a transparent competitive bidding route.

G) A good system of disposal of garbage would have a "sucking effect" on the collection of garbage and would therefore, enhance efficiency of the collection system.

H) The landfill area requirement would reduce significantly as the solid waste will be converted into fuel/fluff for producing power and only 20%-30% of the total incoming waste, inert in nature will be sent for landfill and if viable, it can be reprocessed and recycled as building materials. This would save upon the future requirements of area for landfill. There shall be additional saving on potential increase in transportation costs as vacant land is difficult to be found within city limits of Guwahati and waste might require to be transported to longer distance.

I) The successful implementation of this project will not only boost the public friendly image of GMC but also act as a role model to other municipalities.

As such on the whole, the proposed approach does not entail any financial out flow from the GMC. It is likely to "suck the garbage" from the city of Guwahati.

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SECTION-II
FINANCIAL ANALYSIS

The proposed integrated waste management includes direct collection of waste from waste generators to scientific disposal process. At present Municipality is paying tipping for transportation of waste. . Realizing the problem that the municipalities, in general, are not in very good financial health in proposed project the financial analysis has been structured to ensure that the, Municipality is not burdened with additional tipping fee for processing of waste. The project becomes viable by sale of bye products from processing of waste

The Project has been structured in following way:

A) The project shall be implemented i.e. developed, financed, constructed maintained and operated for the project term, by a SPV in name of Guwahati Waste Management Company Private Limited (GWMCL)

B) The private entity in GWMCL would be selected on behalf of GMC by a process of open competitive bidding with 100% of the subscribed and paid up equity owned and controlled by the private entity.

C) The PPP project belongs to the "Municipal waste management " sector.

D) The project would provide power to beneficiary state against payment of pre-determined tariff

E) GWMCL has submitted proposal for seeking the following benefit from GOI to reduce loading on tariff:

A. Duty Exemptions

B. Grant under "Accelerated Programmes on Energy Recovery from Urban Wastes"- the scheme of Ministry of Non-Conventional Energy Sources (MNES). But the grant from MNES is not included in the financial analysis

The estimated project cost of the integrated municipal waste processing complex is Rs. 504.77 mn. In the base case scenario, no viability gap funding is considered. The details of the cost is placed below:

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Integrated Plant- Cost Details	
Description	Cost (in Rs Mn)
RDF Plant	119.34
Biomethanation & S.P plant	0.00
Power Plant	304.90
IDC	48.76
Finance Charges (0.5% of Debt)	1.77
Project Development expense	10.10
Working Capital margin	8.12
Contingency (3%)	11.79
TOTAL COST	**504.77**

The capital cost for the integrated plant is higher as compared to the stand-alone power plant based on non-conventional energy source like biomass for the following reasons:

A) Additional costs related to segregation and processing of MSW;

B) Additional costs related to designing of boiler capable of using RDF as fuel;

C) Additional costs related to auxiliary fixing requirement;

The financing pattern of the integrated complex is as follows:

Particular	In (%)	In Rs. mn
Equity	30%	151.43
Debt	70%	353.3
TOTAL	100%	504.77

The major assumptions in the financial analysis is as follows:

Power Plant Assumptions		
Capacity of Plant	MW	6
1st year PLF	%	70%
2nd year onwards-PLF	%	70%
No. of days –opeartions	days	365
Gross Generation	in MU	37
Auxilliary Consumption	%	20.3%
RDF	11%	
Bio-methanation	0%	
Power	9%	
Net Generation	in MU	29.32
Debt:Equity ratio		2.33:1
Grant	%	0%
Equity	%	30%

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Power Plant Assumptions		
Debt	%	70%
Tenor of loan	yrs	10
No. of quarters	months	10
Rate of interest before commissioning	%	12%
Rate of interest After Commissioning	%	12%
Moratorium	year	1
Installment start	year	2
Installment end	year	12
ROE	%	14%
WCL rate of interest	%	12%
WC margin	%	25%
O&M expense for the project	Rs. Mn	7.8
O&M escalation	%	4%
Fluff production	TPD	180
Fluff(on-line fired into the boiler)	TPD	170
Biomass allowed (25%)	TPD	57
Cost of Biomass (per Ton)	Rs/Ton	1500
No. of Days		330
Biomass Cost - First Year	Rs Mn	28
No. of working days	days	330
Fluff prouction-yearly	TPD	56100
Gross Calorific Value of RDF	kcal/kg	2600
Overall efficiency of power plant	%	21%
Plant Heat Rate	kcal/kg	4095
Requirement of RDF/unit	kg/kwh	1.58
Methane generation per day	M3/day	0
Calorific Value of Methane	Kcal/kg	4500
Organic fertiliser produced	in TPD	0
Cost of Organic Fertiliser	in Rs	1000
Escalation	in %	4%
Depreciation Rate	in %	3.60%
Income Tax- Basic Rate	in %	30.00%
Surcharge	in %	10.00%
Cess	in %	2.00%
Corporate Tax with Surcharge & Cess	in %	33.60%
Minimum Alternate Tax (MAT)	in %	7.50%
MAT with Surcharge & Cess	in %	8.40%
Royalty fee payable to MB	Paise	0.00
Lease rental	mn	0.00
CDM revenue	mn	0

Base on above assumptions cost based tariff comes out to be

1st year Tariff = Rs. 5.00 /kwh

Levelised Tariff (for 20 years) = Rs. 4.83 /kwh

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SECTION-12.0

SENSITIVITY ANALYSIS OF PROCESSING MSW TO RDF

12.1 Introduction

A sensitivity analysis is a way of examining the effects of uncertainties in the forecasts on the viability of a project. Although it is an essential component of the economic analysis of a project, but it is equally important to carryout the same for any technology process. This importance is more relevant for MSW processing projects where the raw material (MSW) is highly heterogeneous in nature and its quality is a dominant variable factor, and not always controllable.

Quality of MSW .

The quality of MSW meant for processing into RDF depends primarily on two of its gross and major constituents. These are : its composition in terms of combustibles and inert constituents, defined below and its moisture content.

Combustible constituents comprises of wood and biomass pieces, paper, textiles, non-chlorinated plastics etc. These are desirable components for RDF.

Gross inert constituents comprises of sand, grits soil, stones, ceramics bricks etc. that are non-combustible and such undesirable constituents like chlorinated plastics, rubber and leather. Although these components are combustible, but are not burnt due to their obnoxious nature of having detrimental effects on combustion equipment and also major cause of producing pollutants during combustion. These are segregated during the processing. All these undesirable products are termed as INERTS.

The other detrimental component of MSW is its overall moisture content. Both moisture content and higher percentages of inerts of MSW are undesirable constituents, and during its processing have tendency to reduce the heat content of the final product, RDF.

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Composition & Thermal values of MSW

The base data generated by 'In situ' analysis of MSW at delivery site for designing the process plant is given in Table 12.1. This table also includes the calculated thermal energy of MSW and its combustible components

TABLE–12.1 Constituents of MSW

Basis: 100 Tonnes of MSW with 35% moisture content

Components	Wet Qty (%)	Moisture Content (%)	HCVd (kCal/kg)	Dry Amount (Tonnes)	Total Heat Content (KCals x 10^3)
Wooden pieces, Boimass, Paper, Textiles (*)	15	35	4000 (a)	9.75	39,000
Kitchen waste / Organics (*)	50	45	3500 (a)	27.50	96,250
Plastics (non – PVS) (*)	3	20	6500 (a)	2.40	15,600
Others (rubber, leather)	7	20	5000 (a)	5.60	28,000
Sand / Grit / Earth	15	20	0	12.00	0
Stones / Ceramic Bricks	10	20	0	8.00	0
Total	100	35	2741	65.25	1,78,850

(*) Combustible (a) Average values from literature

Heating values of MSW

For combustion purpose, the dominant property of MSW / RDF is its heat content or calorific value, represented by HCVd and NCV. HCVd is the higher heating value of oven dried material and NCV is the net heating value in kCal/kg. These are determined in the laboratory by a bomb calorimeter. For same fuel the moisture has a significant influence on the higher heating value and specific gravity of RDF. The influence on heat content can be seen by the following equation:

$$NCV = HCVd \times (1 - MCg/100) \quad (12.1)$$

Where NCV is the net heating value of fuel also referred to as the as received higher value. NCV is not synonymous with lower heating value of fuel.

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The derived heating value of MSW from Table-12 are

HCVd of MSW on dry basis (incl. Leather (L) & rubber (R) contents)

2741 kCal/kg

NCV of MSW as received (incl. Leather and rubber and rubber contents)

[illegible] kCal/kg

HCVd of MSW on dry basis (excluding L and R)

= 2529 kCal/kg

NCV of MSW as received (excluding L and R)

= 1622 kCal/k

Design data of processing plant – rated capacity

The mass recovery of RDF from MSW and overall thermal energy recovery efficiency are given below. This is considered as the BASE CASE for carrying out sensitivity analysis.

Production of RDF	= 180 TPD
HCVd	= 2800kCal/kg
Moisture	= 15%
Dry RDF	= 153 TPD
Total Thermal Energy in RDF (Dry basis)	= 180 x0.85x2800x10^3 = 428.4 x 10^6 kCals
MSW Utilised	= 500 TPD
Moisture	= 35%
Dry material	= 325 TPD
Overall Thermal Energy present in MSW (dry basis)	= 891.15 x 10^6 kCal

Thermal Energy Recovery in RDF = 47.0%

Mass Recovery (Wet basis) of RDF = 180/500 = 36.00%

Mass Recovery (Dry basis) of RDF = 153.00 = 47.08%

This mass recovery does not include the segregated organic material that is internally consumed in hot air generator (HAG).

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Methodology of sensitivity analysis

The quality and quantity of RDF and correspondingly its heating value depend on the proportional contents of combustibles and inerts moisture content. Since RDF is derived from MSW, its overall quality is highly dependent on the quality of MSW.

The quality of MSW is again dependent on its percentages of desirable combustibles constituents, and its undesirable components of moisture and inerts. The increase in inerts and correspondingly decrease in combustibles of MSW and also changes in its moisture content would not only result in the increased requirement of MSW, but will also affect the separation and drying efficiencies of the processing plant.

For example, more moisture in MSW will tend to give higher moisture content of RDF and vice versa. Similarly change in inert content of MSW from the designed value will change the inert contents of RDF. Both these factors will inturn change the composition and hence the HHV of RDF.

However, the plant has been built with flexible operation that its recovery factor and in turn the quality of RDF will not change to any appreciatable extent, provided the moisture in MSW is within a range of 30-40% (Avg:35%) and inerts 30-35%, (Avg: 32%). For every increase/decrease beyond these ranges of moisture and inerts, there is expected to be a corresponding increase/ decrease of inerts and of moisture in RDF.

Keeping the final energy requirement for boiler as the desired and constant factor, the requirement of RDF with respect to its HCV and correspondingly the quantitative increase and decrease of MSW are calculated as the main part of the sensitivity analysis of the process.

So the output variable is the quantity of MSW required as a function of changes in its compositions of inerts and moisture. Other objective variables are the quantity and quality of RDF in terms of HCV, keeping its overall energy content as the desired

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constant parameter, so as not to effect the production of power. Accordingly the data for sensitivity analysis is generated and given the next section

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Generation of data

As mentioned earlier the independent variables for carrying out sensitivity analysis are the changes in the quantum of inerts and percentage moisture content of MSW from the base case (design values) and the dependent variables are the quanta of MSW required and RDF produced and their effect on the thermal properties of both MSW and RDF. The objective, however, is that the over all energy content of RDF is kept constant to maintain the designed power output. The flexible processing part of the plant and also its limits of operation (turndown ratios) have been considered to get this data.

12.2 Effect of inerts on requirements of MSW

In a situation when inert content increases in MSW then correspondingly its combustible content decreases and the heating value of MSW will proportionally get decreased. Keeping the same separation efficiency and yield of plant, the corresponding presence of additional inerts in RDF will reduce its HCV. This would demand more quantity of RDF and additional MSW to meet the required energy demand to maintain the rated power production level. This correlation is clearly brought out in the data given below:

Data generated with inerts as independent variable

Taking the inerts as 32% in MSW as the rated design case (base case).the change in quantum of inerts is varied at an interval of 10% from the base case. The material and energy balance data, so generated, is given in the following tables. All calculations are based on 100 tonnes of MSW.

TABLE-12.2.1
Composition and heating data
(Basis: 100 TPD of MSW)

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__Case No.: 0 Base ≈35% moisture and 32% inerts__

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonne	Tonnes	KCal/kg (d)	KCal x 10³
Combustibles	68	68	41.7[a]	28.35	39.65	3,805	150,850
Inerts	32[b]	32	20.0	6.40	25.60	1,094	28 000
Total	100	100	34.75	34.75	65.25	2,741	178,850

Calculated from design data of Table-12.1

32% inerts include 25% inorganic + 7% unwanted leather and rubber in MSW

weighted average of desired combustibles average values from literature

__TABLE–12.2.2__

__Case No.: 0 Base: (Desgin Data)__

Material: RDF

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10³
Combustibles	80	27.68	15	4.15	23.53	3,500[b]	82,348
Inerts	20	6.92	15	1.04	5.88	0	0
Total (RDF)	100	34.60(a)	15	5.19	29.41	2,800[c]	82,348

Recovery of RDF (wet basis)

This value is less than that for MSW as textiles and wood is segregated for HAG value of RDF

__TABLE–12.3.1__

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__*Case No.:1 10% increased inerts in MSW (32+3.2 35.2%)*__

Material: RDF

Constituents	Wt wet basis		Moisture		Dry Wt	HHVd	Total Heat Value
	% age	Tonne	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	76.88	26.6	15	4.0	22.6	3,500	79,100
Inerts	23.12	8.0	15	1.2	6.8	0	0
Total (RDF)	100.00	34.6	15	5.2	29.4	2,690	79.100

Explanation of results (Table-12.3.1)

With 10% increase in the amount of inerts in MSW, the percentage increase is 3.2 making inerts in MSW as 32+3.2 = 35.2%. With recovery at 34.6%, 1.1 tonnes of additional inerts end up in RDF. So inerts in RDF + 6.92 + 1.1 = 8 t and correspondingly combustibles in RDF = 26.6 T. So, the HCVd = 2690 instead if 2800 kCal/kg.

The energy content of RDF is 79,100 x 103 kCals instead of the required amount of 82,348 x 103 kCals. Therefore, 1,041 times RDF, that is, 34.6 x 1.041 = 36.018 tonnes is required. Accordingly, MSW requirement = 104.1 tonnes instead of 100 tonnes for base case. So MSW required per day = 500 x 1.041 = 520.5 TPD.

__TABLE-12.3.2__

__*Case No.: 1 Inerts 35.2%*__

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	64.8	64.8	41.7	27.02	37.78	3,830	144,697
Inerts	35.2	35.2	20.0	7.04	28.16	1,095	30,835
Total (RDF)	100.0	100.0	34.05	34.06	65.94	2,661	175,532

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HCVd of MSW = 2,661 kCal/kg (including I & R)

Net NCV of MSW = 1,755 kCal/kg

TABLE–12.4.1

Case No.: 2 Increased inerts 20% in MSW = 38.4%

Material: RDF

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	73.6	25.48	15	3.82	21.66	3,500	75,810
Inerts	26.4	9.12	15	1.38	7.74	0	0
Total (RDF)	100.0	34.60	15	5.20	29.40	2,578	75,810

MSW = 543 TPD RDF = 188 TPD

TABLE–12.4.2

Case No.: 2 Increased inerts 20% in MSW = 38.4%

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	61.6	61.6	41.7	25.69	35.91	3,830	137,535
Inerts	38.4	38.4	20.0	7.68	30.72	1,094	33,608
Total (MSF)	100.0	100.0	33.37	33.37	66.63	2,568	171,143

HCVd = 2,568 kCal/kg Net CV = 1,711 kCal/kg

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TABLE-12.5.1

Case No.: 3 Increased inerts 30% in MSW = 41.6%

Material: RDF

Constituents	Wt. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	70.4	24.36	15	3.66	20.70	3,500	72,450
Inerts	29.6	10.24	15	1.53	8.71	0	0
Total	100.0	34.60	15	5.19	29.41	2,463	72,450

MSW = 570 TPD

RDF = 196 TPD

TABLE-12.5.2

Case No.:3 Increased inerts 30% in MSW = 44.6%

Material : MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	58.4	58.4	41.7	24.35	34.05	3,830	130,411.5
Inerts	41.6	41.6	20.0	8.32	33.28	1,094	36,408
Total	100.0	100.0	32.67	32.67	67.33	2,532	166,819.5

HCVd = 2,532 kCal/kg

NCV = 1,705

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TABLE-12.6.1

Case No.:4 Increased inerts 40% in MSW = 44.8%

Materia : RDF

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	67.2	23.25	15	3.49	19.76	3,500	69,160
Inerts	32.8	11.35	15	1.70	9.65	0	0
Total (MSF)	100.0	34.60	15	5.19	29.41	2,350	69,160

MSW = 596 TPD **RDF = 206 TPD**

TABLE-12.6.2

Case No.:4 Increased inerts 40% in MSW = 44.8%

Material : MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	55.2	55.2	41.7	23.01	32.18	3,830	123,249
Inerts	44.8	44.8	20.0	8.96	35.84	1,094	39,209
Total (MSF)	100.0	100.0	31.97	31.97	68.02	2,391	162,458

HCVd = 2,391 kCal/kg **NCV = 1,625 kCal/kg**

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TABLE 12.7.1

Case No.: 5 Increased inerts 50% in MSW – 48%

Material: RDF

Constituents	Wt. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	64.0	22.14	15	3.32	18.82	3,500	65,870
Inerts	36.0	12.46	15	1.87	10.59	0	0
Total	100.0	34.60	15	5.19	29.41	2,240	65,870

MSW = 625 TPD

RDF = 216 TPD

TABLE-12.7.1

Case No.: 5 Increased inerts 50% in MSW = 48%

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	52.0	52.0	41.7	21.68	30.32	3,830	116,125
Inerts	48.0	48.0	20.0	9.60	38.40	1,094	42,009
Total (MSF)	100.0	100.0	31.28	31.28	68.72	2,300	158,134

HCVd = 2,300 kCal/kg

NCV = 1,581 kCal/kg

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TABLE - 12.8.1

Case No.: 6 Decreased inerts by 10% in MSW = 28.8%

Material: RDF

Constituents	Wt. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	%age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	83.2	28.8	15	4.32	24.48	3,500	85,680
Inerts	16.8	5.8	15	0.87	4.93	0	0
Total (MSF)	100.0	34.6	15	5.19	29.41	2,913	85,680

MSW = 481 TPD RDF = 166 TPD

TABLE -12.8.2

Case No.: 6 Decreased inerts by 10% in MSW = 28.8%

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	71.2	71.2	41.7	29.69	41.50	3,830	158,945
Inerts	28.8	28.8	20.0	5.76	23.05	1,094	25,217
Total (MSW)	100.0	100.0	35.45	35.45	64.55	2,854	184,162

HCVd = 2,854 kCal/kg NCV = 1,841 kCal/kg

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TABLE-12.9.1

Case No.: 7 Decreased inerts by 20% in MSW = 25.6%

Material: RDF

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	% age	Tonnes	% age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	86.4	29.9	15	4.49	25.41	3,500	88,935
Inerts	13.6	4.7	15	0.70	4.00	0	0
Total (RDF)	100.0	34.6	15	5.19	29.41	3,024	88,935

MSW = 463 TPD

RDF = 160 TPD

TABLE-12.9.2

Case No.: 7 Decreased inerts by 20% in MSW = 25.6%

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	%age	Tonnes	%age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	74.4	74.4	41.7	31.02	43.38	3,830	166,145
Inerts	25.6	25.6	20.0	5.12	20.48	1,094	22,405
Total (MSW)	100.0	100.0	36.14	36.14	63.86	2,953	188,550

HCVd = 2,953 kCal/kg

NHV = 1,886 kCal/kg

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TABLE-12.10.1

Case No.: 8 Decreased inerts by 10% in MSW 22.4%

Material: RDF

Constituents	Wt.. wet basis		Moisture		Dry Wt	HHVd	Total Heat Value
	%age	Tonnes	%age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	89.6	31.0	15	4 65	26.35	3.500	92,225
Inerts	10.4	3.6	15	0 54	3.06	0	0
Total	100.0	34.6	15	5 19	29.41	3,136	92,225

MSW = 446 TPD RDF = 154 TPD

TABLE-12.10.2

Case No.: 8 Decreased inerts by 30% in MSW = 22.4%

Material: MSW

Constituents	Wt.. wet basis		Moisture		Dry Wt.	HHVd	Total Heat Value
	%age	Tonnes	%age	Tonnes	Tonnes	KCal/kg	KCal x 10^3
Combustibles	77.6	77.6	41.7	32.36	45.24	3,830	173,269
Inerts	22.4	22.4	20.0	4.48	17.92	1,094	19,604
Total	100.0	100.0	36.84	36.84	63.16	3,054	192,873

HCVd = 3,054 kCal/kg NCV = 1,928 kCal/kg

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12.3 Effect of moisture in MSW

The moisture content in MSW is another parameter that determines its quality. In case the overall moisture content increases from the base case of 35%, correspondingly the requirement of MSW will increase and vice versa. This increase is not only due to the proportionate decrease of dry material in MSW but also for the increased requirement of segregated fuel from MSW for HAG needed to evaporate extra moisture in the dryer and increased requirement of RDF due to its higher moisture content than that of 5% taken for the base case.

For a base case, the quantity of fuel required in HAG is 60 TPD to evaporate 124 TPD of moisture. There is also an inbuilt capacity to evaporate up to 140 TPD of moisture in dryer with additional fuel in HAG. This amounts to 21.5 tonnes of evaporation per 100 tonnes of MSW. In case the additional moisture exceeds this value, the extra moisture will end up in RDF and thereby increases its moisture content. These aspects have been brought out in the following sections. These also include the requirement of additional RDF for extra drying.

A. ***Generation of data for changes in moisture content of MSW***

Basis: 100 tonnes of MSW

Base case: Moisture = 35 t and Dry material = 65 t in MSW

After initial segregation, 80% of material at original moisture content is fed to the dryer.

Dryer has capacity to remove upto 21.53t/100t of MSW, the excess will appear as moisture in RDF.

Because of varying moisture content, the recovery of RDF is taken on dry basis and can be considered as the base case value of 45.25 percent.

The higher heating value of RDF is taken as 2800 kCal/kg. Any excess moisture will correspondingly decrease this value proportional to the dry material content.

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Based on the above design data the amount of MSW required and HCVd value of RDF as a function of changes in moisture content in MSW from base value are commuted and presented in Table [illegible]. A Sample of calculations for one typical case is given below

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(a) Sample case (10% increase in moisture)

Base case Moisture = 35%

Present case Moisture = 35x1.1 (10% increase)

= 38.5%

(b) **Basis: 100 tonnes of MSW (moisture 38.5%)**

Moisture in MSW = 38.5 t

Dry material = 61.5 t

Material fed into dryer = 80%

(c) Quantities fed into dryer

Moisture = 30.8 t

Dry matter = 49.2 t

Total = 80.0 t

(d) Maximum possible removal of moisture

In Dryer = 21.53 t

(e) Moisture in the dried material =30.8–21.53 = 9.27 t

Percentage moisture in dried Material = $\frac{9.27 \times 100}{49.2+9.27}$ = 15.85%

(f) Taking recovery of RDF from MSW on dry basis.

The amount of dry RDF produced= 61.5 x 0.4525

= 27.83 t (dry)

with 15.85% moisture, wet RDF = 32.40t (wet)

(g) HCVd of RDF with 15% moisture (Base case) = 2800 kCal/kg

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(h) Equivalent HCV of RDF $= \frac{2800 \times 0.8415}{0.85}$

(Moisture = 15.85%) = $\underline{2772}$ kCal/kg

(i) For equivalent energy as per base case RDF fluff of 2772 kCal/kg required

$= \frac{2800 \times 29.41}{2772}$ =29.71 t (dry)

Fluff produced from 100 t of MSW (I) =27.83 t (dry)

(j) Additional fluff required for HAG to Evaporate extra moisture

Additional evaporation =(21.53-18.82)=2.71t

RDF required $= \frac{2.71 \times 1200 \times 10}{2772 \times 10 \times 0.8}$ = 1.47t

(1200 kCal is required for evaporation of one kg of moisture in dryer and 0.8 is the efficiency of HAG)

Total fluff required =29.71+1.47 = 31.18 t

(k) MSW required = $\frac{31.18}{27.83} \times 100$ = 112 t

(l) MSW required per day + $\underline{560 \text{ TPD}}$

TABLE-12.11

Data heat and material balance as function of changes in moisture content of MSW basis : 100 Tonnes of MSW

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Case No	%age Increase of Moisture	Moisture in MSW	Evaporation in Dryer (t) of water	Moisture Content of RDF %	RDF Quantity dry Processed basis	HCV of RDF	Amount of RDF Reqd for power dry basis	Extra MSW for Drying	Total RDF DRY WET (t)	MSW reqd TPD
Base	0	35.0	18.82	15.00	29.41	2800	29.41	NIL	29.41/34.60	500
1M	10	38.5	21.53	15.85	27.83	2772	29.71	1.50	31.21/40.82	560
2M	20	42.0	23.68	17.61	26.25	2714	30.34	2.6	32.94/45.68	627
3M	40	49.0	23.68	27.56	23.08	2386	34.51*	2.6	37.11/58.53	804
4M	-10	31.5	18.82	10.43	31.00	2951	27.91	NIL	27.91/32.77	450
5M	-20	28.0	18.82	5.85	32.58	3101	26.55	NIL	26.55/29.66	407

***Includes 3% extra for poor burning characteristics**

TABLE-12.12

Sensitivity analysis of RDF process

(as a function of inert content)

Case No.	MSW Inerts		MSW Moisture	MSW MSW	MSW HCVd RDF	RDF Moisture Content	MSW Required
	%age increase	%age	%	KCal/kg	KCal/kg	%	TPD
Base	0	32.0	35.00	1798	2800	15	500
1	10	35.2	34.00	1755	2690	15	521
2	20	38.4	33.37	1711	2578	15	543
3	30	41.6	32.67	1705	2463	15	570
4	40	44.8	31.97	1625	2350	15	596
5	50	48.0	31.28	1581	2240	15	625
6	-10	28.8	35.45	[illegible]	2913	15	481
7	-20	25.6	36.14	1886	3024	15	463
8	-30	22.4	36.84	1928	3136	15	446

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12.4 Observations and conclusion

Table-12.11 indicates that the requirement of MSW to produce RDF with rated energy is very sensitive to its moisture content. For example, an increase of moisture content from 35% to 42% an increase of 20% from design value, may marginally reduce the HCVd of RDF from 2800 to 2714 kCals. RDF requirement from 34.6 to 45.68 tonnes per 100 tonnes of MSW, an increase of about 30%, but requirement of MSW is substantial, from 500 TPD to 626 TPD, which amounts to 25 percent. This is so, because the dry material content is reduced and the separation efficiency depends upon the dry material content. In addition, RDF requirement goes up because of its reduced HCV and correspondingly the MSW requirement in increased. The separation in the case of a moist material is less effective as here the separation of moisture between wanted and unwanted materials also takes place, which is not productive for separation. Therefore, in order to reduce the requirement of extra MSW, the drying capacity should be increased. Since this is an expensive operation, one has to deal with a reasonable trade off.

In the case of increase in inert content, the comparative requirement of MSW is not that much because the drying load is not increased to that extent what is needed for MSW with increased moisture. For example, increase of inerts in MSW from 32 to 38.2% (increase of 20%) will decrease RDF's HHVd from 2800 to 2578 (8%) but the MSW requirement goes up from 500 to 548 and an increase of 10%.

~~The generation of data and its analysis concludes that the calorific values of RDF and the~~ corresponding requirement of MSW are both sensitive to increases in moisture and inert contents of MSW, but the moisture content is definitely more sensitive to the quality and quantitative recovery of RDF than the increase of inerts in MSW. Therefore, all possible efforts should be directed to procure MSW with least possible content of moisture and also the inerts. This is possible with the progressive adoption of source segregation of MSW.

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13.0 CLIMATE CONDITIONING IN MSW PLANT

13.1 Identification of problem

Since handling and processing of MSW has many health hazards some special measures are imperative that should provide a proper hygienic and congenial working environment for the operating plant personnel Although most of the operations are mechanized yet some manual intervention is essential for its smooth and trouble free operation of this plant. Before these measures are discussed. it is important to first identify such specific factors present in MSW processing plants and are responsible for the health hazards to plant personnel These are,

- **Infectious nature of MSW due to the presence of food remnants with sufficient moisture content ideal to promote the growth of bacteria.**
- **An obnoxious smell and odour due to MSW decomposition and evolution of volatile aromatic organic components.**
- **Generation of dust due to total solid processing, especially in those operations that are carried out after MSW gets dried in the dryer.**
- **Attraction and breeding of rodents, dogs, birds, other disease vectors and insects & their menace.**

13.2 Proposed remedial measures

The following remedial and climatic control measures in the MSW processing building are undertaken to provide safe and hygienic working environments.

13.2.1 Design of building and plant layout

The first step is the design of building and then its plant layout that should be taken in a manner that a minimum possible floor area is needed so that climate conditioning of the building can be effectively and economically achieved. Furthermore, layout of plant and machinery is so devised as to involve minimum possible of manual [illegible]

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intervention. Accordingly, in the proposed layout the material MSW is first taken to the requisite high level using [illegible] and then it is allowed to move downwards through various operations as the gravity flow pattern. This way, the spreading of MSW and its yard manual segregation involving lifting of various unwanted components using manual force can be totally avoided. Also, most of the operations are taken up on ground level to keep the height and hence, the volume of enclosed building as low as possible.

13.2.2 Control of odour and infectious nature of MSW

To control the odour and also for convenient unloading of MSW from trucks to the processing plant, it is essential that it should be dropped into one of the two specially designed pits and immediately after its unloading, the fresh lot of MSW is disinfected by spraying with an herbal insecticide. This confinement of MSW, thus exposing its minimum surface area, should produce much less smell and its further disinfection should facilitate its ultimate odour elimination by discouraging any further decomposition of MSW.

This unique spray system is further detailed in Section-13.3. These pits are also located inside the building itself for confinement of pollutants. However, to enable unloading of MSW from trucks, each pit is provided with a set of mechanized collapsible shutters. These shutters are opened only during the unloading of MSW.

Furthermore, the entire process building is kept under a slight negative pressure, which allows fresh air to enter the building and does not allow both odour and suspended particles to escape outside into the surrounding areas of the plant. Also the process cycle has been so devised that the raw MSW is not allowed to stay in the storage pits for more than 20 hours. These pits are sprayed periodically with mild disinfectant solution.

After the initial segregation and homogenisation, once the materials is dried involving thermal treatment and simultaneous deposition of aerosol fine particles on to MSW, present in hot flue gases, in the dryer, the resulting dryer product gets totally sterile with no further chances of its decomposition.

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13.2.3 Climate conditioning

As mentioned earlier, most of the operations for MSW processing are carried out mechanically. However, in those areas where manpower requirement is necessary provisions have been made to supply fresh air continuously to these identified areas.

Also to take care of the weather conditions in Guwahati and to provide the necessary comfort working level, humidified and cool air in hot dry summer months and warm air during winter months should be injected into the selected areas of the process building. The air-cooling can be done through humidifier coolers, while air can be warmed using the heat energy from the hot air generator.

13.2.4 Control of Dust

A specially designed central dust suction and control system is installed to take out dust from all dust producing machinery such as, crushers, trommels, etc. and from all material transfer points. The control system comprises enclosures with negative pressure for all trommels, hoods and proper duct connections at all dust producing points and connected to a network of pipes and ductings. The dust laden air is taken out of the building and entrained dust is recovered at a central point through a set of cyclones and bag filters before letting the air off to the atmosphere.

This arrangement comprising (a) spraying the MSW with herbal insecticide (b) providing negative pressure inside the process building (c) allowing fresh and conditioned air with temperature controls and (d) having a dust collection and removal system should ensure the establishment of desired congenial and hygienic environments in the process plant building.

In addition to these provisions, plant personnel will also be provided with safety gears such as, safety boots, gloves, masks, safety goggles and suitable working dress like boiler suits.

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13.2.5 Control of rodents, menace from dogs, birds and insects

Apart from a few mandatory design features to be incorporated, the most important requirement to control the menace of these disease factors including those from the flies, mosquitoes and other insects is to keep up and maintain good house keeping the work place and MSW storage pits should be periodically cleansed and disinfected with household/industrial insecticides

Amongst the many appropriate design and operational features incorporated, the notable measures to control menace of insects are:

- Dumping of MSW in enclosed pits
- Efficient disinfection by fogging of insecticide
- Control of odour
- Storage of MSW for no more than 20 hrs

In addition, the following should be provided to take care of other disease factors.

1. All drains going out of the building should be provided with proper bar guards to prevent entry of big animals like dogs and flying birds. In addition, a small sump filled with liquid disinfectant should be installed at the exit of each drain in which the rodents have to swim through before entering the process building. This will act as a deterrent for rodents to enter the building from outside.

2. The flooring inside of the building and outside in the surroundings areas of the plant should be made of concrete or hard enough so that rodents are unable to dig up these areas to make their dwellings.

3. Inside the building, a few electric fly/mosquitoes killing devices should be installed for the flying insects.

4. Being fully enclosed with no spreading of waste, one does not expect birds to enter the building. However, to discourage these birds to make their dwellings [illegible]

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surrounding the plant, ultrasound hooters at appropriate sites and periodic bursting of loud shots (like gun shots) should be incorporated

5. Periodic automatic fogging of the open area of the plant and its surroundings with fine insecticides will discourage the pests from breeding in the plant

13.3 Herbal disinfectant spray system

13.3.1 Basis

As mentioned in Section-13.2.2 that spray of a suitable herbal disinfectant is essential to control the decomposition of MSW during its processing to avoid emission of odour, generation of disease vectors and to prevent attraction of rodents and birds to feed on MSW. Since this disinfections involves an additional operating cost and also add on to its moisture content it is desirable to develop a technological system, which is automatic and involves the least possible consumption of disinfectant. Therefore, spraying of this solution by a fogging mechanism is considered as the most appropriate method. Accordingly, a spray system has been devised to meet these requirements.

13.3.2 System configuration

The recommended dosage of a commercially available herbal disinfectant is 1.5 litre/tonne of MSW with 1% concentration. This implies that the disinfectant solution should be first prepared, pumped and then sprayed through special fogging nozzles in a judicious manner. The system envisaged is schematically shown in Fig.13.1. The mixing and pumping arrangement has been located outside the building for its convenient handling and comprises the following components.

A. Two mixing tanks with mechanical stirrers

While one tank is ready for its use the other is deployed for making solution. As about 1000 litre of solution is needed per day, the capacity of each tank should be about 1.5 m^3 and constructed in SS 304 to avoid their atmospheric corrosion.

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B Two positive displacement pumps (gear pumps) in CI with adjustable by-pass valves

Only one pump is used at a time and other is meant as a standby. The capacity of each pump should be 250 liters/hr at 2 bar pressure.

C Interconnecting piping and valves is shown in Fig 13.1

All these items should be in rigid PVC to avoid corrosion due to their constant contact with MSW.

13.3.3 Spray Arrangement

The liquid is pumped through a 2.5 cm dia main manifold to the pit area and then connected to 20 segmental piping manifolds. These are fixed on the top of pits on their three sides through a network of solenoid valves. Each segmental piping manifold is fitted with four fogging nozzles that are slightly inclined to direct the fog in downward direction into the pits.

Depending upon where a particular truck has located itself for unloading of MSW, only those areas specific set of nozzles are energized by electrical switches which are coupled to the opening of the corresponding rolling shutter. This arrangement will minimize the consumption of disinfectant with enhanced effectiveness without any human intervention.

These fogging nozzles made in SS 316 are commercially available in various sizes and ranges in term of their spray angle, spray length and duration of suspension. Furthermore, to increase this duration of suspension of fog before its settling a small amount of surfactant (like cheap industrial detergent) can be added into the solution. In industry, these nozzles are commonly used for suppressing of dust during handling of fine solids.

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13.4 Maintenance of negative pressure in MSW processing building

13.4.1 Methodology

The negative pressure in any enclosed space can be created by extracting air from it through high capacity exhaust blowers/fans. In addition, this polluted exit air has to be treated before it could be allowed to go into the atmosphere. This stand alone process is envisaged for installation in the RDF plant.

The areas in RDF plant which are considered for negative pressure maintenance are MSW pit area with hoist, manual segregation section, shredder room, conveyor shredder to trammel passage and trammel area.

TABLE 13.1

Section	Size M x M	Area Sq.M	Height M	Volume Cum	Volume changes/hr	Air flow Cum/hr
MSW pit area with hoist	48 x 12	576	14 Max Avg.13.5	8,000	2	16,000
Manual segregation station	11 x 6	66	4	264	6	1584
~~Shredder room~~	~~11.18x10~~	~~111.8~~	~~10~~	~~1118~~	~~4~~	~~4472~~
Conveyor, shredder to trammel passage	6 x 6.5	39	6	234	2	468
Trommel area	6 x 15.5	93	10	930	4	3720
Total		885.8		10,608		26,244

The Table 13.1 gives the size of the building, volume changes and air flow etc. For Ballistic separator as [illegible] the material is dry there is no smell. Only dust evacuation system will be adequate.

13.4.2 Openings for ingress of fresh air

The following openings/avenues have been identified for the ingress and forced injection of outside air, which have a direct effect on the maintenance of negative pressure inside the building.

A. Collapsible pit shutters

For obvious reasons mentioned earlier, MSW storage pits are located inside the buildings which have been provided with electrically operated collapsible shutters on one side of the building towards the main road meant for trucks to bring in fresh MSW. A large amount of fresh air will ingress into the building when these are opened to facilitate unloading of trucks. This movement of air will prevent the dust and pollutants to escape outside the building. However, it is desirable that these doors should be kept open for as minimum period as possible so as not to disturb the negative pressure appreciably inside the process building.

B. Leakages from other unavoidable openings and interconnecting doors

Since after segregation various solid feed streams and inerts have to be taken outside the building through various means such as chutes, belt conveyor trolleys, there are bound to be some leakages even if their respective openings are sealed through appropriate techniques by having flexible curtains. Furthermore, all interconnecting doors for movement of men and material should have double door system to avoid too much ingress of air into the building.

C. Fresh air injection at manual interventional areas

To enable the plant personnel to have safe and hygienic working environments a number of isolated areas/cubicles/isolated cabins, EOT pulpits have been identified wherein the forced injection of conditioned air is provided in sufficient quantity. This [illegible]

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pressurized air will also provide outward airflow from these working areas making them free from dust. Atleast Six volume per hour should be incorporated

13.5 Climatic control for plant personnel

13.5.1 Identification of areas needing fresh air

As mentioned above, sufficient fresh air has to be supplied by forced convection to the isolated areas having manual activities. As envisaged the plant is highly mechanized with a centralized and automatic dust extraction ducting networking system connecting all dust producing equipment and solid transfer points. However, there have to be some areas, where mandatory manual intervention is required. It is necessary to provide Six volume changes in these locations with fresh air during normal weather, climatically controlled air during very hot and cold weather months throughout the year.

Strategies for climatic conditioning of fresh air

In order to provide climatically controlled air for the plant personnel, the following techniques can be adopted. As mentioned earlier the air will be cooled or heated by their respective centralized systems and then supplied through a networking of properly insulated ducting and dampers to all the identified areas.

For most of the months in a year, that is, from February to April and then August to November, only filtered and fresh air will be supplied. During extremely hot months of May to June and part of July air shall be cooled. During winter months of December to end January, it shall have to be heated to provide comfortable working environments. A schematic arrangement of this system is shown in Fig.13.2.

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11.9 RISK MATRIX

Risk factor	Allocated	Proposed mitigation mechanism
Pre-construction risks		
Finalization of key contracts	Project Developer	Finalization of all key contracts to the satisfaction of lenders is being stipulated as a condition precedent to financial closure.
Approvals and permits	GWMCL7 project Developer	All the major approvals for the project are being obtained. Obtaining all approvals and permits is being stipulated as a condition precedent to financial closure.
Financing Risk		
Equity	Project Developer	The developer has to identify the sources of equity To ensure the equity of others are tied and brought, a condition precedent to Financial Closure for the signing up of shareholders agreement is put up.
Term loan	Project Developer	The developer has to approach banks and Indian financial institutions for tying up its debt requirement. Tying up of the entire debt is being stipulated as a condition precedent to financial closure.
Interest Rate	Project Developer	In the eventuality of interest rates being higher, the increase in IDC shall be borne by the developer and a

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Risk factor	Allocated	Proposed mitigation mechanism
		suitable condition in this regard has been stipulated
Construction risk		
Land availability	Project Developer	A [illegible] condition for acquisition/ lease agreement of land prior to Financial Closure has been stipulated Land (about24. 12 Hectares) has been identified for the project at Boragaon. Site Guwahati.
Inflation	**Project Developer**	Fixed price, fixed time turnkey contract has to be executed with the EPC contractor for each package.
Completion	**Project Developer**	Liquidated damages for delay in completion on account of default of the EPC contractor has to be provided in the EPC contract for each package. In addition, suitable insurance in the form of ALOP would also be stipulated for the project
Plant performance	**Project Developer**	Provision for suitable liquidated damages for non-performance has to be provided in the EPC Contract for each package.
Delay in connection to grid	**Project Developer**	To be taken care in the PPA. Moreover the substation to which exportable power is connected is located very near the plant.

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Risk factor	Allocatee	Proposed mitigation mechanism
Operational risks		
Reduced plant performance.	Project Developer	Preferred vendors will be stipulated in the bid documents. Vendors with proven experience in their field will alone be considered for the procurement. O&M contract shall have certain minimum performance standards to be maintained by the O&M contractor, which includes the production of RDF and minimum PLF of the plant and Heat Rate as guaranteed. In the event of failure of O&M contractor to achieve these standards adequate LD clauses will be incorporated in the contract.
Environmental requirements	Project Developer	The EPC Contract provides for suitable guarantees to conform to emission norms as per government guidelines. The O&M contractor would address the risk during the operational phase.
Strikes	Project Developer	Low risk in light of trained personnel.
Off-take risk		
Price risk	Project Developer	To be taken care in the PPA
Payment risk	Project Developer	Suitable payment mechanism to be ensured

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Risk factor	Allocated	Proposed mitigation mechanism
Political Risks		
Change in Law	Project Developer	To be taken care in all contracts
Force Majeure: Political	Project Developer	To be taken care in all contracts

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15.0 ARCHITECTURAL INPUTS

The proposed integrated waste processing complex would be first of its kind with the start-of-art design not only in India but also in the world

To create a model MSW plant in India, visits have been undertaken to the operating plants in India, Europe & other Asian countries to witness the infrastructure facilities. GWMCL has initiated discussions with Indian and foreign architects for the designing of the integrated complex. As GWMCL is the process of finalizing the architecture, the details of the same will be provided later.

GWMCL is working to make the layout of the plant such that the flow of material is uniform and the plant buildings are aesthetically good. The large industrial complex deserves architectural treatment, however, it may not be to the level of European conditions. which take care of climatic requirements also. A balance between aesthetics and costs will be evaluated.

It is important to establish whether the plant / elements of a plant shall be required to be enclosed in a building envelope or leave the equipment out doors. For the power plant, the boiler will be an out door unit and the air cooled condenser, switchyard, transformers, etc. will be kept out doors. The turbogenerator, all the electrical panels, compressor, DCS control system, TG hall crane, etc. will be inside the building. This building will have a good architectural view and this building will also be kept under slight positive pressure to avoid dust entry.

The complete RDF plant, MSW receiving area, palletizing area, fluff storage area, etc. will be housed in a building, whereas, the hot gas generator, recyclable material storage area will be kept out doors

The general guidelines for the building design will be,

- To adopt energy conservation
- To use colour, shapes and different building materials to give an aesthetic look internally and externally
- To go vertically up to minimize ground coverage

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In addition, green belts will be developed during the course of plant installation and tall varieties of trees will be planted along the roads at regular intervals in order to have an aesthetic look in the plant.

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16.0 SPECIAL FEATURES OF THE PLANT

16.1 General

The Plant has been conceived as an integrated MSW Processing Plant, consisting of municipal waste processing to RDF and ultimately producing Power to an extent of 6.0 MW. The Plant has been designed to ensure that there is maximum reutilization of all by products at various stages thus reducing the effluents let out from the plant to meet the National Standards. The following sub-sections briefly mention special features of the individual processing plants and the Power Plant.

16.2 Special Features of RDF Plant

- The Plant has been designed to handle MSW with a minimal manual intervention e.g. there is no yard for spreading the incoming garbage and hence no yard segregation.

- The incoming MSW is dumped into two engineered pits and immediately sprayed with herbal disinfectants through fogging nozzles to control the associated odour and elimination of any disease vectors such as flies, mosquitoes, rodents etc. Furthermore the raw MSW is not allowed to stay in plant for more than 24 hours.

- The storage and processing of MSW is completely carried out in a multi-floor enclosed building kept under slightly negative pressure to avoid spread of dust and odour (if any) to the surrounding areas. The air removed to maintain this negative pressure is filtered and scrubbed before letting it off to the atmosphere.

- Sound pollution is minimized by isolating rotating machinery such as blowers etc with suitable enclosed sound barriers.

- To eliminate occupational hazards to the plant personals each manned place/station will be provided with fresh air through air incoming [illegible]. Furthermore, the dust emanating machinery and material transfer points will have [illegible]

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individual dust aspiration hoods and ducting to have dust free environment in the plant.

- Unwanted materials including inert recovered during processing are either recycled in the plant or properly taken out as segregated items for their utilization as raw materials to other recycling industries. In short, integrated inert management is an important feature of the plant

- Adequate fuel back up has been provided, so that the Power Plant can continue to run even during monsoon period, where the arrival of the MSW itself may not be possible due to wet conditions.

16.3 Special Features of Power Plant

In the power block, the plant and machinery are conventional with proven track record for decades. In other words, there is no special feature in the power plant after the steam is generated in the boilers. The only special feature in the power block is boiler design to suit the type of fuel, in this case RDF fluff. The boiler design will take care of the following requirements:

- The steam cycle parameters have been chosen conservatively because of the nature of fuel and the presence of Chlorine in the fuel. To avoid high temperature corrosion, the stem cycle parameters have been fixed as 43 ata 415 Deg.C at boiler outlet. The flue gas velocity across the transfer surfaces will be conservatively kept at 5 M/sec to 7 M/sec.

- The corrosion effect during the burning of RDF is very high and hence, the heat absorption surfaces are designed to avoid high metal temperature zones. Moreover, provision is made for refractory lining in the lower part of the furnace.

- The grate design is also taking care of the unique characteristics of the fuel and its ash content apart from the metallurgy of grate components.

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- The soot blowing system is designed to take care of the sticky nature of the ash which gets deposited at various heat transfer sections

- The fuel feeding system is designed to take care of the vagaries in the fluff size to ensure uninterrupted flow of the fuel

- The pressure and temperature of steam cycle is also kept at a very conservative level to avoid the high temperature corrosion in the super heater sections.

- Staged combustion will be adopted in the furnace to avoid NO_X emission.

- Provision will be given in the furnace for chemical injection, to control emission of SO_X / NO_X. Bag house are provided to reduce particulate emission. The layout make provision for introduction of scrubbers for controlling dioxins, SO_X, etc. at a later date.

- RO and DM plants are envisaged in the water treatment plant of the power plant to generate DM water for boiler

- This power plant is going to use air-cooled condensers for condensing the steam exhaust from the turbine. The steam is cooled using heat transfer surfaces across which atmospheric air is passed through. The air-cooled condensers require very little water, that too only for cleaning purposes. Use of air-cooled condensers reduces the water pollution due to blow down from large cooling towers.

- The power export is at 33kV level and the sub station to which the power is connected is very near to the power plant.

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ANNEXURE-I
DRAWINGS

S.No.	Drawing no.	Drawing title
1.	GWMCL-EE-SLD-001	Single Line Diagram
2.	GWMCL-ME-GA-007	RDF Feed System
3.	GWMCL-ME-SCH-001	Energy Balance Diagram For the Plant
4.	GWMCL-ME-SCH-002	Water Balance Diagram For the Plant
5.	GWMCL-ME-SCH-003	Material Balance Diagram for RDF & Power Plant
6.	GWMCL-ME-SCH-007	Organization Chart for Integrated Complex

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ANNEXURES II

TABLE – 1	FINANCIAL ANALYSIS
TABLE – 2	BASIC DATA FOR DESIGN
TABLE – 3	RDF PLANT: REQUIREMENT OF FIRE FIGHTING EQUIPMENT
TABLE – 4	LIST OF SUPPLIERS

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ANNEXURE I

TABLE. 1 (FINANCIAL ANALYSIS)

6MW POWER PLANT AT INTEGRATED WASTE MANAGEMENT COMPLEX, GUWAHATI

Basic Assumptions	
PLF (in %)	70%
Loan period(yrs)	10
Gross generation (in MU)	37
Auxiliary consumption (in %)	20%
Net power (in MU)	29.32
Debt:Equity ratio	2.33:1
Rate of interest(in %)	12%
Tax with surcharge & cess(in %)	33.60%
MAT with surcharge & cess(in %)	8.40%

Plant Details		
RDF	TPD	500
Biomethanation Plant	TPD	0
Sewage Treatment Plant	MGD	0
Power Plant	MW	0
Biomass	TPD	0

Particulars	In %	Cost(in Rs. Mn)
Grant	0%	0.00
Equity	30%	151.43
Debt	70%	353.34
Total	100%	504.77

Integrated Plant- Cost Details	
Description	Cost(in Rs. Mn)
RDF Plant	118.34
Biomethanation & STP plant	0.00
Power Plant	304.80
IDC	48.78
Finance Charges(0.5% of Debt)	1.77
Project Development Expense	10.10
Working Capital margin	8.12
Contingency(3%)	11.79
TOTAL COST	504.77

Financials		
1st year Tariff (20 year period)	Rs. Kwh	5.00
Levelised Tariff (20 year period)	Rs. Kwh	4.83
Internal Rate of return	%	10.18%
DSCR		
Min		1.08
Max		1.35
Avg		1.11

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TABLE - 1 (FINANCIAL ANALYSIS)

RDF Plant - Cost Details				
Description	Unit	Qty	Rate	Amount Rs. in mn
Land & Land Development				
Land	Acres	1	[illegible]	[illegible]
Land filling, dressing, plantation, boundary wall	Lumpsum			[illegible]
Paved yard	sq.m.	[illegible]	[illegible]	[illegible]
SUB TOTAL				[illegible]
Civil Works				
[illegible]	sq.m.	[illegible]	[illegible]	[illegible]
[illegible]	sq.m.	[illegible]	[illegible]	[illegible]
[illegible]	sq.m.	[illegible]	[illegible]	[illegible]
[illegible]	Lumpsum			[illegible]
[illegible]	Lumpsum			[illegible]
Administrative Building	Lumpsum			[illegible]
Foundation of equipment	% of P&M	[illegible]	[illegible]	[illegible]
SUB TOTAL				[illegible]
Plant & Machinery				
Plant & Machinery				[illegible]
Transport & erection including	% of P&M	[illegible]	[illegible]	[illegible]
[illegible] cost	% of P&M	[illegible]	[illegible]	[illegible]
SUB TOTAL				[illegible]
Misc. Fixed Assets				
Electrical Work	Lumpsum			[illegible]
[illegible] power distribution board				
[illegible]				
[illegible]				
[illegible]				
Lighting				
[illegible]				
[illegible]				
[illegible]				[illegible]
SUB TOTAL				[illegible]
TOTAL				[illegible]
[illegible]				

RDF- Plant & Machinery				
Plant Layout No	Description	QTY	Rate (Rs. mn)	Amount (Rs. mn)
[illegible]	ELECTRONIC WEIGH BRIDGE	[illegible]	[illegible]	[illegible]
[illegible]	MSW STORAGE PIT (Additional)	[illegible]	[illegible]	[illegible]
[illegible]	CHEMICAL SPRAY SYSTEM WITH MECH. ARM	[illegible]	[illegible]	[illegible]
[illegible]	EOT CRANE WITH GRAB BUCKET (Existing)	[illegible]	[illegible]	[illegible]
[illegible]	EOT CRANE WITH GRAB BUCKET (Additional)	[illegible]	[illegible]	[illegible]
[illegible]	VIBRATORY FEEDER	[illegible]	[illegible]	[illegible]
[illegible]	SORTING CONVEYOR WITH MAG. SEPARATOR	[illegible]	[illegible]	[illegible]
[illegible]	MANUAL PICKUP ZONE	[illegible]	[illegible]	[illegible]
[illegible]	FINES SEPARATION ROTARY SCREEN	[illegible]	[illegible]	[illegible]
[illegible]	FINES EXTRACTION SCREW CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	BIN FOR DUST COLLECTION	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY SCREEN (CLASSIFYING)	[illegible]	[illegible]	[illegible]
[illegible]	CUTTER CHIPPER FEEDING CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	CUTTER CHIPPER	[illegible]	[illegible]	[illegible]
[illegible]	FLUFFING MACHINE	[illegible]	[illegible]	[illegible]
[illegible]	PRIMARY SHREDDER	[illegible]	[illegible]	[illegible]
[illegible]	PRIMARY SHREDDER DISCHARGE CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY DRYER WITH CYCLONE, FAN, CHIMNEY	[illegible]	[illegible]	[illegible]
[illegible]	HOT AIR GENERATOR (HAG) WITH FA/ID FAN	[illegible]	[illegible]	[illegible]
[illegible]	PLANT	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY SCREEN FEEDING CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	FEED DIVERTOR	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY SCREEN	[illegible]	[illegible]	[illegible]
[illegible]	SCREW CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	DUST TRANSFER BELT CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	BIN FOR DUST COLLECTION	[illegible]	[illegible]	[illegible]
[illegible]	AIR CLASSIFIER FEEDING CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	VIBRATORY FEEDER CUM FEED DIVERTER	[illegible]	[illegible]	[illegible]
[illegible]	AIR CLASSIFIER	[illegible]	[illegible]	[illegible]
[illegible]	HEAVY REJECT TRANSFER CONVEYOR	[illegible]	[illegible]	[illegible]
[illegible]	CYCLONE WITH AIR LOCK & FAN	[illegible]	[illegible]	[illegible]
[illegible]	STORAGE BUNKER	[illegible]	[illegible]	[illegible]
	TOTAL			72.84

RDF- Electricity Consumption		
Processing Load		
Connected Load [illegible]	[illegible]	[illegible]
Operating Hours in a day	[illegible]	[illegible]
Utility Factor	[illegible]	[illegible]
Consumption in day	[illegible]	[illegible]
[illegible] Load		
[illegible]	[illegible]	[illegible]
Operating Hours in a day	[illegible]	[illegible]
Utility Factor	[illegible]	[illegible]
Consumption in day	[illegible]	[illegible]
Total Consumption	[illegible]	[illegible]
RDF Production	TPD	[illegible]
CONSUMPTION PER MT OF RDF	[illegible]	[illegible]

RDF- Connected Load				
No.	Description	No. in Operation	Load (HP)	Total Load (HP)
[illegible]	EOT CRANE WITH GRAB BUCKET	[illegible]	[illegible]	[illegible]
[illegible]	VIBRATORY FEEDER	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY SCREEN	[illegible]	[illegible]	[illegible]
[illegible]	PRIMARY SHREDDER	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY DRYER WITH HAG	[illegible]	[illegible]	[illegible]
[illegible]	ROTARY SCREEN	[illegible]	[illegible]	[illegible]
[illegible]	AIR CLASSIFIER	[illegible]	[illegible]	[illegible]
[illegible]	CYCLONE WITH AIR LOCK & FAN	[illegible]	[illegible]	[illegible]
[illegible]	CONVEYOR & OTHER INTER CONNECTED LOAD [illegible]	[illegible]	[illegible]	[illegible]
	TOTAL CONNECTED LOAD			[illegible]

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6MW POWER PLANT AT INTEGRATED WASTE MANAGEMENT COMPLEX,GUWAHATI

Power Plant- Cost Details		
Description	**Quantity**	**In Rs. Mn**
Mechanical		
STG	1	42.00
Boiler	1	130.00
Cooling Tower	1	6.60
Compressed Air System	3	1.30
Fire Fighting system	Lot	4.40
Piping	Lot	8.80
EOT crane	1	5.00
WTP/DM Plants		12.00
Raw water pumps	2	0.70
DM transfer Pumps	2	0.35
HVAC system	Lot	0.90
Misc Pumps	Lot	0.20
Ash Handling		3.30
Fuel handling		1.70
Sub -total		217.25
Electrical		18.00
Civil		19.00
Instrumentation		4.50
Spares	3%	7.19
Packaging & Freight	1%	2.40
Insurance	0.25%	0.60
CST(4%) + Freight(1%)	5%	11.99
Erection & Commissioning	10%	23.98
Contingency	0%	0.00
Total		304.90

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