PUBLIC VERSION

MPX Energia SA

Rio de Janeiro • Brazil

Feasibility Study for the Waste to Energy Plant

USTDA Activity No: 2009510019A

Final Report

April 2013

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Tables

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Acronyms and Abbreviations

AD	Anaerobic digestion
ANEEL	National Agency of Electrical Energy
AP	Planning Area (Area de Planejamento)
BOT	Build – Operate - Transfer
CCGT	Combined Cycle Gas Turbine
CER	Certified Emission Reduction
COFINS	Contribution to Social Security Financing - a federal tax levied on gross revenue
COMLURB	Companhia Municipal de Limpeza Urbana
CONAMA	Comision Nacional del Medio Ambiente - the national environment council of Brazil
EPC	Engineer – Procure - Construct
GDP	Gross Domestic Product
LHV	Lower Heating Value
MJ/kg	Megajoule/kilogram
MPX	MPX Energia SA
MSW	Municipal Solid Waste

mtpd	Metric Tons per Day
$mtCO_2e$	Metric Tons Carbon Dioxide Equivalent
PPP	Public/Private Partnership
MW	Megawatt
MWh	Megawatt hour
NPV	Net Present Value
O&M	Operations and Maintenance
PIS	"Programa de Integração Social – a federal tax levied on gross revenue
RDF	Refuse Derived Fuel
RE	Renewable Energy
TJLP	Taxa de Juros de Longo Prazo – Brazil subsidized long term interest rate
TSS	Total Suspended Solids
USTDA	US Trade and Development Agency
WTE	Waste to Energy

Executive Summary

ES-1.1 Introduction

Malcolm Pirnie, a division of Arcadis US has undertaken a feasibility study for a proposed waste to energy (WTE) facility in the city of Rio de Janeiro, Brazil.

This study was sponsored by the US Trade and Development Agency (USTDA) with the goal of assisting economic and social development in Brazil, and promoting export of US products and services.

The study team included MPX Energia SA (MPX) - a private Brazilian energy developer, and the waste management authority for the City of Rio (Companhia Municipal de Limpeza Urbana - COMLURB). MPX has an agreement with COMLURB to use its Caju Transfer Station as the site for this feasibility study. Although parts of the study focus on this site, the results may be applicable to any potential site in Brazil.

The feasibility study is broken into nine tasks, as follows:

Task 1 - Assessment of Municipal Solid Waste (MSW) Supply and WTE Options
Task 2 - Evaluation of Proposed Options via Least Cost Analysis
Task 3 – Detailed Cost and Implementation Schedule Estimates
Task 4 – Economic Evaluation of the Selected Alternative
Task 5 – Environmental and Social/Economic Impact Assessment
Task 6 – Legal, Regulatory, and Institutional Review
Task 7 – Financing Options Review
Task 8 – Tender Document Preparation (Optional task, not requested by MPX)
Task 9 – Final Report

The USTDA's definitional mission sets out the objectives for the project, which include the diversion of nominally 1000 metric tons per day (mtpd) of Municipal Solid Waste (MSW) to an energy recovery facility, where up to 30 megawatts (MW) of electric power could be generated for sale to the grid.

ES-1.2 Task 1 - Assessment of Municipal Solid Waste (MSW) Supply and Waste to Energy (WTE) Options

The assessment includes sources of waste by geographical region and type, seasonal variation and waste characteristics. Based on flow data provided by COMLURB, potential exists for diversion of sufficient MSW from landfill sites to a commercial WTE facility. Table ES-1 shows the tonnage of MSW from various transfer stations and the major destination landfills Gramacho, Gericino and Nova Iguaçu. The mass of waste arriving at Caju transfer station (2800 mtpd) would be sufficient to generate 30 MW of electricity in a conventional Mass Burn WTE facility.

ES Table - 1 **Flow of Waste by Type and Destination (October 2010)**

Transfer Station (ETR)	Mass flow of waste by type (mtpd)							
	A	B	C	D	E	F	Total	
Caju	1490	1130	0	0	0	180	2800	28%
Jacarepaguá	580	300	0	0	0	70	950	10%
Irajá	300	0	0	0	0		300	3%
Missčes (construction waste only)	0	10	0	620	0	60	690	7%
Direct to Gramacho	620	350	0	630	10	120	1730	18%
Total to Gramacho	**2990**	**1790**	**0**	**1250**	**10**	**430**	**6470**	**66%**
Direct to Gericinó	1330	1140	0	80	0	60	2610	26%
Total to Gericinó	**1330**	**1140**	**0**	**80**	**0**	**60**	**2610**	**26%**
Caju	0	0	120	0	0		120	1%
Jacarepaguá	0	0	30	0	0		30	0%
Direct to Nova Iguaçu	0	0	676	0	0		676	7%
Total to Nova Iguaçu	**0**	**0**	**826**	**0**	**0**	**0**	**826**	**8%**
Total	**4320**	**2930**	**826**	**1330**	**10**	**490**	**9906**	**100%**

Household waste from Rio is high in moisture and organic fraction, with a typical heat content of 7.5 – 8.6 MJ/kg. Data for household waste shows heating value increasing steadily over the years 2005 to 2008.

The available technologies were compared and assessed for the Rio de Janeiro application. The assessment was based on guiding principles adopted for this project and included: electrical generation, technology maturity, operational requirements, environmental performance and human factors.

By combining the assessment with site considerations, the following technology choices were recommended for further evaluation.

A. Combustion

   This technology is commercially proven on the scale required and makes the maximum use, in terms of energy recovery, of the heat content in the mixed MSW.

B. Combined Anaerobic Digestion (AD), Composting and Combustion.

   A combination of technologies suits the waste characteristics of Rio de Janeiro. The high organics fraction and moisture is suitable for treatment by AD and composting. The combustion plant would make maximum use of the heat content of residual fraction and provide electrical generation. Since the Caju Transfer Station already includes a pre-sorting plant, this would be included in the integrated facility.

ES – 1.3 Task 2 – Evaluation of Proposed Options via Least Cost Analysis

Determination of the least cost alternative was based on 20 year lifecycle operating costs, taking account of all revenues and expenses.

Preliminary estimates of construction cost for Option A and Option B, both sized to produce net 30MW electricity, were essentially equal. Mass and energy balances were written for both options to establish annual revenues and expenses. A debt service payment was added based on 5% borrowing rate and a 20 year term. From these factors, and using reinvestment rate of 1.0%, the resulting Net Present Value (NPV) and Internal Rate of Return (IRR) for each option were determined as follows:

Option A: NPV = $10,500,000 USD, IRR = 9.2%

Option B: NPV = $25,000,000 USD, IRR = 17.9%

On this analysis the preferred option was the combined facility using the existing pre-sort station. Note that these were preliminary estimates with the sole purpose of comparing two potential technology options. More accurate capital and operating costs and more realistic borrowing rates are discussed in Tasks 3 and 4.

ES – 1.4 Task 3 – Detailed Cost Estimate of the Preferred Option

The project would require two major new facilities on the Caju site:

1. 1400 mtpd mass burn WTE plant treating combined feedstock including mixed waste direct from collections and rejects from the sorting operation.

2. 50 mtpd AD plant treating organics from the sorting operation, sending AD residual for onsite composting and the biogas to the WTE plant.

The costs associated with any upgrades necessary to the existing presorting facility and on-site composting are to be borne by the owners COMLURB, and are not included in this estimate.

Table ES-2 summarizes the preliminary capital budget for construction of the mass burn WTE facility and the anaerobic digestion plant.

ES Table -2 Preliminary Capital Budget (1000 $US)	
Item	**Cost**
Land Acquisition Costs	$ -
Site Preparation and civil work for the AD plant	$ 2,000
Pre-processing	$ -
AD plant	$ 7,115
Mass burn Combustion	$293,752
Total Construction Cost	**$302,900**
Additional Costs (Permitting, Legal, Procurement, Due Diligence)*	$10,700
Total Project Cost	**$314,000**
* Based on 3.5 % of Construction Cost	

A detailed estimate including equipment, construction materials and construction labor is included in Appendix 3-A

Task 4 – Economic Evaluation

A project financial model was used to assess its economic feasibility and to carry out a sensitivity analysis on the major lifecycle cost and revenue factors. Model inputs were derived from the mass and energy balance developed in Task 2 and the capital cost estimate from Task 3.

Under these present financial conditions the plant is not economically feasible, with an NPV of -$250M. The major reason is the high debt service payments and the fact that tipping fees and electrical sales rates do not escalate in line with inflation. Another major factor is that federal sales taxes (PIS and COFFINS) are levied on gross revenues even before the project begins to show profit.

A sensitivity analysis was carried out to determine hypothetical scenarios under which the project could become profitable, defined as achieving IRR of 15%. These focused on reducing debt service payments and increasing tipping fee or electric sales revenue.

For example in Scenario 1, if the capital cost came down to $250M at a borrowing rate of 7.5%, a tipping fee escalation of 10.3% would be needed to achieve an IRR = 15%. In Scenario 2, if the capital cost came down to $250M at a borrowing rate of 7.5%, the flat electric sales rate would need to be $173/MWh to achieve IRR = 15%.

Task 5 – Environment and Social/Economic Impact Statement

The preliminary review of the project's environmental impact focused on compliance with local environmental laws, regulations and requirements, including factors such as air quality, water quality, nuisance impacts, infrastructure, jobs creation, technology transfer and productivity enhancement.

The estimated air emissions for the Caju WTE facility can be seen in ES Table 4, compared with the values prescribed by CONAMA Resolution No. 316/02 – which indicates procedures and criteria for the operation of thermal waste treatment systems.

Table -4 – Estimated Values of Air Pollutant Emissions and Comparison with the Limits Defined by CONAMA Resolution Nº. 316/02										
	NO_x	**SO_2**	**CO**	**PM_{10}**	**Pb**	**Cd**	**Hg**	**HCl**	**HF**	**Dioxins / Furans**
Estimated emissions	215 mg/Nm^3	21.5 mg/Nm^3	60 ppm	12.2 mg/Nm^3	21.5 $\mu g/Nm^3$	1.2 $\mu g/Nm^3$	2.4 $\mu g/Nm^3$	8.1 mg/Nm^3	3.1 mg/Nm^3	0.02 ng/Nm^3 (TEQ)
CONAMA No. 316/02[(1)]	560 mg/Nm^3	280 mg/Nm^3	100 ppm	70 mg/Nm^3	7.0 mg/Nm^3 (Total Metals Cl 3)	0.28 mg/Nm^3 (Total Metals Cl 1)		80 mg/Nm^3	5 mg/Nm^3	0.5 ng/Nm^3 (TEQ)*

An on-site wastewater treatment plant would accept all non-reusable effluents and treat them to below the limits defined by CONAMA Resolution Nº 357/05 and the Rio de Janeiro State Technical Norm of Criteria and Standards for Liquid Effluent Discharge (NT-202.R-10), prior to discharging to any bodies of water.

Other physical environment effects include reduced atmospheric emissions and reduced number of vehicles on certain roads that currently receive heavy traffic. This is due to the reduced number of truck movements from Caju Transfer Station to the remotely located landfill sites currently used.

To the extent that the additional electrical power replaces fossil fired power generation, the project would reduce the emission of greenhouse gases. In addition, the diversion of biodegradable wastes in MSW would reduce the release of methane to the atmosphere. It is estimated this would result in further GHG emission reduction of 27,540 $mtCO_2E$ annually.

Construction Employment is expected to contribute a total of 854 direct, indirect or induced jobs, which becomes significant when viewed at the district level, 5.74% of Active Age Population (AAP) in 2010.

At least 49 full-time workers would be needed to operate the new facilities. Positions would include plant operators, hoist operators, mechanics, electrical maintenance personnel, control technicians, and managers.

Workers at the existing recycling cooperative at Caju Transfer Station would be kept in place, and the new facility would utilize the rejects form this process. Therefore, the work of waste pickers is still of major importance to the collection and processing of urban solid residues in Rio de Janeiro.

Task 6 - Legal, Regulatory and Institutional Review

The Brazilian legislative framework for environmental protection is comprised of many stringent federal, state and local environmental laws and regulations. One of the most relevant Brazilian environmental laws is Federal Law 6.938/1981, which created the Brazilian Environmental Policy and establishes its purposes, formulation and enforcement mechanisms. These mechanisms include, among others, the imposition of environmental licensing requirements for certain plants and activities.

Local laws and regulation of the power sector provide incentives and some specific charges for a WTE generation unit in Brazil. The main incentive is the wire fee exemption, which may have a great impact especially for those consumers supplied in lower voltages, whose wire fees can represent up to R$100/MWh. The wire rate is the tax paid for the use of the distribution system and transmission system. Resolution 271 of ANEEL (National Agency of Electrical Energy) assures the right to a 100% reduction, for generators whose capacity is less than or equal to 30 MW, and use at least 50% biomass as energy input. Biomass in this context includes MSW.

Task 7 – Finance Options

Several Brazilian, US and international institutions have the capability and interest to participate in project financing for the Rio Waste to Energy Facility. These include the Brazilian development bank, multilateral development banks, US government agencies, regional development banks and commercial banks.

Lending institutions were surveyed based upon past commitments to objectives that support projects such as waste to energy and carbon credit financing. Of these, the most actively interested party was the Brazilian Economic and Social Development Bank (BNDES). The BNDES is the largest source of credit for companies in Brazil and can offer below-market interest rates for its loans due to risk-free funding from the Brazilian Treasury through access to the Taxa de Juros de Longo Prazo (TJLP), a subsidized rate set by the Brazilian Finance Ministry.

Features of the BNDES funding proposal would include:

a) Interest rate: TJLP (currently at 5.5%) + BNDES Basic Spread (0.9%) + BNDES Risk Spread (maximum of 3.57% depending on the company's credit rating at BNDES)

b) BNDES financing: maximum of 90% of the entitled investments

c) Duration: approximately 10 years, but may vary depending on the project analysis.

d) BNDES financing may cover investments in new machinery and equipment, (including industrial systems) accredited by BNDES with a minimum domestic content of 60% in value and weight.

US Government agencies including US Export- Import Bank (EX-IM) and Overseas Private Investment Corporation (OPIC) indicated an interest in this project. However, their support would depend on a US firm emerging as a major supplier, operator or equity partner for the facility.

Project Summary

The project has shown that MSW resources within the city of Rio are sufficient to support the development of a WTE facility. In terms of waste characteristics, the low heating value and high organic content would need to be carefully considered in the design phase. One potential approach is to separate organics in a pre-sorting plant and take advantage of their potential for aerobic and anaerobic digestion, while incinerating the rejects stream in a mass burn WTE facility.

The challenges of meeting environmental and regulatory guidelines can be met by adopting best practice in air pollution control and an integrated water reuse facility.

At the present financial conditions considered for this study, the project is not financially feasible, with an NPV of -$250M. The major contributing factors are: high debt service payments, low tipping fees, and the expectation that tipping fees and electrical sales rates will not escalate in line with inflation throughout the project life.

Prospective US Sources of Supply

The following table lists US companies with capabilities to supply equipment for the proposed project. Many of these companies specialize in the waste to energy industry. Others, such as the turbine/ generator companies and the air pollution control companies serve a wide variety of industries.

Waste to Energy Technologies	
1. General Contractor/Vendor	**Contacts**
Wheelabrator	Mark P. Schwartz Wheelabrator Technologies 4 Liberty Lane West Hampton, New Hampshire, 03842 Phone: (603) 929-5419 Fax: (603) 929-3123 email: mschwar1@wm.com
Covanta Energy Company	Matthew R. Mulcahy 445 South Street Morristown, NJ 07960 Phone: (862) 345-5000 www.covantaenergy.com
Energy Answers Corporation	Pat Mahoney 79 North Pearl Street Albany, NY 12207 Phone: (518) 434-1227 www.energyanswers.com
Babcock & Wilcox Power Generation Group Inc.	Jim Gittinger 20 South Van Buren Avenue, Barberton, OH 44203 Phone: (330) 860-6066, Fax: (330) 860-9211 E-mail: jsgittinger@babcock.com

Waste to Energy Technologies	
2. Mass Burn Incinerator	**Contacts**
Detroit Stoker	Dave Jackson 1510 E. First St., Monroe, Michigan, 48161 Phone: (734) 243-2883, Fax: (734) 241-7126 e-mail: djackson@detroitstoker.com web: www.detroitstoker.com
B&W Volund	Jim Gittinger 20 South Van Buren Avenue, Barberton, OH 44203 Phone: (330) 860-6066, Fax: (330) 860-9211 E-mail: jsgittinger@babcock.com
Novo Energy, LLC	155 East Boardwalk, #448 Fort Collins, CO 80525 pschwolert@novo-energy.com jbarlow@novoenergy.com www.novoenergy.com
Green Conversion Systems	Marc McMenamin 411 Theodore Fremd Ave. Suite 102 Rye, NY 10580 Phone: (914) 925-1077, Fax: (914) 925-9344 info@gcsusa.com
3. Boiler /Turbine/Generator Vendors	**Contacts**
Babcock & Wilcox Power Generation Group Inc.	Jim Gittinger 20 South Van Buren Avenue, Barberton, OH 44203 Phone: (330) 860-6066, Fax: (330) 860-9211 E-mail: jsgittinger@babcock.com

Waste to Energy Technologies	
Babcock Power Inc.	One Corporate Place 55 Ferncroft Road, Suite 210, Danvers, MA 01923 Phone: (978) 646-3300, Fax: (978) 646-3301 sales@babcockpower.com www.babcockpower.com
Indeck Keystone Energy	Gary Blazek 5340 Fryling Road - Suite 200 Erie, PA 16510-4660 Phone: (814) 464-1203, Fax: (814) 897-1089 gblazek@indeck-keystone.com
Foster Wheeler Global Power Group	Kirk Jenson 53 Frontage Road PO Box 9000, Hampton, NJ 08827-9000 Phone: (908) 730-4000, Fax: (908) 713-3245 www.fwc.com
Dresser-Rand	Robyn Scalley 299 Lincoln St., Worcester, Mass. 01605 Phone: (508) 595-1701 , Fax: (508) 595-1780 www.dresser-rand.com
Elliott Group	Scott Wilshire 901 N. Fourth Street, Jeannette, PA 15644 Phone: (724) 600 8119, Fax: (724) 600 8442
4. Air Pollution Control Vendors	**Contacts**
Amerex Industries	201 Houston Street, Suite 200, Batavia, IL 60510 Phone: (630) 406-7756 Fax: 630) 406-7758 info@amerexind.com
Siemens Environmental Systems	Jonathan Jones 1345 Ridgeland Parkway, #116. Alpharetta, GA 30004

Waste to Energy Technologies	
and Services	Phone: (678) 867-7438, Fax: (678)256-5522 jones.jonathan@siemens.com
Babcock & Wilcox Power Generation Group Inc.	Jim Gittinger 20 South Van Buren Avenue, Barberton, OH 44203 Phone: (330) 860-6066, Fax: (330) 860-9211 E-mail: jsgittinger@babcock.com
Babcock Power Environmental	5 Neponset Street PO Box 15040, Worcester, MA 01615-0040 Phone: (508) 852-7100, Fax: (508) 854-38001 E-Mail: sales@babcockpower.com www.babcockpower.com
BWF America, Inc.	Clinton Scoble 7453 Empire Dr. #340, Florence, KY 41042 Phone: (859) 282-4550
Donaldson Company Inc.	James Sandy 85 Railroad Dr., Ivyland, PA 18974 Phone: (215) 396-8349
Croll Reynolds	Henry Hage Six Campus Drive, Parsippany, New Jersey 07054 Phone: (908) 232-4200 hhage@croll.com
W.L. Gore & Associates Inc.	Chris Polizzi 101 Lewisville Rd., Elkton, MD 21922 Phone: (410) 392-3300
Fuel Tech, Inc.	Bill Son 27601 Bella Vista Pkwy, Warrenville, Illinois 60555 U.S.A. Phone (630) 845-4500, Fax: (630) 845-4502

Waste to Energy Technologies	
	info@ftek.com
FLSmidth – AFT Division	Shari Bell 715 N. Belair Rd., Evans, GA 30809 Phone: (706) 228 3382

Introduction

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Work on this study was performed by:

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In addition the following subcontractors performed work on this study:

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Fax: +55 (11) 4613.3000

Enerconsult S.A.
Contact: Thiago de Moraes
R Líbero Badaró, 377 - 14º and, 01009-906, São Paulo/SP
Phone +55 11 3226-3400
Fax +55 11 3226-3434

1 Task 1 - Assessment of Municipal Solid Waste and Technology Options

The initial task of the FS included the assessment of Municipal Solid Waste (MSW) supply and its characteristics, and identified options available for energy recovery.

The study included the development of the following:

- Guiding principles – overall criteria for operation and performance on which potentially applicable and acceptable technologies are considered.
- Waste Generation and Characteristics – review of available data on the sources and composition of waste in Rio.
- Review of technologies – an overview of potentially applicable WTE processing options for recovery of electrical energy.
- Facility Location – preliminary assessment of the proposed site identified by MPX for the proposed facility.

The possible operational modes for the facility are included in schematic form. Detailed analysis of plant operations for the selected technology is presented in Task 2.

1.1 Guiding Principles

The following guiding principles were established by the project team as the foundation of the study.

- **Electricity Generation** - The technologies must provide for energy recovery in the form of electricity. Net electrical export is limited to 30 MW, allowing the facility to be designated Renewable Energy (RE) producer and take advantage of market allowances for RE.

- **Processing Capacity –** A technology, or combination of technologies must be capable of processing nominally 1000 mtpd MSW at a single facility.

- **Technology Maturity –** The waste processing technologies should be proven on a commercial scale, at processing capacities required for the facility envisioned in this feasibility.

- **Operational Requirements –** The technology must be capable of handling mixed solid waste (as delivered from collections) at a dedicated site, and would then include any pre-processing required within the facility boundary.

- **Environmental Issues** – the technology must meet regulatory environmental standards and should minimize impact to the surrounding environment, both natural and man-made.

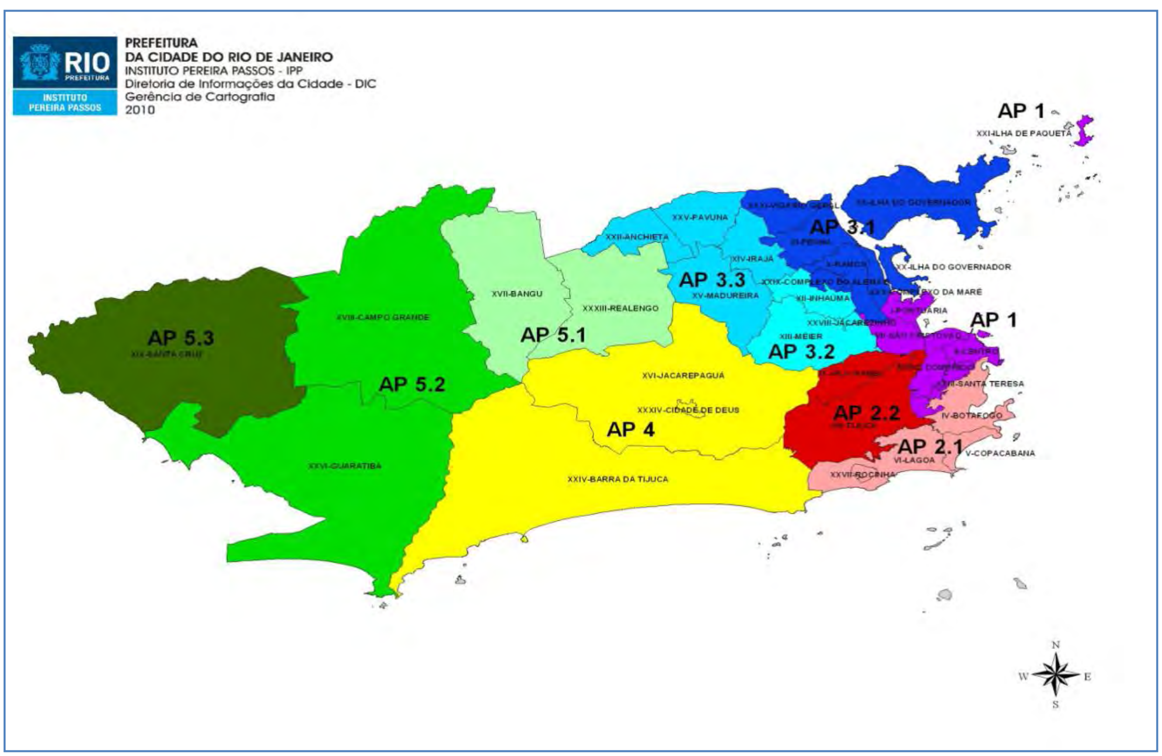
- **Human Factors** – the technology should benefit or not adversely affect the local community and its environment.

1.2 Waste Generation and Characteristics

Sources of Waste

In relation to collection of MSW, the city of Rio de Janeiro contains five planning areas (Area de Planejamento [AP]), symbolized by AP1 through AP5 in Figure 1.2-1. Data on the flow and characteristics of waste have been gathered for each of these areas. Several of these areas are subdivided to specific neighborhoods with differing generation profiles and waste characteristics.

Figure 1.2-1 Rio de Janeiro Planning Areas



Flow and Types of Waste

The MSW collected is categorized into the following types; household, public, large generators, construction waste, city waste, hospitals and other. Each type of waste may be generated throughout Rio and is currently directed to one of three landfills; Nova Iguaçu, Gericinó and Gramacho. Discussions with Comphania Municipal de Limpeza Urbana (COMLURB) indicate Nova Gramacho is scheduled to close within two years. The landfills are located either on the outskirts of the city (Gericinó) or in neighboring municipalities. Waste destined for Gramacho or Nova Iguaçu may be hauled directly to the landfill site or via one of three transfer stations; Caju, Jacarepaguá and Irajá. MSW destined for Gericinó is not transferred but delivered directly by collection trucks. Table 1.2-1 shows the breakdown of waste flow for the City of Rio, by type and destination, as reported for October 2010. Note that Table 1.2-1 represents available data for a single month and does not indicate seasonal or historical trends that may be apparent using flow data for longer periods (seasonal variation is addressed later in this memo). Additionally, the flow of waste collected to disposal facilities (where waste collected from each planning area is disposed) is not tracked. However, selected targeting of waste from specific planning areas may be appropriate depending on the waste processing technology identified as a result of this feasibility study.

Table 1.2-1 indicates the most heavily trafficked routes to landfill are: via Caju Transfer Station to Gramacho (28%), direct to Gericinó (26%), and direct to Gramacho (18%).

Generation Rates

Table 1.2-2 shows the generation rate of reported MSW generated in 2009 by Planning Area. It is clear from this data, and that of Table 1.3-1, the Rio Metropolitan Area generates in excess of 9000 mtpd MSW destined primarily for landfill. Regarding future growth expectations, based on discussions with MPX and COMLURB it was deemed reasonable to adopt a generation growth rate of 2% annually over the project life. From the viewpoint of waste quantity, diversion of MSW to sustain a 1000 mtpd WTE facility is considered feasible over the intended 25 year planning period. Waste generation will increase with population growth as well as with improvements in Gross Domestic Product (GDP). Appendix 1-A provides supplementary data as a generalized comparison of waste generation in Rio compared with cities of other developing nations.

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Total	**4320**	**2930**	**826**	**1330**	**10**	**490**	**9906**	**100%**

Source: Comphania Municipal de Limpeza Urbana (COMLURB) Fluxo do Lixo - Outubro de 2010

Legend

A: Household Waste

B: Public

C: Large Generators

D: Construction Waste

E: Hospitals

F: Other

Table 1.2-2 Mass flow of all types MSW by region (2009)

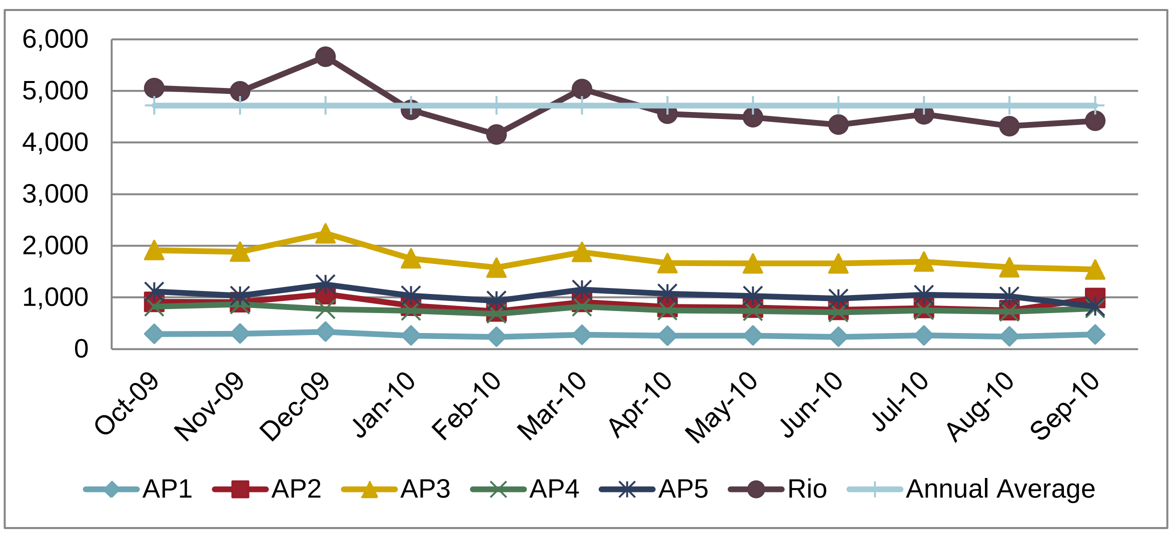
Planning Area	Mass of MSW (mtpd)	Population	Generation rate (kg/day/capita)
AP1	747	228,549	3.268
AP2	1,484	919,685	1.614
AP3	3,512	2,253,958	1.558
AP4	1,438	807,750	1.780
AP5	2,224	1,714,894	1.297
Total/Ave.	9,405	5,924,836	1.587

Source: Graphic provided by Comphania Municipal de Limpeza Urbana (COMLURB)

Seasonal Variation

COMLURB provided data showing monthly average tonnages collected for an aggregate of three waste types: household, large generator and hospital waste; representative of a portion of the overall Rio MSW stream.

Figure 1.2-2 Seasonal Variation in MSW generation - mtpd household, large generator, and hospital type MSW (Oct 2009 – Sep 2010)



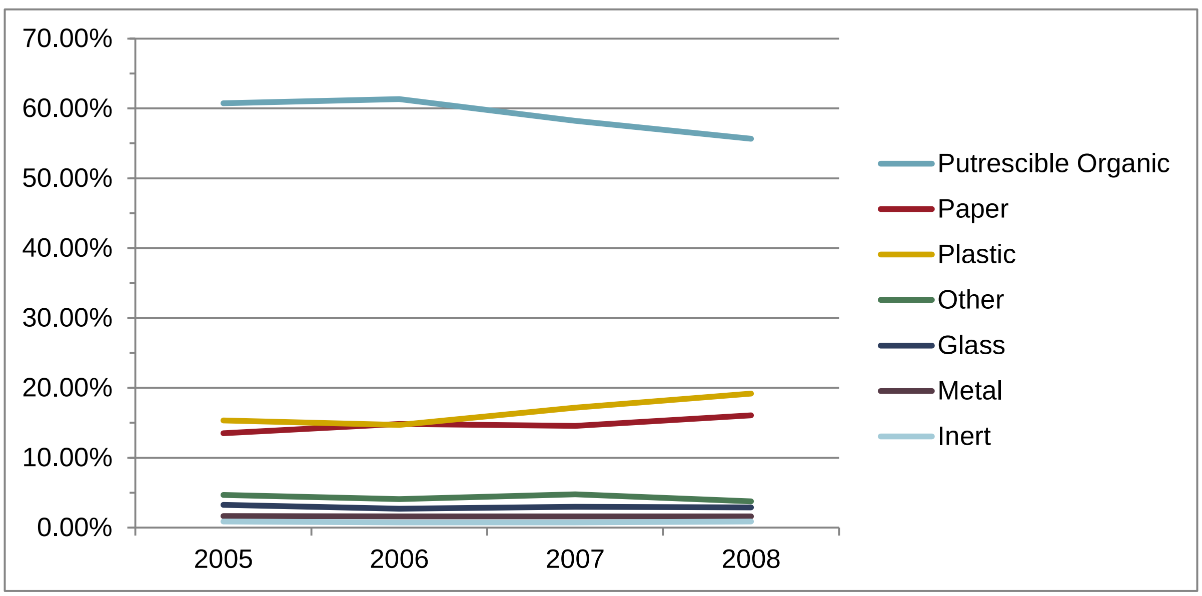
The data in Figure 1.2-2 covers 12 months up to September 2010 and shows a peak for Rio in December, which is 20% above the yearly average, and a low in February, which is 12% below the yearly average. These seasonal variations for Rio are reflective of the fluctuations in AP1, AP2 and AP3, while planning areas AP4 and AP5 remain relatively flat with negligible seasonal variation. Seasonal variation is a normal factor of waste generation and waste composition, as many factors (tourist seasons, major events, wet weather periods, and holidays) influence short-term variances. The seasonal variation is important to understand as the selected waste processing technology would have to provide for such fluctuations on an operational basis.

Waste Characteristics

Additionally, COMLURB provided waste composition data for household waste for the entire City of Rio for the years 1995 through 2009. COMLURB advised the most reliable composition data will be obtained by considering only the years since 2005. In assessing the composition data, 2009 figures were considered separately, as the reported moisture in the overall waste stream appears to be significantly less than the previous fourteen years**.** The moisture content of the waste is reported to range from 50 to 65 % over the years 2005 – 2008.

In general the waste is high in putrescible organic content (reported range of 56 – 61%) with a slight downward trend in the last two years. As illustrated in **Figure** 1.2-3, the percentages of paper and plastic have risen steadily over the same time period, while glass, metal and inert materials have consistently remained low, by comparison to other components in the waste.

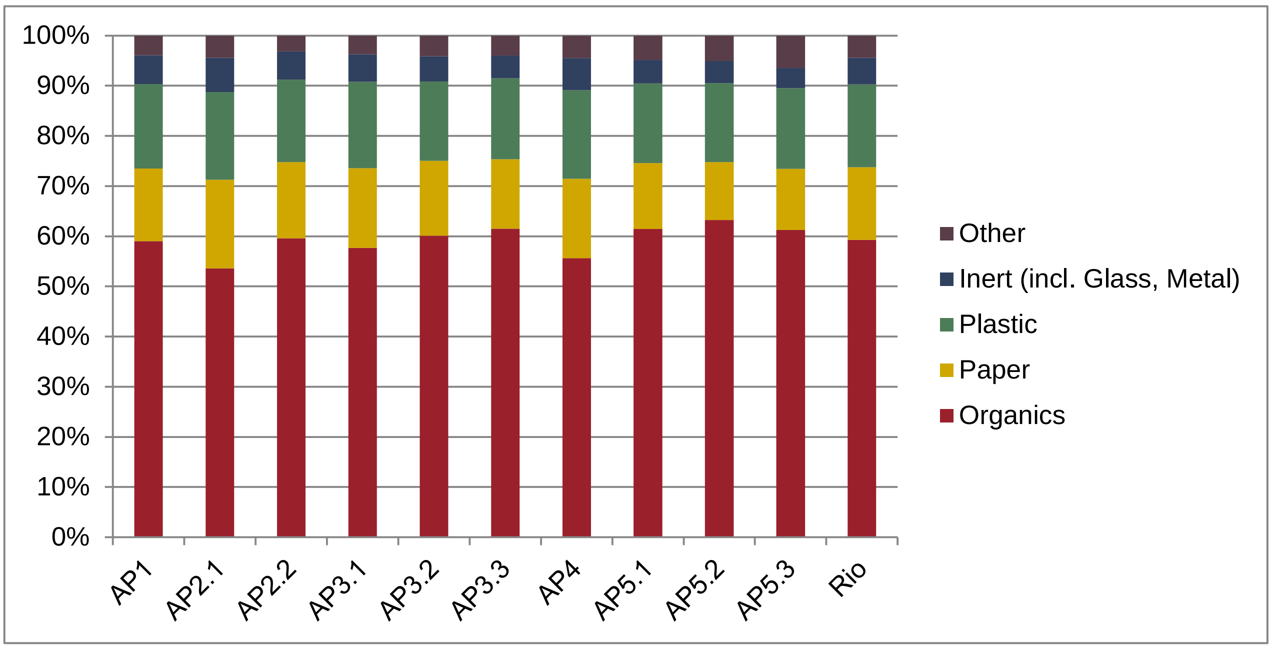
Figure 1.2-3 Seasonal Variation in MSW generation - mtpd household, large generator, and hospital type MSW (Oct 2009 – Sep 2010)



Note: "Other" category includes leaves, wood, rubber, rags, leather, bone, coconut and wax.

In addition to the city-wide Rio figures presented in **Figure** 1.2-3, data has been obtained for household waste composition by area and neighborhood. A summary of the data is presented in Figure 1.2-4. The data shows minor variations in the waste composition across the planning areas. Putrescible organic matter is lowest in AP2.1, AP3.1 and AP4, with paper and plastic a greater contributor in these planning areas.

Figure 1.2-4 Household Type MSW Composition by Weight for Planning Areas (Average 2005-2008)



Heat Content of Waste

To assess the potential for combustion-based energy recovery, information on heat content of the waste is required. No heating value data is available from the detailed waste information collected from COMLURB. However, from the available waste composition data, the Lower Heating Value (LHV) of the waste was estimated using empirically derived heating values for each component[1]. The results of this calculation

[1] S. Consonni, M. Giugliano and M. Grosso, "Alternative Strategies for Energy Recovery from Municipal Solid Waste: Part A: Mass and Energy Balances," Waste Management, Volume 25

are shown in Figure 1.2-5 and indicate a range of LHV's for household waste from 7.5 - 8.6 MJ/kg on an annual average basis between 2005 and 2008. These LHV's indicate the waste is potentially suitable for combustion energy recovery processes. The highest LHVs were calculated from AP2.1, AP3.1 and AP4.

The results are broken down by individual years and show a consistent increase in LHV of household waste in most planning areas over the period. Various studies[2] have shown the heat content of MSW is in direct relation to GDP and in high-income and commercial areas within a city. The national GDP of Brazil increased steadily each year from 2005 - 2008[3] so it can be expected that the GDP for the City of Rio also increased over this period. As the City of Rio improves its standard of living into the future, as indicated by GDP, the heat content of waste would also be expected to increase. Appendix 1-A provides supplementary information regarding the relationship of waste generation and GDP.

Selective collection and delivery is the practice of collecting from particular locations that are known to generate high LHV waste. Based on the waste composition data available, selective collection from AP2.1, AP 3.1 and AP4 would appear favorable to maximize LHV.

Seasonal variation of waste characteristics, and hence LHV, is not known; however, combustion technologies would require the capability to process waste within a defined range of LHV. Section 1.5 includes further information regarding LHV and suitability for combustion-based energy recovery.

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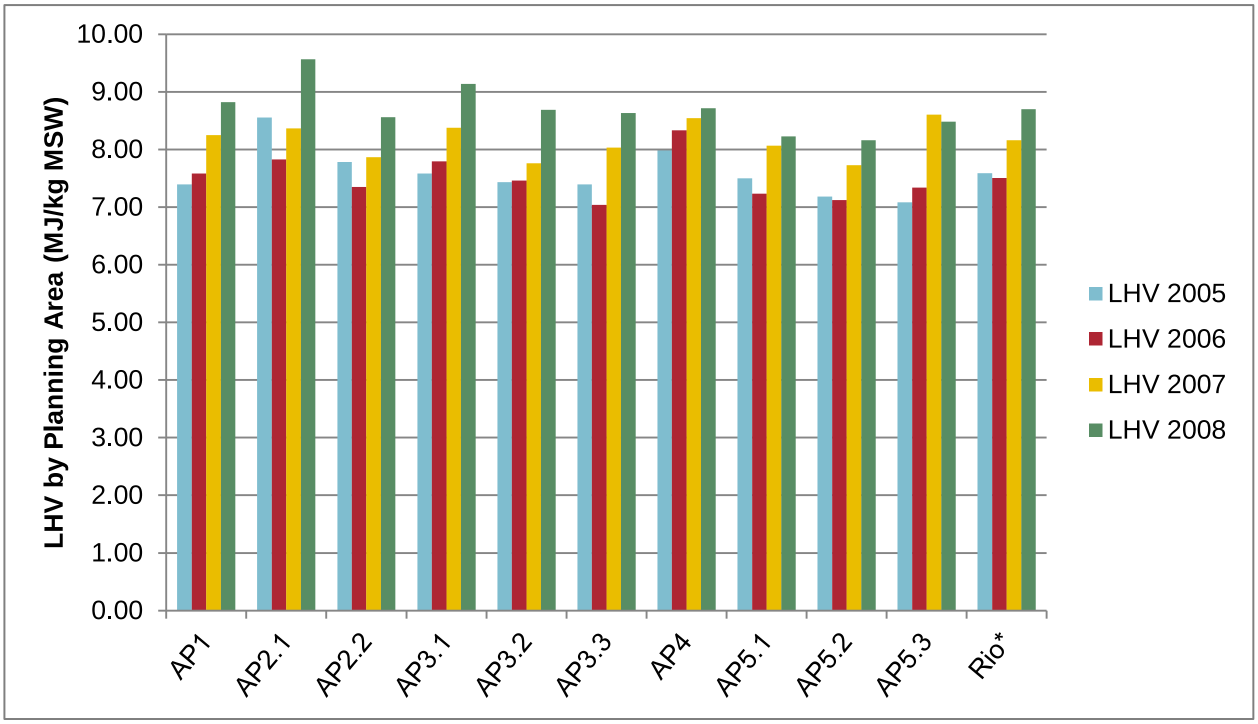
[2] S Cointreau, (Project Manager), Nippon Koei and Research Triangle Institute (Project Consultants), Global Study on Holistic Decision Modeling of Solid Waste Technologies, (2007-2009), World Bank. For the main report and appendices, see www.sandracointreau.com/civilengineering.htm

[3] Data sourced from World Bank website http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

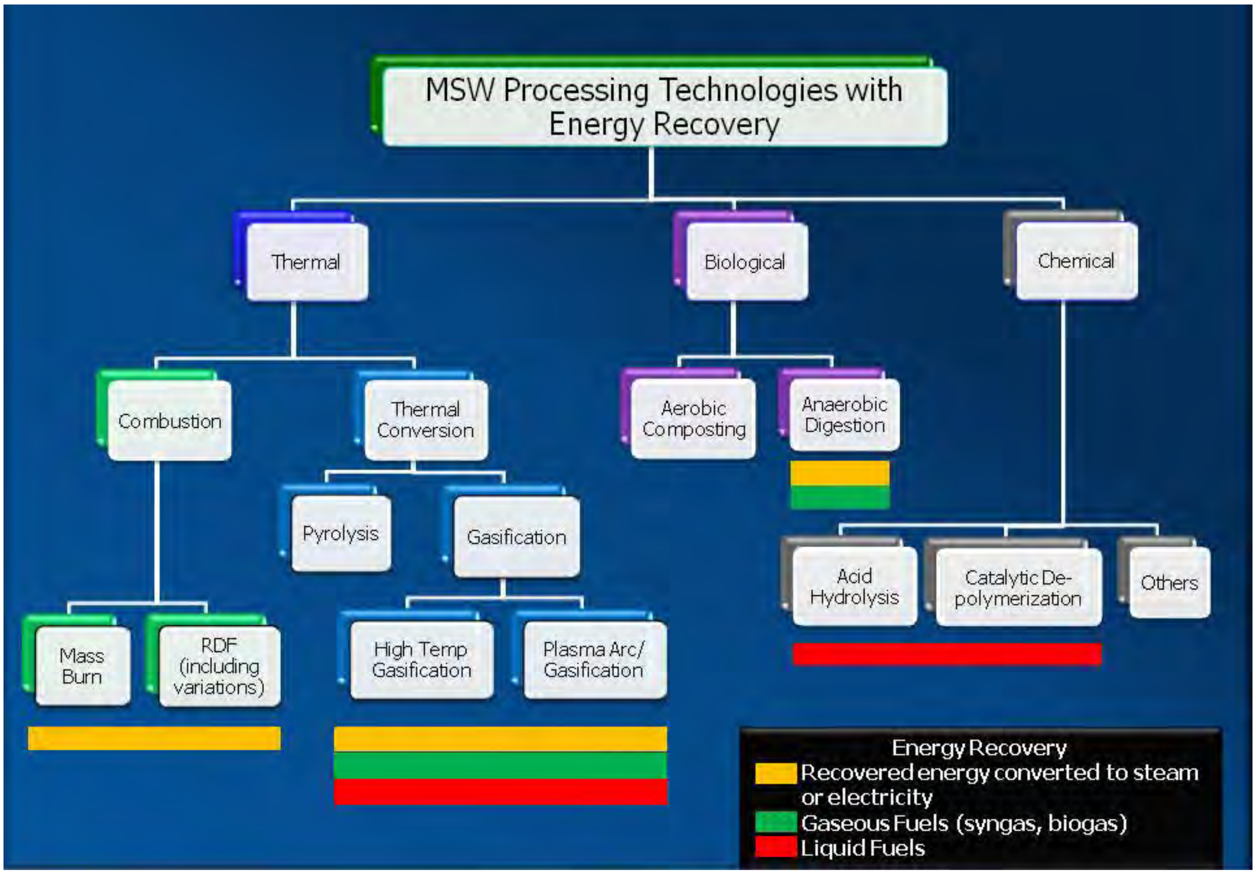
Figure 1.2-5 Household Type MSW calculated heat content for planning areas (2005 - 2008)



1.3 Review of Waste to Energy Technology

For the purpose of energy recovery, MSW processing technologies are broadly divided into three categories; combustion, thermal conversion and biological. These categories are described in more detail in the following paragraphs and the process schematics in Appendix 1-B. As this study was based on processing MSW, the technologies considered are those solely for the handling and energy recovery from MSW. Figure 1.3-1 provides an overview of the processes available for converting waste into various energy forms. Table 1.4.1 at the end of this section provides a partial list of vendors for the three main technologies.

Figure 1.3-1 Overview of MSW Processing Technologies with Energy Recovery



Combustion

Heat generated from combustion of MSW is used to raise steam which drives a steam turbine typically in a conventional Rankine cycle. Combustion systems may also provide combined heat and power which improves plant efficiency if a suitable heating demand is nearby. Two main types of combustion systems are available; mass burn which features minimal pre-processing of the waste and requires combustion on a reciprocating or similar grate; and refuse derived fuel (RDF) which features extensive preparation of the waste permitting a combination of suspension firing and grate burning. There are also a variety of enhancements that may improve energy efficiency and operational flexibility of combustion systems.

Combustion system suppliers provide equipment to operate successfully over a wide range of waste heat content – from a low end of average LHV of 5.5 MJ/kg to a high end average of 15 MJ/kg[4]. The operating range for a specific operation is commonly documented in a graphical form often referred to as a “Stoker Diagram” or “Furnace Firing Diagram”. Some developing nations opting for combustion based waste-to-energy, including China, have cities where the average waste heat content is similar to or less than that observed for Rio de Janeiro. To provide an example of a combustion application with low heat content, some recent mass burn combustion systems installed in China were designed for a waste heat content LHV range of approximately 4.6 MJ/kg (1,100 kilo calories [kcal]/kg) to 8.37 MJ/kg (2,000 kcal/kg), with an average condition of 6.07 MJ/kg (1,450 kcal/kg). These applications had the prediction of no supplementary fuel firing within this operating range. The LHV range for Rio de Janeiro waste will be significantly higher than the lower end of the combustion system design limitations. In Task 2 the sizing of the waste-to-energy system specifically for Rio de Janeiro is established.

Thermal Conversion

This group covers a broad range of technologies that are characterized by treatment of the waste at high temperature in a reducing (limited oxygen) atmosphere to produce

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[4] Note that a combustion system is typically designed for a given nominal throughput and a given value of LHV which defines “design maximum heat input”. A typical operating range of throughput is 80 percent to 110 percent, and a LHV variation typically at 75-80 percent to 130 percent of the nominal values. The LHV range takes into account normal and seasonal differences in waste qualities.

gaseous or liquid products. The most common technologies are fluid bed gasification, plasma arc gasification, pyrolysis or a combination of these. The combustible gas produced (syngas) can be fed to a gas turbine or boiler/steam turbine to generate electricity, or used as a feedstock for liquid fuels or other chemicals.

Biological Treatment

The typical process begins with separation and diversion of the MSW into an organic fraction and inorganic fraction. The organic fraction then undergoes decomposition of the biodegradable components under anaerobic conditions to produce biogas. The gene rated biogas consists mainly of methane (55 – 60%) and carbon dioxide as well as moisture and trace contaminants such as hydrogen sulphide and siloxane. Typically the biogas is utilized as a fuel for internal combustion engines to generate electricity and heat. There is also the potential for beneficiating biogas for direct sale to pipeline as fuel gas. Mixed MSW requires significant pre-processing including classifying, shredding and separation of large objects and non-digestibles. Inherently, biological treatment produces a second stream which is high in non-digestible organics, which may be land filled but may also be suitable for material recovery or combustion.

Partial List of WTE Vendors

Table 1.3-1 shows a partial list of vendors for waste to energy technologies.

Table 1.3-2 Partial List of Vendors for Waste to Energy Technologies

Combustion	Thermal Conversion	Biological
Waterleau	Hitachi	Arrow-Bio
Martin	GE	Gore-Tex
von Roll	Westinghouse	Omrin
Keppel Seghers	Solena	bta
Vølund	Enerkem	Kompogas
Fisia Babcock	IWT	Waasa
Detroit Stoker	Ebara	Entec
Takuma	Thermoselect	Dranco
Consumat	EAI	Valorga
JF Engineering	Mitsui Babcock	

Partial List of Installations

Table 1.3-3 shows a partial list of installations for several waste to energy technologies. This is intended as a brief coverage of projects relevant to this report rather than a comprehensive list. There are more than 400 combustion Waste-to-Energy plants in Europe, 88 plants in the USA, and 190 plants in Japan; therefore, a list of specific combustion plant names is not included here.

Table 1.3-3 Partial List of Waste to Energy Installations

Location	Technology	Capacity	Comments
Ontario, Canada	Plasco plasma gasification	85 mtpd	Actual performance shows significantly lower capacity.
Japan	Thermoselect gasification	Various	Several plants process industrial waste alone or a combination with MSW
Utashinai City	Plasma gasification	280 mtpd	-
Japan	Mitsui Babcock rotary kiln pyrolysis	Various	Several plants in Japan and three (3) in other countries
Gunzburg, Germany	Pyrolysis (kiln)	100 mtpd	-
Holland	Gasification	Various	Several small plants
Oudehaske, NL	AD (Wet/ Mesophilic)		Operations since 2003, metals and paper recovered.
Groningen, NL	AD (Wet/ Mesophilic)	230,000 tpy	Operating since 1987
Brecht, Belgium	AD (Dry/ Thermophilic)	50,000 tpy	Operating since 2000
Montreal, Canada	AD (Wet/ Mesophilic)	25,000 tpy	Operating since 2002
Marseille, France	AD +Combustion	390,000 tpy	-
Madrid	AD +Combustion	1,200,000 tpy	Valdemingomez Complex
Guadalupe	AD +Combustion	150,000 tpy	(in construction)
Mallorca, Spain	AD +Combustion	490,000 tpy	TIRME project. Combustion in operation and AD under construction
Manchester, England	AD +Combustion	1,300,000 tpy	(in construction)
Wijster , NL	AD +Combustion	840,000 tpy	AD plant is being added
Groningen, NL	AD +Combustion	160,000 tpy	-

1.4 Assessment of Technology Options

In this section the main categories of waste to energy technologies are assessed against the guiding principles stated in Section 1.2. For each guiding principle the technologies are relationally rated as follows:

- 1 – most suitable/lower risk
- 2 –suitable/moderate risk
- 3 –potentially suitable/higher risk

The above rating system is intended to be reflective of the capability of the technology to provide commercial operations using Rio MSW. Risk factors include proven track record of operations, operating facilities with design capacities similar to that desired in this study, and reliability of capital and operational cost information.

A more detailed comparison of combustion, conversion (thermal) and biological (anaerobic digestion) processing technologies is presented in Appendix 1-C.

Electrical Generation	***Rating***
Combustion Electrical generation from a combustion plant is dependent on many factors including; heat content of the waste (fuel), degree of recyclables recovered pre-combustion, operating conditions, thermodynamic efficiency of the steam cycle, and parasitic load of the plant. The net electrical efficiency, based on the heat content of the fuel (MSW) for a combustion energy recovery plant is reported in the range of 19 – 27 %. Most plants have the ability to co-fire various fossil fuels so exact energy conversion figures from operating plants are not readily available. Several enhancements to a simple steam cycle have been proposed[5], including the use of a Combined Cycle Gas Turbine (CCGT) which allows steam to be superheated externally, with heat recovery supplementing the MSW combustion plant. These enhancements would theoretically result in higher net electrical efficiency, albeit at higher capital cost and operational complexity	1
Thermal Conversion When comparing efficiencies, both the conversion efficiency and the generation efficiency must be considered. Thermal conversion processes are inherently less efficient when compared to direct combustion in converting the heat content of the waste into useful energy. However, thermal conversion processes produce syngas which can be utilized in gas engines and CCGT, both having higher generation efficiency than a simple steam cycle. Based on a survey of vendor data[6], the overall net efficiency of thermal conversion plants utilizing steam cycles is reported to be 14 - 20 %, while those utilizing gas engines is 13-24%. The use of a combined cycle gas turbine would potentially increase the overall net efficiency further.	2
Biological Anaerobic digestion plants vary greatly in the amount of electricity they can produce, depending on the specific technology chosen and the quantity of digestible material in the MSW. Since the biological processes only convert the digestible portion of the feed into usable energy, anaerobic digestion alone will generally result in lower net electrical efficiency than either combustion or thermal conversion processes. An average biogas production rate of 112 Nm^3/Mg of digester feed has been reported[7] based on published biogas yields from fourteen plants in Western Europe. The net generation efficiency of the fuel will depend on methane content, engine performance and plant parasitic load. Net energy surplus of 40 – 170 kWh per Mg of organic waste input has been reported[8].	3

[5] Dr. Sergio Guerreiro Ribeiro, “Waste Management in Brazil” ;WTERT 2010 Bi- Annual Meeting at Columbia University October7-8, 2010

[6] Fichtner Consulting Engineers, Ltd, “The Viability of Advanced Thermal Treatment of MSW in the UK,” March 2004.

[7] “Current Anaerobic Digestion Technologies Used for Treatment of Municipal Solid Waste”; California EPA, 2008

[8] Klaus Fricke, Heike Santen, Rainer Wallmann, “Comparison of Selected Aerobic and Anaerobic Procedures for MSW Treatment,” Waste Management, Volume 25, Issue 8, October 2005, Pages 799-810, ISSN 0956-053X, DOI: 10.1016/j.wasman.2004.12.018.

Combination Anaerobic Digestion + Combustion See above related to Combustion and Biological. Use of combustion and AD in combination (combustion preceded by AD) provide the potential for improved operations due to removal of low calorific and high moisture content digestible organics, thereby improving the heat value of the resulting waste processed in a combustor.	1

Technology Maturity	***Rating***
Combustion Proven experience on a commercial operating basis in USA, Europe, Japan and China. There are over 89 facilities in the USA and Over 600 worldwide. Technology is available from several commercially-viable multinational vendors and operators.	1
Thermal Conversion An emerging MSW treatment technology. Has been in operation in Asia (predominantly Japan) processing typically 300 to 500 mtpd and generating 5-12 MW. So far this technology has not been proven commercially viable for MSW alone on this scale. Commercial viability has been limited to combined MSW/ industrial/ hazardous waste feedstock and smaller processing capacity systems.	3
Biological Technology is widely used in the wastewater industry; however, application to MSW is a re-emerging field with most experience in Canada and Europe. The number of MSW facilities and total net production has shown a significant increase in recent years. In 2006 alone, over 3,500,000 metric tons per year of new capacity was installed in Europe[6]	2
Combination Anaerobic Digestion + Combustion As indicated above, technologies are commercially available and proven in combustion and AD applications utilizing mixed solid waste. The technologies can be co-located or located at independent sites.	2

Operational Requirements	***Rating***
Combustion Mass burn combustors can accept mixed MSW with minimal pre-processing such as physical separation of bulky items (e.g. large durables, stumps, construction debris) and hazardous wastes. Removal of metals, papers and plastics is not necessary. Note that RDF combustion technology requires a higher level of pre-processing to achieve efficient combustion.	2
Thermal Conversion Limited ability to accept mixed MSW. Must be pre-processed using one or more of the following techniques: sorting, separation, shredding/size reduction, densification and drying.	3
Biological For this process to be efficient with mixed MSW, significant pre-processing is required to remove non-digestible and oversized materials. The feedstock is often shredded and pulped to assist removal of inorganic material and grit. The resulting digestible organic feedstock is processed in one or more digestion units.	1
Combination Anaerobic Digestion + Combustion Operational requirements are as stated above for Combustion and Biological. With AD systems, physical processing is required to separate digestible organics (a process that supports the concurrent separation of recyclables depending on equipment used and system configurations); a methane recovery, storage and electrical generation system; and a residuals (or sludge) dewatering and handling system.	2

Environmental Issues	*Rating*
Combustion Release of air emissions are controlled within regulated levels: these include carbon dioxide, nitrogen oxides, sulfur dioxide, hydrogen chloride, hydrogen fluoride, volatile organic compounds, volatilized metals (e.g., cadmium, nickel, arsenic and mercury) and dioxin/furan compounds.[9] Air emissions are addressed by the use of advanced combustion control and state of the art pollution control systems including catalytic or non-catalytic reduction of NOx, lime injection/semi-dry absorbers and baghouse filters. Facility design minimizes the off-site release of dust and odors. In addition to air emissions, the production of ash and a moderate amount of wastewater account for the primary environmental impacts.	2
Thermal Conversion Thermal conversion facilities comply with emissions regulations similar to combustion technology. A recent study of 16 thermal conversion plants around the world showed good compliance with relevant local emissions standards for hazardous air pollutants. Based on United States Environmental Protection Agency (USEPA) standards some minor exceedances were reported.[9] In addition to ash and wastewater most thermal conversion processes generate a waste slag byproduct.	2
Biological Available data on anaerobic digestion air emissions is limited. There are some fugitive emissions of biogas from the digesters and storage tanks. Internal combustion engines are fitted with pollution controls including catalytic reduction of nitrogen oxides to meet strict environmental compliance laws. Water emissions from digestion include nitrogen compounds, dissolved solids and moderate levels of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Residual solids from the digester may be disposed of separately or after suitable processing may be used for composting. Separated non organic waste may be sent to a combustion facility or other disposal.	2
Combination Anaerobic Digestion + Combustion Environmental emissions from AD systems include, as stated above, fugitive emissions from the AD process, allowable emissions from methane-fired internal combustion engines used to generate electricity, process water effluent (can be minimized through reuse in the process), and solid residuals or sludge. Primary environmental issues associated with combustion facilities include air emissions, process wastewater, and ash residue.	2

[9] Enviros Consulting Ltd, "Review of the Environmental and Health Effects of Waste Management: Municipal Solid Waste and Similar Wastes," report to Defra, UK, 2000.

Human Factors	***Rating***
Historically, there have been strongly organized waste picker cooperatives in Rio de Janeiro and much social concern for the individuals to maintain their livelihood. Efforts to provide them with space to sort and recover recyclables have been a routine commitment by COMLURB at the various sites for transfer and disposal. Normally, in considering waste-to-energy, the assessment would consider ways to maintain access of the waste pickers to recyclables and their current livelihood. However, changes have already taken place and remedial actions are underway that remove the need for the waste-to-energy plant proposals to address this issue. First, there is a national solid waste policy that now forbids waste pickers from working in permitted landfills. This policy is expected to be enforced in two years, as there was a four year grace period. Second, COMLURB has tendered for implementation of a new sanitary landfill and 5 new transfer stations, awarding all of these facilities to one private contractor. Under the new contract, no waste pickers or sorting will be conducted at any of these facilities. COMLURB is planning pilot source segregation of wastes and separate waste collection with the involvement of waste pickers, in hopes of minimizing the adverse socio-economic impacts that the new policy and private contract could have on waste picker livelihood. Each of the technologies being considered can accept post recycling waste and therefore would support recycling, whether it is by the waste pickers or in a more traditional recycling program. Each of the technologies would create a market for a number of full time skilled and non-skilled jobs in operating and managing the facility, in addition to the jobs and economic stimulus created during the planning and construction phase. It is reasonable to conclude that each of these technologies provide similar risk and opportunity in terms of human factors.	
Combustion	**2**
Thermal Conversion	**2**
Biological	**2**
Combination Anaerobic Digestion + Combustion	**2**

1.5 Facility Location

Based on discussions with MPX and COMLURB it is understood the Caju Transfer Station site would be available for the development of a WTE facility.

COMLURB reports the Caju Transfer Station receives an average of 2800 mtpd of MSW, which is then transferred to Gramacho landfill. Costs associated with transfer and then haulage to landfill could be saved if the Caju site is the final destination for the waste, benefitting the overall waste management costs for Rio constituents. It is understood that COMLURB is planning to close Gramacho landfill, so a portion of this flow could be assigned to a WTE plant located at Caju.

A site layout of Caju has been obtained from COMLURB, and it has been reported that 100,000 m^2 would be available for development. In total this would be sufficient for any of the alternatives being considered, however, the long narrow shape of the site (length to width is >3) may present some challenges. In addition to the transfer station, Caju currently houses a recycling facility and composting plant, which may need to be relocated depending on the layout of the WTE technology ultimately selected.

Five additional transfer stations are under construction in Rio, however, graphical representations provided by COMLURB indicate there is not sufficient land available at these sites for the proposed facilities.

Another site under consideration is the newly built landfill at Seropédica. This site provides existing waste handling infrastructure and would have some benefits from a permitting perspective. The location, however, presents a potential economic challenge due to the long distance from Seropédica to where most of Rio's waste is collected, contributing to higher haulage costs. For this reason, the Seropédica site was excluded from further consideration in this study.

1.6 Summary

Within the terms of reference set out by the USTDA and the guiding principles identified by the project team, the preceding pages analyzed waste data provided by COMLURB and reviewed the range of technologies potentially available for this project.

Based on this review, thermal conversion technology such as gasification or pyrolysis would not be a suitable choice for implementation in Rio e Janeiro. Although there are projects cited by technology vendors, these processes are not commercially proven with mixed MSW on a scale required for this project. Therefore, it is considered a high risk choice to implement the first large scale plant in Rio de Janeiro.

Biological treatment for MSW is commercially proven and can be adapted to operate on the scale required. However, due to the low net electrical efficiency a large amount of material would need to be processed in order to approach the 30MW size plant envisaged. A large mass of MSW (including significant heat content) would need to be handled in pre- processing, reject and digestate streams in order to generate biogas on the scale required. This bulk material processing would require large amounts of land and energy, which in turn reduces the net efficiency of the facility. For these reasons biological treatment alone is not considered a good choice for this project.

Based on this review, the following two approaches were recommended for further consideration for the Task 2 – Evaluation of Proposed Options via Least Cost Analysis:

- **Combustion (with or without enhancements).**
  This technology is commercially proven on the scale required and makes the maximum use, in terms of energy recovery, of the heat content in the mixed MSW to be processed.

- **Combination Anaerobic Digestion + Combustion.**
  A combination of technologies may suit the waste characteristics of Rio de Janeiro. The high organics fraction and moisture is suitable for digestion, while a combustion plant would make maximum use of the heat content of residual fraction, and minimize landfill requirements.

These selected technologies at this point were identified at the generic level as there are a number of innovative approaches or specific capabilities that may or may not be cost-effective and operationally efficient in this application. These and other issues are evaluated and reported later in this document.

2 Task 2 – Least Cost Analysis

2.1 Preface

In Task 2 the proposed options were evaluated using a least cost analysis. The purpose of this task was to generate comparative operating and capital cost data, then select the least cost alternative in consultation with MPX.

It is important to note the estimates developed for Task 2 were based on limited cost information, solely for the purpose of comparing expected cost of the two options. A more detailed cost estimating methodology and more accurate estimate for the preferred option is included in Task 3.

This task included the following steps:

- Preliminary Process Design - Material and energy balances for each option and a summary of the process and equipment included.
- Facility Location and Sizing Considerations – preliminary layout of the proposed options and comparison with available area at the chosen site.
- Cost and Revenue Estimates – preparation of capital cost, operating revenue and expenses data.
- Least Cost Assessment – the data obtained for construction and operating phases for each of the proposed options has been analyzed to determine least cost alternative using an economic model.

2.2 Preliminary Process Design

In Task 1, the following two technologies were selected as being most suitable to meet the guiding principles of the study:

- Option A - Combustion only (with or without enhancements)
- Option B – Combined Technology (Combustion + Anaerobic Digestion)

2.2.2 Option A – Combustion Only

Figure 2.2-1 and Table 2.2-1 show the preliminary process flow diagram and the mass and energy balance respectively for the Option A combustion system. The preliminary design is based on mass burn technology, the most commonly used WTE technology because of its simplicity, involving the combustion of minimally processed waste. Please refer to appendix 2-A for a discussion of alternative combustion technologies.

Figure 2.2-1 Process Flow Diagram for Option A (Mass Burn)

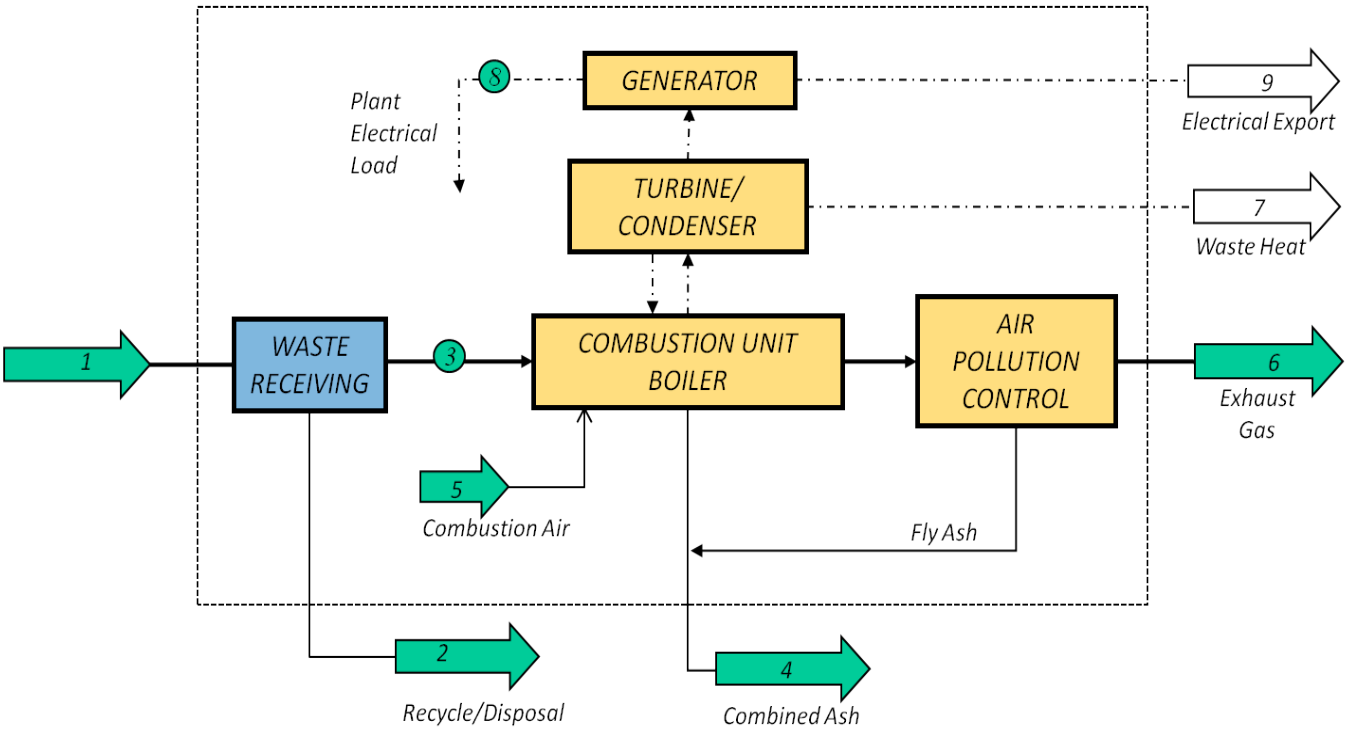


Table 2.2-1 – Mass and Energy Balance for Option A (Mass Burn)

Stream	1 Mixed MSW	2 Non-Processible	3 Feed to Furnace	4 Ash (3)	5 Combustion Air 1	6 Furnace Exhaust1	7 Waste Heat	8 Plant Elec. Load	9 Electrical Export
Mass Flow(mtpd)	1,500	-	1,500	165	235,000	288,000	-	-	-
Energy (2) (MW)	139	-	139	2	-	25	77	5	30

1) Gas flows are in Nm3/hr wet basis
2) Energy represents contribution to each stream of the original calorific value of the feed stream
3) Ash rate does not include entrained moisture from the ash quenching process

The system is designed to meet the following estimated performance and design data:

- Average Throughput: 492,750 tons per annum (90% availability)
- Design Capacity: 1500 mtpd
- MSW Lower Heating Value: 8.0 MJ/kg (average)

- Steam Generation (Maximum Continuous Rating [MCR]): 138,000 kg/h
- Steam Condition at Turbine Inlet: 42 bar/400°C
- T-G Capacity: 43.6 MVA (Power Factor of 0.8)
- T-G Output (Maximum Continuous Rating [MCR]): 34.9 MW
- Net Average Export: 30 MW

The main components of a mass burn WTE facility are listed below:

- Waste receiving, handling, and storage system. This includes a tipping hall, suitably sized refuse pit, overhead grappling cranes and waste feed chute. These facilities are housed within a covered structure which provides protection from weather and allows control of odorous emissions.
- Furnace/boiler system, capable of handling fluctuations in heat content, moisture content, and the composition of the waste processed. Design criteria include destruction/minimization of hazardous air pollutants within the furnace and maximization of waste burn-out and energy recovery. Along with advanced combustion control (ACC), reduction in NOx emissions may be achieved in the furnace by selective non catalytic reduction (SNCR).
- Boiler water/steam cycle system, including water-tube boiler, superheater and economizer sections suitable for high temperature corrosive combustion products typical of refuse incineration.
- Power generation equipment including steam turbine and water-cooled condenser sized for steam generation rate of the boiler at MCR, steam extractions, generator, ancillary equipment and operating controls.
- Air pollution control (APC) or flue gas cleaning system designed to meet emission limits for various regulated pollutants. Additional NOx control and continuous emissions monitoring system (CEMS) may also be required depending on permit requirements.
- Ash residue handling system to serve the boiler/furnace/APC system, consisting of the collection of bottom ash from the furnace bottom ash discharger, grate siftings, fly ash from the boiler ash hoppers, and APC fly ash.
- A distributed control system (DCS) to monitor and control the combustion system, steam generating equipment, and other related equipment from the control room. The DCS provides monitoring and control of the overall facility, alarm display, and reports configured from transmitted data.
- Auxiliary systems such as steam condenser, condensate, feedwater, deaerator, closed cooling water, and other miscellaneous systems are provided as required. Design margin provides for operational variations, transients, and emergency conditions.
- The electrical interconnection system must meet the requirements of the electric utility and is provided with required redundancy and reliability to provide electrical power for the entire plant.

2.2.3 Option B – Combined Facility

Recycling/Composting/Anaerobic Digestion/Combustion

During the course of this task several process models for combined technologies were discussed. The final decision was to integrate COMLURB's existing sorting facility and composting operation at Caju with a new combustion WTE facility.

For the purpose of this study the integrated facility is treated as a single entity and the revenue and cost data are generated on this basis.

The overall mass and energy balance for Option B is based on data provided by COMLURB for the operation of their sorting plant, including recovery rates of recyclables, separation efficiency of organics and weight losses due to evaporation. In addition, COMLURB have advised the desired capacity of an AD plant to complement their composting facility and also weight losses during composting. The biogas generated from AD would be utilized in the combustion plant rather than in more conventional reciprocating engines. This configuration may reduce the reliance on importing natural gas as a supplemental fuel from outside the facility. Option B is effectively four plants operating together as an integrated waste management system:

- Mechanical and manual sorting/recycling,
- Batch aerobic digestion (composting),
- Anaerobic digestion, and
- Combustion.

These systems are each discussed separately in the following sections.

2.2.4 Mechanical and Manual Sorting System

The existing sorting plant at Caju has the capacity to process 800 mtpd and consists of two lines of process equipment operating in parallel. Each line includes a series of trommels, manual sorting stations, ferrous metal removal equipment, and conveyors to transport waste through the process and divert separated materials to designated storage areas. The pre-processing system accepts mixed MSW and separates metallic, cardboard and plastic recyclables in a combination of manual and automated processes. The output from the plant includes:

- Recyclable cardboard, plastic bottles and ferrous metals (46 mtpd)
- Organic fraction of MSW consisting of food wastes and fine organics (214 mtpd)
- Rejects, remaining material which includes the non-recovered organic material, plus inerts and non-recovered metal, paper and plastic materials (502 mtpd)

During the pre-processing stage approximately 5% of the water in the incoming waste is removed.

2.2.5 Aerobic Digestion (Composting) Facility

Most of the organic fraction (165 mtpd) from the sorting plant is then sent to an existing composting facility. The waste is piled into open windrows and turned periodically for several weeks to promote aeration of the bed. The aerobic decomposition produces heat, which sanitizes the waste and results in significant moisture loss. The stabilized waste is then screened to remove residual inerts and large pieces, then sold as a soil supplement for the eucalyptus plantations. Due to drying and aerobic digestion the mass of the composted material is approximately half the original organics fraction.

The remaining organics fraction (49 mtpd) is directed to an anaerobic digestion facility as described in the following section.

Figure 2.2-2 Process Flow Diagram for Option B Combined Facility

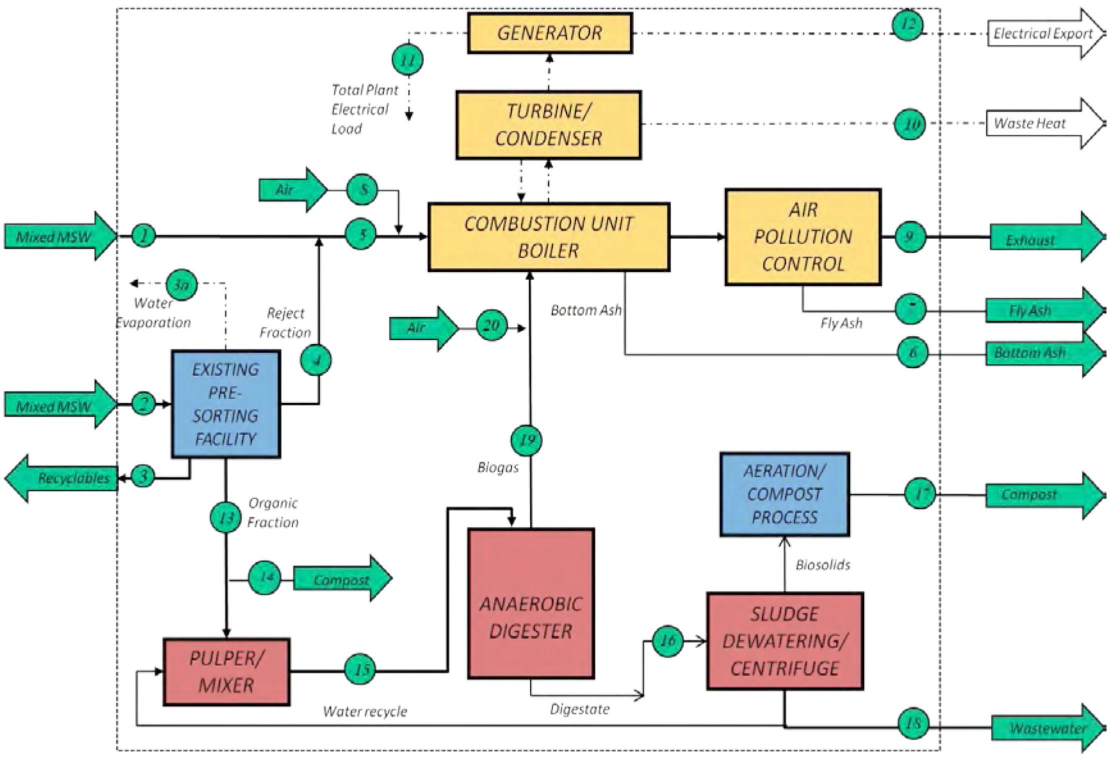


Table 2.2-2 Mass and Energy Balance for Option B Combined Facility

Stream	1 MSW to Combust	2 MSW to Sorting	3 Recyclables from Sorting	3a Water loss	4 Reject Sorting	5 Feed to Furnace	6 Bottom Ash[3]	7 Fly Ash[3]	8 Furnace Combust Air[1]	9 Furnace Exhaust[1]
Mass Flow (mtpd)	900	800	46	38	502	1,402	161	5	235,400	284,900
Energy [2] (MW)	83	74.1	7.1	-	56.1	139.4	1.8	0.1	-	25.0

Stream	10 Waste Heat	11 Plant Electrical	12 Electrical Export	13 Org from Sorting	14 Org to Compost	15 Org to Digester	16 Digestate	17 Residual Solids	18 Waste water	19 Biogas[1]	20 Biogas Combust Air[1]
Mass Flow (mtpd)	-	-	-	214	165	49	42	18	24	260	1400
Energy [2] (MW)	78.4	5.3	30.1	10.8	8.3	2.5	1.3	1.3	-	1.2	-

1) Gas flows are in Nm^3/hr wet basis
2) Energy represents contribution to each stream of the original calorific value of the feed stream
3) Ash rate does not include entrained moisture from the ash quenching process

2.2.6 Anaerobic Digestion (AD) System

There are a range of viable AD technologies that are considered suitable for this project. At this planning level, a decisive determination was not necessary, with the selection of AD technology recommended to occur in the formal procurement process.

The AD system would process approximately 18,250 tons of organic fraction of MSW per year. The net result of processing the waste using the AD technology is a biogas generation rate of approximately110 Nm^3 per metric ton of organic waste and dewatered residual solids of approximately 6,000 tons per year. The residual solids would then be used to augment to organic waste being treated aerobically, producing compost.

For this least cost analysis, a dry, single stage system is modeled. The AD system operates 52 weeks per year, six (6) days a week, and two shifts (16 hours) per day. The following items are the major components of the AD system:

- **Pretreatment** – During the mechanical sorting stage, the incoming waste particle size must be screened to below 45 mm. The waste is fed into the AD pretreatment stage by dosing screws which are located on weighing cells so that the amount of fresh waste sent to the digesters is known. The dosing screws deliver the waste to the feeding pump via a mixing unit above each pump. Here the fresh organic waste is intensively mixed with a portion of excess residue from the digesters. This residual mixture serves as inoculum so that the anaerobic digestion commences quickly and smoothly as soon as the fresh waste enters the reactor vessels. In the mixing vessel a small amount of steam is injected to heat the waste to a temperature of 48 – 55°C. From the feeding pumps the waste mixture is fed to the digester reaction vessels via pipes that pass vertically through the conical bottom section.

- **Digester** –The anaerobic digestion takes place in a single vertical, insulated tank, with a retention time of 20 to 25 days. This stage of the system produces biogas and reduces the volume of waste. To control process between 48 to 50˚C, steam must be supplied to the process from the waste to energy plant. The waste enters to top of the tank then moves slowly down under gravity to the conical outlet where it is removed by extraction screws. The biogas is generated spontaneously from the anaerobic digestion and rises through the void space to accumulate at the top of the vessel and is removed due to pressure difference to the gas storage vessel.

- **Dewatering** - After the digester tanks, the digestate is pumped to a dewatering unit. The digestate residue may be mixed with polymers to aid efficient dewatering. Flocculants are added to the residue to increase dewatering degree and also improve waste water quality. There are several kinds of dewatering mechanisms that can be used, typically this would be a batch filter press operation and may also include centrifugal separation. Depending on the design of the system, process water is recycled at varying rates; however, steady state waste water production is dependent mainly on incoming waste characteristics. The following items are major components of the dewatering system for a single stage dry AD system:

- **Wastewater Treatment System** An onsite wastewater treatment plant (WWTP) is required for the AD facility to manage the effluent from the dewatering plant.

- **Biogas Conditioning** – The collected biogas is stored in an intermediate low pressure vessel to provide pressure control and surge capacity between the digesters and the end users. The biogas would require condensate removal before being sent to the combustion WTE plant. A gas flare is for emergency purposes to burn the biogas in case of a failure (e.g. maintenance or breakdown) and is designed to flare 120% of the hourly gas production. The fully automated operation comprises the ignition and gas pressure supervision, the opening and closing of all valves, the flame supervision, possible post-ignition as well as the shut-down of the AD system.

- **Plant Control System** – A main computer system would provide the plant manager access to optimize several key components. Automatic alarms and corresponding action is provided with the operating system.

2.2.7 Combustion Facility

The combustion facility for Option B would process a combined feedstock of raw MSW (900 mtpd) plus the rejects stream (502 mtpd) from the sorting plant and contains the same basic components described in Option A. The Option B plant would be sized for a lower tonnage of solid waste having a higher calorific value as a result of the sorting and removal of high moisture organics. The combustion system would also include the biogas from the AD plant. The system configuration would allow the following estimated performance and design data:

- Average Throughput: 460,000 tons per annum (90% availability)

- Design Capacity: 1402 mtpd
- MSW Lower Heating Value: 8.6 MJ/kg (average)
- Steam Generation (Maximum Continuous Rating [MCR]): 140,000 kg/h
- Steam Condition at Turbine Inlet: 42 bar/400°C
- T-G Capacity: 44.1 MVA (Power Factor of 0.8)
- T-G Output (Maximum Continuous Rating [MCR]): 35.3 MW
- Net Average Export: 30 MW

2.3 Facility Location and Sizing Consideration

As detailed in the mass and energy balance, both options have been sized to export 30 MW of electricity to the grid. In the case of Option A this requires a 1500 mtpd combustion facility, which is comprised of two (2) combustion lines each capable of 750 mtpd. This arrangement was chosen to minimize the plant capital investment and overall footprint. The facility can operate at 50% capacity in the event of maintenance shut-down of one line. Each combustion line would have its own feed hopper, combustion grate, boiler, air pollution controls and exhaust flue. The facility would be served by a common steam and energy recovery system including a single steam turbine, generator, condenser and water cooling system. The combustion building itself would occupy approximately 14,000 m^2 of land area. For Option A the proposed site of the waste-to-energy facility is the un-used land at the northern end of the COMLURB site. The waste would be received at a tipping hall on the southern end of the building while ash would be collected and dispatched from a truck loading bay at the eastern side of the building.

For Option B the existing sorting facility and composting area would remain in their current locations. The Option B combustion facility includes two (2) 700 mtpd combustion lines and a common steam system and generator. The tipping floor would be located at the southern end of the building and modified to accommodate the un-sorted MSW arriving in trucks, plus the rejects from the sorting plant arriving by conveyor. The combustion facility would occupy approximately 14,000 m^2 located on the un-used land at the northern end of the COMLURB site. A preliminary layout of the Option B combustion facility and its proposed location on the Caju site are provided in Appendix 2- B.

The 50 mtpd AD plant would require approximately 1500 m^2 including feed storage and preparation area, digester, residual solids dewatering plant, wastewater treatment plant, biogas storage and flare. A preliminary layout of the AD plant is included in Appendix 2-B. The most cost effective location for the AD plant would be adjacent to the composting facility, as these plants have a common feedstock and the AD residual is to be blended with the raw organics fraction prior to composting.

This layout would minimize the distance for conveying organics and AD residual solids.

Note that the approximate areas described above do not include set back allowances from the plant boundary that may be necessary for safety or permitting requirements.

2.4 Cost and Revenue Estimates

2.4.1 Plant Construction Costs

The following cost data has been compiled based on preliminary design considerations and review of plant cost factors from historical WTE project data. As such, the estimates developed for Task 2 were based on limited cost information, solely for the for the purpose of comparing the two options. A more detailed cost estimating methodology and more accurate estimate for the preferred option is included in Task 3.

Table 2.4-1 - Preliminary Capital Budget (2011 $US)

	Option A Combustion Only	Option B Combustion and AD
Land Acquisition Costs	$ -	$ -
Site and Civil	(included below)	$ 2,000
Pre-processing	$ -	$ -
AD plant	$ -	$ 7,000
Mass Burn Combustion	$260,000	$ 249,000
Total Construction Cost	**$260,000**	**$ 258,000**
Additional Costs (Permitting, Legal, Procurement, Due Diligence)	$10,000	$12,000
Total Project Cost	**$270,000**	**$270,000**

2.4.2 Operating Cost and Revenue Inputs

The following data are estimates based on experience in the international waste to energy industry and discussion with MPX and COMLURB to establish a realistic economic basis for comparison of the options. Debt costs have not been included in this analysis as they would be determined based on financing approach.

Table 2.4-2 - Preliminary Input for Operating Cost and Revenue Budget (2011 $US)		
Tipping Fee	($/metric ton)	$ 25
Bottom Ash Disposal Fee	($/metric ton)	$ 25
Fly Ash Disposal Fee	($/metric ton)	$ 400
Combustion O&M (Option A)	($/metric ton)	$ 27
Combustion O&M (Option B)	($/metric ton)	$ 29
Electric Sales Rate	($/MWh)	$ 115
Ferrous Metals	($/metric ton)	$ 40
Non-Ferrous Metals	($/metric ton)	$ 400
Clean Development REC	($/metric ton CO_2 E)	$ 16
Compost Sales rate	($/metric ton)	$ 9

The following data is based on the mass balances for each option presented in Section 2.2.

Table 2.4-3 - Preliminary Operating Parameters, Cost and Revenue Data		
	Option A	**Option B**
Waste Data (metric tons per annum)		
Waste Delivered	493,000	558,000
Total waste to Combustion	493,000	460,000
Ferrous Metals recovered	5,000	3,000
Non-Ferrous Metals recovered	2,000	1,000
Wet Bottom Ash (to disposal)	76,000	81,000
Fly Ash Generation (to disposal)	2,300	2,400
Total waste to AD system	-	18,000
AD System Dewatered Solids (to disposal)	-	-
Net Electrical Export - AD System (MWh/annum)	-	-
Net Electrical Export - Combustion System (MWh/annum)	237,000	238,000

Table 2.4-3 - Preliminary Operating Parameters, Cost and Revenue Data		
	Option A	**Option B**
Total Electrical Export (MWh/annum)	237,000	238,000
Annual Revenue ($USD 1000)		
Tipping Fees Revenue	$ 12,300	$ 14,000
Ferrous Metals	$ 200	$ 100
Non-Ferrous Metals	$ 800	$ 400
Net Electric Sales - AD System	-	-
Net Electric Sales - Combustion System	$ 27,300	$ 27,400
CDM REC's	$ 500	$ 500
Revenue from Sale of Compost	-	$ 300
Total	**$ 41,100**	**$ 42,700**
Annual Operating Costs (EXCLUDING FINANCE COSTS, $USD 1000)		
Operations & Maintenance		
Pre-Processing - Maintenance (Labor & Supplies)	-	$ 144
AD - Maintenance (Labor & Supplies)	-	$ 120
AD System - Operations Labor	-	$ 110
O&M Combustion*	$ 13,300	$ 13, 300
Disposal - AD Dewatered Solids	-	-
Disposal - Combustion Bottom Ash Residue	$ 1,900	$ 2,000
Disposal - Combustion Fly Ash Residue	$ 900	$ 1,000
Total	**$ 16,100**	**$ 16,700**

The estimated capital cost for Option A and Option B is essentially equivalent. Both plants have the same heat input; however, as Option B plant accepts a slightly lower feed rate it would result in a lower construction cost.

Option B receives more waste overall and, therefore, the opportunity to generate greater revenue from tipping fees. Option B also has a small additional revenue stream in the sale of compost.

While O&M costs of the combustion plant are the same, Option B requires the operation and maintenance of the sorting plant, composting facility and AD plant.

As noted above, the operating costs presented in are exclusive of debt payments on financed capital costs.

Several operational assumptions have been made in the analysis thus far, including:

- The residual dewatered solids from the AD system in Option B would be sent to the compost facility rather than to the combustion unit. While it is possible to include these solids in the feed to the furnace, hence increasing total combustible; the processing capacity would be increased and the energy recovered per ton would be reduced; thereby negatively affecting the overall process.
- Combustion bottom ash may not have any commercial value in the construction or road building industry and therefore appears as a disposal cost rather than a potential revenue source. Combustion fly ash is likely to be regulated as a hazardous waste, and therefore attracts a higher disposal cost.
- Operating labor for the sorting facility is at no cost to the project. This is supplied by an agreement between COMLURB and the waste pickers, who then receive the recyclables removed.
- An estimated cost of $12,000 USD/month ($20,000 BRL) has been provided by COMLURB for the maintenance of the sorting plant. It was assumed this also covers maintenance and operation of the composting facility.

2.5 Least Cost Assessment

2.5.1 Life Cycle Costs

Based on the assumptions in Table 2.4-2 and expense and revenue data in Table 2.4-3, a simple life cycle cost comparison of the two options has been made.

Both options show positive revenue initially, which then gradually reduces as the inflation linked O&M fee grows steadily while revenue from tipping fees remains constant. As a result, Option A has a revenue shortfall in Year 14, while option B has a shortfall of revenue starting in Year 16. Net Present Value and modified IRR were calculated to demonstrate the relative financial viability of the options. Based on the cost inputs used, Option A is showing a positive +$10.5M NPV while Option B is showing a positive +$25M NPV.

On this least cost assessment, Option B is economically favorable.

3 Detailed Cost Estimate

3.1 Preface

The purpose of Task 3 is to prepare a detailed Engineer-Procure-Construct (EPC) type cost estimate, which can then be used for further economic analysis.

The task consists of the following activities:

- Outline the Estimating Strategy - determines the basis for the EPC estimate.
- Identify sources of cost information and state any assumptions in the estimating strategy.
- Prepare a detailed cost estimate based on the required construction activities of the plant, and budget estimates received from vendors for capital equipment.

3.2 Estimating Strategy

3.2.1 Procurement Model

The procurement model adopted for this cost estimate, assumes that major chute to stack components of the combustion lines are sourced from a single international supplier. It is important to note this estimating approach is not intended to affect or pre-determine the eventual procurement process. In the implementation of this project, the procurement strategy should ensure an open, competitive process and create opportunities for both Brazilian and US companies to participate, including design and supply of any chute-to-stack components.

3.2.2 Estimating Strategy

For the purpose of this cost estimate, the procurement model is based on an Engineer – Procure - Construct (EPC) type contract with a major Brazilian construction company. The EPC contractor would in turn order major components of the plant from specialist vendors. It is assumed for the purpose of this estimate that a US, European or Japanese company would provide the detailed engineering and supply of the major chute-to-stack components for the combustion lines, including:

- Combustion grate and associated waste charging, combustion air, burner management, supplementary fuel and bottom ash removal systems.

- Heat recovery system including boiler, superheater economizer and associated pipework.
- Ash handling, metals removal and storage
- Air Pollution Control plant including control of NOx, acid gas, mercury, collection of particulates plus the induced draft fan and flue.

Based on discussions with vendors, the high cost of producing fabricated items in Brazil may result in the chute-to stack components being manufactured outside Brazil, therefore, the estimate model is constructed based on overseas supply of chute-to-stack components from a single design/supply contractor.

There are several international specialist WTE companies, whose capability and experience may be suitable for this type of contract, including (in alphabetical order)

- Babcock and Wilcox (VØlund)
- Fisia Babcock
- Hitachi Zosen (Von Roll)
- Keppel Seghers
- Martin
- Waterleau

Similarly, the anaerobic digestion system would be procured under a contract with an experienced MSW anaerobic digestion company. There are several companies whose experience may be suitable for this contract, including (in alphabetical order):

- Arrow Bio
- BTA
- Dranco
- Entec
- Kompogas
- Omrin
- Vajorga

The contractor would provide the design and detailed engineering. Fabrication of major components would be carried out in Brazil.

The EPC contractor would source the remaining major equipment components from Brazilian companies. These components would include:

- Cranes

- Instrumentation and controls
- Turbine-Generator and auxiliaries
- Power cycle equipment (condenser, deaerator, boiler feed pumps, preheaters)
- Cooling towers
- Power system piping
- Electrical components (switchgear, transformers, MCCs, power panels, cables, conduits, lighting)

All site demolition, civil work, buildings and roads would be carried out by the EPC contractor using local labor.

3.3 Sources of Cost Information

3.3.1 Sources of Data and Assumptions

This cost model is based on many years of experience in the WTE construction industry and provides a relative cost for major system components, based on cost categories for a typical mass burn facility. In order to determine a relevant location specific cost, a budget proposal for the chute-to-stack supply contract was obtained, based on the proposed Rio waste and the mass and energy balance from Task 2. The Babcock and Wilcox Company, amongst others, were approached to provide a budget proposal. Babcock & Wilcox Power Generation Group Babcock and Wilcox Power Generation Group (B&W) is a US based company affiliated with Danish combustion grate designers Vølund, and have recent project experience in supplying equipment globally, including the Brazilian market. B&W carried out preliminary design calculations and provided a chute-to-stack budget proposal, which was used as the basis for the overall facility cost. Using the chute to stack price from B&W, the cost model was adjusted to reflect the overall cost expected for this location and waste characteristics. The overall cost estimate is broken down into major equipment cost (including freight to Rio), construction materials and construction labor. Labor cost and labor efficiency has been adjusted to reflect the Brazilian construction industry, in accordance with methods outlined by the American Association of Cost Engineers. This method is in line with the American Association of Cost Engineers' recommendations on location factors.

The major equipment and material costs were then adjusted by adding import duty and port fees where applicable to arrive at the final installed cost. Table 3.3-1 lists the assumptions that have been used to develop the EPC cost estimate.

Table 3.3-1 Cost Factors and Tax Rates Used in the Construction Cost Estimate			
Inputs		**Sales Tax[1]**	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate[2] (USD)	$17.54		
Brazil Labor Efficiency Factor	1.80		

1) It is assumed the project would be exempt from state and federal sales tax
2) Fully burdened rate reflecting a mixture of skilled and non-skilled occupations

It is understood that PIS, COFINS, ICMS and IPI taxes would receive full exemption for a project of this nature, as reflected in the Sales Tax column. The cost summary and detailed component cost estimates are included in Appendix 3-A.

In addition to the chute to stack proposal, the following vendors provided budget proposals, included in Appendix 3-B.

- Enfil – Air Pollution Control System (70 % Brazil manufacture)
- Advanced Power Products (TGM) – Steam Turbine Generator (100% Brazil manufacture)
- Organic Waste Systems (Dranco)– Anaerobic Digestion (Brazil manufacture to be determined)

From discussions with several manufacturers, it appears likely that local procurement of the major components would not necessarily result in a lower capital cost. For example, the Enfil quote for design and supply of the APC system, including sales tax would be slightly more than the estimated cost of the fully imported system as part of the chute to stack supply.

The cost model shows a good correlation to the actual prices received from vendors. Both the APC and Turbine/Generator proposals are within several percent of the component costs predicted by the cost model. Based on the current stage of design development, the cost model is considered to be an accurate and suitable estimating tool for this feasibility stage of the project.

Construction industry data sources providing material costs in Brazil have been reviewed. At this preliminary stage it was decided to use a cost index of 1.00 for comparing cost of Brazilian construction materials with the USA materials.

In addition to the budget estimates received from vendors, the following sources of data were used to construct the cost model:

1. http://www.informativosbc.com.br/
2. http://www.construcaomercado.com.br/pmp/
3. http://thebrazilbusiness.com/import-tax-guide/steam-vapour-generating-boilers-than-central-heating-hot/sp/84021100-1

3.3.2 Estimation of Construction Labor Rate

To determine a suitable average hourly rate for the project, a range of hourly wages were combined in a typical mix of labor for a construction crew.

Table 3.3-2 shows the breakdown used for atypical work crew. From the table, the calculated labor rate for an average man hour of construction labor is 7.28 $R. This was marked up by a factor of 3.80 to determine a fully burdened labor rate of 27.44 $R, then converted to US Dollars ($17.5 USD). The fully burdened rate is inclusive of all overhead costs such as taxes, overtime, insurance, site allowances and rental of tools and equipment.

Table 3.3-2
Hourly Wages for Typical Work Crew

Occupation and number of workers		Rate ($R)	Total ($R)
General Foreman (1)	1/3	12.50	4.15
Foreman	1	8.50	8.50
Skilled worker (2)	7	6.17	43.20
Assistant	3	5.65	16.95
Total man hours	10		72.80

1) One General Foreman at 12.50 $R split between three crews
2) Average for electrician, control technician, plumber, insulator, mechanical adjuster, rigger, welder and safety technician

3.4 Project Cost Summary

The project is made of two major new facilities on the Caju site:

- The mass burn waste to energy plant treating combined feedstock including mixed waste direct from collections and rejects from the sorting operation.
- Anaerobic digestion plant treating organics from the sorting operation and sending biogas to the WTE plant.

Table 3.4-1 summarizes the preliminary capital budget based on the cost models and inputs detailed in Appendix 3-A.

Table 3.4-1
Preliminary Capital Budget (1000 $US)

Item	Cost
Land Acquisition Costs	$ -
Site Preparation and civil work for the AD plant	$ 2,000
Pre-processing	$ -
AD plant	$ 7,115
Mass burn Combustion	$293,752
Total Construction Cost	**$302,900**
Additional Costs (Permitting, Legal, Procurement, Due Diligence)*	$10,700
Total Project Cost	**$314,000**
* Based on 3.5 % of Construction Cost	

4 Task 4 – Economic Evaluation

4.1 Preface

The purpose of Task 4 is to prepare a financial life cycle model of the project and conduct a sensitivity analysis related to major external factors that may impact plant profitability.

The balance of this section includes the following components:

- Financial Model – Describes the inputs and results of the base case life cycle financial model.
- Sensitivity Factors – Identifies factors that impact the financial performance of the project.
- Sensitivity Analysis – sensitivity of financial model and NPV over the planned 20-year life of the facility, based on reasonable variation of the sensitivity factors.
- Feasible Alternatives – an exploration of possible project scenarios that may lead to a profitable project.

4.2 Financial Model

The major inputs for the financial model come from the capital cost estimate in Task 3 and the mass and energy balance developed in Task 2, also included in Appendix 4-A.

Inputs for the financial model are presented in Tables 4.2-1, 4.2-2 and 4.2-3.

To evaluate the potential profitability of the project, the base case financial model calculates life cycle estimates of annual operating costs, revenues, debt service expense and taxes. From these annual figures, the net present value (NPV) and internal rate of return (IRR) are then calculated. The base case model with NPV and IRR is shown in Appendix 4-B.

Based on the inputs considered and the capital cost estimate, the project is not economically feasible since the NPV is ($250M USD). The following sections explore the reasons for the poor financial profile of the project and possible feasible scenarios.

Table 4.2-1 Preliminary Capital Budget ($USD 1000)	
	Combustion and AD
Land Acquisition Costs[10]	$ -
Site and Civil for the AD plant	$ 2,000
Pre-processing[11]	$ -
AD plant	$ 7,115
Mass burn Combustion	$293,752
Total Construction Cost	**$302,900**
Additional Costs (Permitting, Legal, Procurement, Due Diligence)*	$10,700
Total Project Cost	**$314,000**
* Based on 3.5 % of Construction Cost	

Table 4.2-2 Base Case Inputs for Operating Cost and Revenue Budget (2011 $US)		
Tipping Fee	($/metric ton)	$ 25
Bottom Ash Disposal Fee	($/metric ton)	$ 25
Fly Ash Disposal Fee	($/metric ton)	$ 400
Combustion O&M	($/metric ton)	$ 29
Electric Sales Rate	($/MWh)	$ 115
Ferrous Metals	($/metric ton)	$ 40
Non-Ferrous Metals	($/metric ton)	$ 400
Clean Development CER[12]	($/metric ton CO_2 E)	$ 8
Compost Sales rate	($/metric ton)	$ 9

10 It is assumed for the purpose of this study, the required land at Caju is made available by COMLURB.

11 The pre-processing of mixed MSW is to be carried out at the existing Caju sorting and recycling facility.

12 Price for Certified Emission Reduction (CER) from http://www.carbonpositive.net/ accessed Feb 29 2012

Table 4.2-3 Base Case Operating Parameters, Cost and Revenue Data	
Waste Data (metric tons per annum)	
Waste Delivered	558,000
Total waste to Combustion	459,000
Ferrous Metals recovered	3,000
Non-Ferrous Metals recovered	1,000
Wet Bottom Ash (to disposal)[13]	81,000
Fly Ash Generation (to disposal)	2,400
Total waste to AD system	18,000
AD System Dewatered Solids (to compost)	6,000
Compost from Organic Fraction Direct	27,100
Total Electrical Export (MWh)	238,000
Emissions Reduction (mt CO2e)	27,540
Annual Revenue ($USD 1000)	
Tipping Fees Revenue	$ 14,000
Ferrous Metals	$ 100
Non-Ferrous Metals	$ 400
Net Electric Sales	$ 27,400
Revenue from Clean Development CER's	$ 220
Revenue from Sale of Compost	$ 300
Rounded Total	**$ 42,400**
Annual Operating Costs (EXCLUDING FINANCE COSTS AND TAXES, $USD 1000)	
Operations & Maintenance	
Pre-Processing - Maintenance (Labor & Supplies)	$ 144

[13] Tonnage of ash for disposal includes residual moisture (up to 40%) from the quenching process, and hence is greater than figure derived from the mass balance.

AD - Maintenance (Labor & Supplies)	$ 120
AD System - Operations Labor	$ 110
O&M Combustion*	$ 13, 300
Disposal - Combustion Bottom Ash Residue	$ 2,000
Disposal - Combustion Fly Ash Residue	$ 1,000
Rounded Total	**$ 16,700**

4.3 Sensitivity Analysis

4.3.1 Sensitivity Factors

The financial model relies on various factors that influence the project. Many of the factors are subject to variability over time and may be external factors of which several are outside MPX's control. The following provides a brief discussion of the key assumptions utilized in the financial model, the factors that impact future revenues and costs, and the potential range of values for these factors.

4.3.1.1 Availability

This factor refers to the annual capacity of the plant to process waste. The most significant variable is the planned maintenance downtime required to keep the mass burn facility running reliably. The availability of the plant is determined by the number of down days each combustion line has per year. Based on industry experience for mass burn plants, the base case availability is set to 90 % (i.e. 37 days downtime each year). The sensitivity analysis was completed for a range of availability with a best case scenario of 93% and a low case of 87%.

4.3.1.2 Inflation rate

The financial model escalates the O&M service fee annually by a percentage equal to the national inflation rate. A review of the annual change in Consumer Price Index from publicly available sources[14] identified that inflation is steadily increasing in Brazil and is currently 7.3% (Sep 2011). However, over the five years to Oct 2011 the rate has tended to fluctuate rather than climb continuously, suggesting a base case of 5% with low and high values of 3.0% and 7.0%, respectively.

[14] http://www.tradingeconomics.com/brazil/inflation-cpi

4.3.1.3 Plant Electrical Efficiency

The base case design includes a conventional mass burn waste to energy plant. The thermal design includes a boiler efficiency of 82% and a power cycle efficiency of 31.1%, resulting in gross efficiency of 25.5% (LHV) in line with a conventional plant design at typical WTE steam pressures. As mentioned in Task 2 and in industry research papers[15], there are several novel design alternatives that may be used to increase plant efficiency. These may include, amongst others:

- Low Combustion Air
- High Steam Parameters
- External Superheater
- Exhaust Gas Cooling
- Steam Reheat

Scenarios incorporating one or more of these designs into the plant have been investigated, improving gross electrical efficiency by 10%, (i.e. 28.05 %). However, since the electricity production of the plant is capped at 30MW, the net result is that less waste is required for the same electrical output. In order to model this scenario, mass flow of waste to the sorting plant was held constant, while the flow direct to the WTE plant is decreased. The revised mass balance and resulting cost and revenue data were modeled to show the sensitivity to improvements in plant efficiency.

4.3.1.4 Operations and Maintenance Service Fee

The estimated operating and maintenance service fee for the mass burn plant is $29 USD per metric ton of waste processed. This is based on industry experience and includes plant operators' wages, purchase of chemicals, supplemental fuel and major scheduled servicing and replacement parts for the plant. A breakdown of these costs is provided in Appendix 4-B.

With a base case of $29.00 USD, a low and high value of $24.00 and $35.00 USD respectively have been nominated to reflect the uncertainty in this estimate.

[15] Armin Main, M.Sc. TU, P.E. & Thomas Maghon, M.Sc. TH, P.E., "Concepts and Experiences for Higher Plant Efficiency with Modern Advanced Boiler and Incineration Technology". NAWTEC 18, 2010

4.3.1.5 Borrowing Rate

The borrowing rate will depend on how the finance for the project is set up, which is not clear at this stage. One possible source of finance is the National Development Bank of Brazil (BNDES), who advise that a typical lending rate for a project of this nature is approximately 9 - 10%. Accordingly, the base case borrowing rate is assumed to be 9.5% and the sensitivity analysis was completed for low and high of 7.5% and 11.5 % respectively.

4.3.1.6 Capital Cost

The detailed capital cost estimate from Task 3 results in required capital investment of $314M USD. This capital cost was built on a cost model including:

- Actual budget estimate from a technology vendor for the chute to stack components
- Brazil labor rates and efficiency
- Import duty
- Sales tax exemption under the Special Incentive Scheme for the Development of Infrastructure (REIDI)

Because of the high potential for variability in construction costs, the sensitivity analysis is conducted for approximately +/- 20% of the base case (i.e. $250M, $375M).

4.3.1.7 Electric Sales Rate

The base case electrical sales rate is set to $115 USD per MWh as suggested by MPX. A sensitivity analysis range of $100 to $130 USD was considered to allow for uncertainty in this figure. It is assumed that the electricity sales rate escalates annually at a rate of 1% in all cases.

4.3.1.8 Tip Fee annual escalation

The base case tip fee is set to $25 USD per metric ton as advised by COMLURB and is not escalated annually, in accordance with existing agreements. The sensitivity analysis considers an annual tip fee escalation of 5 % to improve financial viability; however, it is unclear whether this escalation is attainable. A decrease in the tip fee is not considered.

Table 4.3-1 summarizes the high and low values used for the sensitivity analysis and their base case values.

Table 4.3-1 Sensitivity Factors			
Factor	**Low**	**Base**	**High**
Availability	87%	90%	93%
Inflation Rate	3%	5%	7%
Gross Electrical Efficiency	-	25.5%	28.05%
O&M Service Fee	$24USD	$29 USD	$34 USD
Borrowing Rate	7.5%	9.5%	11.5%
Capital Cost	$250M USD	$314M USD	$375M USD
Electric Sales Rate	$100USD/MWh	$115USD/MWh	$130USD/MWh
Tip Fee Annual Escalation	-	0%	5%

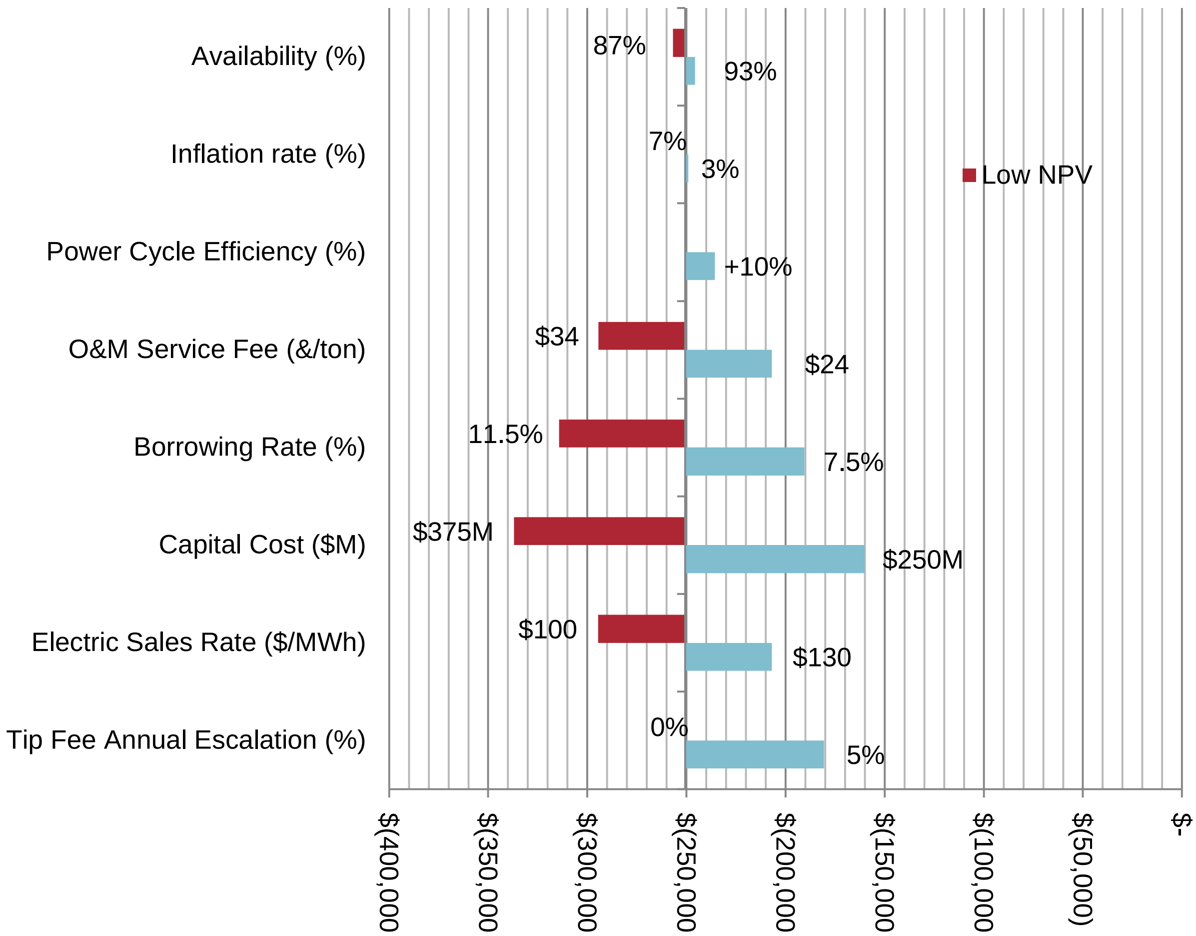
4.3.2 Sensitivity Analysis

The base case model was adjusted to calculate NPV and IRR for the high and low cases for each of the eight factors while keeping the remaining factors at base values. This shows the sensitivity of the financial model to each of the factors within a reasonable range of variation. The results of the sensitivity analysis are presented in Figure 4.3-1. The horizontal axis represents the NPV and the vertical center line represents the NPV with all factors at their base case ($250M USD). Each set of red/blue lines indicates changing one factor while the remaining factors are held constant.

No single factor results in a positive NPV; however, the most significant factors are O&M service fee, borrowing rate, capital cost, electric sales rate and tip fee escalation. The effect of inflation rate is negligible due to the high borrowing rate, which dominates the fixed costs of ownership. Plant efficiency and availability are also minor factors in this financial model.

A majority of the cost assumptions used in the model are outside the control of MPX and as such, actual costs can vary substantially from those presented in the model. In addition, each of the scenarios presents its own unique pricing risk which further complicates the decision process and ability to conduct direct comparisons. This is particularly true the further costs are projected beyond a five- to ten-year period.

Figure 4.3-1 Sensitivity Analysis NPV in $1000,s USD for high and low scenarios for each factor



4.4 Feasible Alternatives

Having determined the base case is not profitable, the project team explored scenarios under which the project can be economically feasible by changing the most sensitive factors of the financial model.

In order to make the investment attractive a target IRR of 15% was postulated, as discussed with MPX at the project kickoff. It is not realistic to achieve this turnaround by changing just one factor so a series of scenarios were developed that show how improving several factors together can result in a feasible project (IRR = 15%). As with any WTE project the primary sources of income - tipping fees and electrical sales - are the most important factors in determining profitability.

The following hypothetical scenarios help to define the extent of changes that would need to occur for the project to become feasible. Understanding that changes to tipping fees, electrical sales rates and tax rates are easily made on paper, these factors are not controlled by MPX so in practical terms may not be achievable. For the purpose of these scenarios, it is assumed the low end capital cost of $250M USD can be achieved through low cost design features, procurement strategy and local construction processes. This analysis is intended to be hypothetical, and does not supersede the Task 3 cost estimate.

4.4.1 Scenario 1 –Tip Fee Increase

Scenario 1 considers an increase in tip fee plus two other sensitivity factors. The tip fee required to reach 15% IRR is calculated when two other sensitivity factors are adjusted to their high NPV values. Alternatively the tip fee revenue can be increased gradually by annual escalation. The results are shown in Table 4.1 with escalation required for an equivalent benefit shown in parentheses. Note that all factors not mentioned in the table are set to their base case values.

Table 4.4-1
Calculated Tip Fee in USD/metric ton (annual escalation rate) to achieve 15% IRR

	Capital =$250M	Borrowing Rate = 7.5%	Elec Sales =$130/MWh	O&M Fee = $24/mt
Capital = $250M		$53.34 (10.3%)	$52.32 (10.8%)	$50.79 (11.5%)
Borrowing Rate = 7.5%			$58.43 (13.4%)	$56.69 (13.9%)
Electricity Sales = $130/MWh				$57.82 (15.1%)
O&M Fee = $24/metric ton				

For example if the capital cost came down to $250M at a borrowing rate of 7.5%, the flat tip fee for the life of the plant would need to be $53.34 /metric ton to achieve an IRR = 15%. Alternatively, the same IRR could be achieved by starting with the tip fee at $25/metric ton (base case) and increasing it annually by 10.3%

In all cases a significant increase in tipping fee is required, more than double the base case. The combination of low capital cost and low O&M Fee results in the lowest required tip fee increase.

4.4.2 Scenario 2 –Electric Sales Rate Increase

Similarly, shows the electric sales rate required to reach 15% IRR when two other sensitivity factors are set at their high NPV values and all other factors are set to their base case.

Table 4.4-2 Electric Sales Rate in USD/MWh to achieve 15% IRR				
	Capital =$250M	**Borrowing Rate = 7.5%**	**Tip Fee Escalation = 5%**	**O&M Fee = $24/mt**
Capital = $250M		$172.92	$147.53	$168.00
Borrowing Rate = 7.5%			$158.45	$179.63
Tip Fee Escalation = 5%				$167.84
O&M Fee = $24/metric ton				

For example if the capital cost came down to $250M at a borrowing rate of 7.5%, electric sales rate would need to be $172.92/MWh to achieve IRR = 15%.

All scenarios require tipping fee well above the high case considered in the sensitivity ($130 USD/MWh). The most favorable scenarios include high tip fee escalation in conjunction with reduction in debt payments (low capital cost).

4.4.3 Scenario 3 - Reduction in Debt Service Payments

Debt Service reduction can be achieved by either reducing the capital borrowed for the plant, or reducing the borrowing rate applicable to the debt.

Further capital cost reduction may be achieved by removing the 14% duty that is levied on the imported components of the construction project. This would require a project-specific exemption from the government. Without import duty the project cost is reduced from $314M to $296M and the base case is still highly unfavorable, NPV is ($225.3 M).

Debt payments can be further reduced by obtaining a more favorable borrowing rate than the 9.5% assumed in the base case. However, even if a borrowing rate of 7.5% is possible, then combined with the import duty relief, the project NPV is still negative ($168.5 M).

The total capital cost that would be required for the project to obtain an IRR = 15%, while all other factors remain at base case, would be $95.5M USD.

5 Environmental and Social/Economic Impact Assessment

5.1 Introduction

Task 5, is a preliminary review of the project's environmental impact focused on compliance with applicable local environmental laws, regulations and requirements, including factors such as air quality, water quality, nuisance impacts, infrastructure, jobs creation, technology transfer and productivity enhancement.

The WTE plant is an alternative solid waste treatment process with energy recovery that employs state-of-the-art technology still unused in Brazil. It is worth noting, however, that some initiatives are now being implemented in the country – such as WTE São Bernardo do Campo and WTE São José dos Campos, both of them in São Paulo State.

Such alternatives however, have generated some conflicts between civil society (represented mainly by waste pickers organizations), subject specialists and the government, as can be seen in some recent news provided by the Brazilian Federal Senate (http://www.senado.gov.br/NOTICIAS/JORNAL/EMDISCUSSAO/revista-em-discussao-edicao-junho-2010/noticias/lei-sobre-residuos-solidos-nao-pode-excluir-novas-tecnologias-1.aspx) and also on the website entitled "Incinerator, NOT" (http://www.incineradornao.net). The debate is mainly focused on issues such as air pollutant emissions, reduction of solid waste (as predicted in the Solid Waste National Policy), and on the waste pickers, that allege that their jobs could be prejudiced because of the use of recyclable materials by incinerators.

The importance of WTE can be justified by the worldwide trend of growing urban expansion, the growing production of solid waste and the unavailability of areas to implement and expand landfills. It is also an alternative for power generation. The proposed WTE plant complies with the National Solid Waste Policy and, in the specific case of Rio de Janeiro, with the "Rio Capital da Energia" program, because this city has a strategic importance in the energy issue.

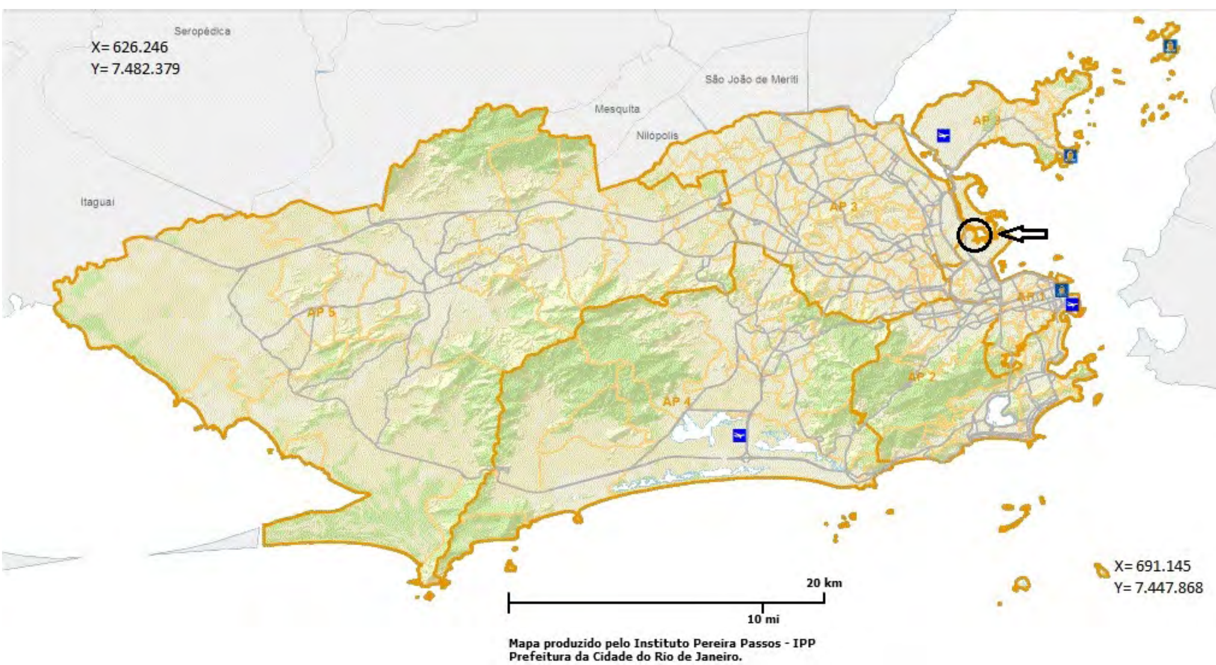
The remaining sections contain a brief description of the enterprise, a diagnostic of the environmental and social-economic aspects, and the possible expected impacts with enterprise implementation and operation – in addition to some suggestions to leverage positive interventions and to mitigate negative ones.

5.2 General Information and Enterprise Description

5.2.1 Enterprise description

For the development of a thermal treatment unit for municipal solid waste (MSW) in the region of Caju, Rio de Janeiro (Figure 5.2-1), several process models for combined technologies were discussed. Based on a set of guiding principles (refer to Task 1 technical memo), the most suitable alternatives were combustion only and the combined technology of combustion with anaerobic digestion.

Figure 5.2-1 - Caju District Location and Municipal Limits of Rio de Janeiro.



Source: Rio de Janeiro´s Digital Map – Mayorship of Rio de Janeiro, 2011.

According to the Least Cost Analysis of Task 2, the most advantageous option is the combined facility of Recycling – Composting – Anaerobic Digestion – Combustion. This option is effectively a combination of four plants operating together as an integrated waste management system:

- Mechanical and manual sorting/recycling,
- Batch aerobic digestion (composting),
- Anaerobic digestion, and
- Combustion.

These systems are each discussed separately in the following sections.

5.2.1.1 Mechanical and Manual Sorting System

There is an existing sorting plant at Caju which consists of two lines of process equipment operating in parallel with capacity to process 800 mtpd (metric tons per day). Each line includes a series of trommels, manual sorting stations, ferrous metal removal equipment, and conveyors to transport waste through the process and divert separated materials to designated storage areas. The system accepts mixed MSW and separates metallic, cardboard and plastic recyclables in a combination of manual and automated processes. The output from the plant includes[16]:

- Recyclable cardboard, plastic bottles and ferrous metals (46 mtpd)
- Organic fraction of MSW consisting of food wastes and fine organics (214 mtpd)
- Rejects, remaining material which includes the non-recovered organic material, plus inerts and non-recovered metal, paper and plastic materials (502 mtpd)

During the pre-processing stage approximately 5% of the water in the incoming waste is removed.

5.2.1.2 Aerobic Digestion (Composting) Facility

Most of the organic fraction (165 mtpd) from the sorting plant is then sent to an existing composting facility. The waste is piled into open windrows and turned periodically for several weeks to promote aeration. The aerobic decomposition produces heat,

[16] Data is based on Comlurb document “Balanço Massa Usina Compostagem aer-anaer–rdf fluxo (5)”

reduces the moisture and, consequently, reduces the mass of the composted material to approximately half of the original organics fraction.

After the inert residues and large pieces are removed, this product is sold as a soil supplement for eucalyptus plantations. The remaining organics fraction (49 mtpd) is directed to an anaerobic digestion facility.

5.2.1.3 Anaerobic Digestion (AD) System

There are a range of viable AD technologies that are considered suitable for this project. At this planning level, a decisive determination is not necessary. The AD system is designed to process approximately 18,250 tons of organic waste per year. The net result is a biogas generation rate of approximately 110 Nm^3 per metric ton of organic waste and dewatered residual solids of approximately 6,000 tons per year. The residual solids would then be used to augment the organic waste being treated aerobically, producing compost.

In the least cost analysis (Task 2), a dry, single stage system was modeled including: pretreatment, digester, dewatering, onsite wastewater treatment plant (WWTP), biogas conditioning, and a main computer for the Plant Control System.

The AD system operates 52 weeks per year, six (6) days a week, and two shifts (16 hours) per day.

5.2.1.4 Combustion Facility

The combustion facility would be designed to handle a combined feedstock of raw MSW (900 mtpd) plus the rejects stream (502 mtpd) from the sorting plant. The combustion system would also be designed to accept the biogas from the AD plant as required. The system is designed to meet the following estimated performance and design data:

- Average Throughput: 460,000 tons per annum (90% availability)
- Design Capacity: 1402 mtpd
- MSW Lower Heating Value: 8.6 MJ/kg (average)
- Steam Generation (Maximum Continuous Rating [MCR]): 140,000 kg/h
- Steam Condition at Turbine Inlet: 42 bar/400°C
- T-G Capacity: 44.1 MVA (Power Factor of 0.8)
- T-G Output (Maximum Continuous Rating [MCR]): 35.3 MW
- Net Average Export: 30 MW

The main components of a mass burn WTE facility are listed below:

- Waste receiving, handling, and storage system, housed within a covered structure which provides protection from weather and allows control of odorous emissions.
- Furnace/boiler system, capable of handling fluctuations in heat content, moisture content, and the composition of the waste processed. Design criteria include destruction/minimization of hazardous air pollutants within the furnace and maximization of waste burn-out and energy recovery. Along with advanced combustion control (ACC), reduction in NOx emissions may be achieved in the furnace by selective non catalytic reduction (SNCR).
- Boiler water/steam cycle system, including water-tube boiler, super heater and economizer sections suitable for high temperature corrosive combustion products typical of refuse incineration.
- Power generation equipment including steam turbine and water-cooled condenser sized for steam generation rate of the boiler at MCR, steam extractions, generator, ancillary equipment and operating controls.
- Air pollution control (APC) or flue gas cleaning system designed to meet emission limits for various regulated pollutants. Refer to Appendix A for details of the proposed air pollution control system. Additional NOx control and continuous emissions monitoring system (CEMS) may also be required depending on permit requirements.
- Ash residue handling system to serve the boiler/furnace/APC system, consisting of the collection of bottom ash from the furnace bottom ash discharger, grate siftings, fly ash from the boiler ash hoppers, and APC fly ash.
- A distributed control system (DCS) to monitor and control the combustion system, steam generating equipment, and other related equipment from the control room. The DCS provides monitoring and control of the overall facility, alarm display, and reports configured from transmitted data.
- Auxiliary systems such as steam condenser, condensate, feedwater, deaerator, closed cooling water, and other miscellaneous systems are provided as required. Design margin provides for operational variations, transients, and emergency conditions.
- The electrical interconnection system must meet the requirements of the electric utility and is provided with required redundancy and reliability to provide electrical power for the entire plant.

5.2.1.5 Air Emissions and Wastewater

5.2.1.5.1 Air Emission

The average estimated emissions from a typical US Mass Burn WTE Plant are presented in the following table (Table 5.2-1 along with applicable national emission standards from USA, EU and Brazil.

Table 5.2-1- Estimated Emissions from typical US Mass Burn Plant.

Pollutant	Units (1)	Brazil CONAMA 316/2002	US EPA (2)	EU (3)	Estimated Emissions from typical US Mass Burn Plant
NO_x	mg/Nm^3	560	300	281	215
SO_2	mg/Nm^3	280	100	70.2	21.5
CO	ppm	100	100	56.2	60
PM	mg/Nm^3	70	20	70.2	12.2
Pb	µg/Nm^3	7000	140	700	21.5
Cd	µg/Nm^3	280	10	70.2	1.2
Hg	µg/Nm^3	280	50	70.2	2.4
HCl	mg/Nm^3	80	40	14	8.1
HF	mg/Nm^3	5	-	-	3.1
Dioxins/ Furans	ng/Nm^3	0.5 (TEQ)	13	0.14 (TEQ)	0.02 (TEQ)
VOC (as C3H8)	mg/Nm^3	-	-	-	13.7

1) Dry basis, corrected for 7% O_2 in stack

2) Standards of Performance for New Stationary Sources, subpart EB

3) EU Directive 2000/76/EC/Annex V. Values adjusted from 11% O_2

4) The TEQ value for dioxin and furan emission is calculated according to a toxicity weighting scale. The compound 2,3,7,8 tetra chlorinated dibenzo-p-dioxin (TCDD) is usually considered the most toxic compound and is assigned a weighting factor of 1.0

Source: Malcolm Pirnie, 2011.

This facility is presented as a “typical” facility in an urban area location. Air pollution control consists of: NOx control using Good Combustion Practice design and Selective Non-Catalytic Reduction (injection of ammonia in combustor); Lime injection post boiler for control of SO_2 and other acid gases; VOC and CO controlled primarily by Good Combustion Practice design; Dioxin/furans control based on design of combustor (temperature/residence time); Control of metals (Hg, Ni, Cd, Pb) by carbon injection, semi-dry absorbers, and fabric filters/baghouse.

5.2.1.5.2 Wastewater

The water balance of the WTE plant would be designed to maximize wastewater reuse within the plant and thus to minimize effluent and fresh water demand.

For the waste water that is not re-used on site, a suitable treatment plant would be included as an integral part of the plant. The effluent from the treatment plant would be suitable to meet the discharge quality and quantity of the local permitting authority.

At this preliminary stage the following sources of waste water and the mitigating design features may be considered:

- Polluted water from rain falling on incinerator ash, raw MSW and APC residues: In a modern WTE plant the facility is designed to include an enclosed structure for all storage end treatment areas to prevent contaminated run-off entering local storm-water catchments.
- Water for collection, treatment and storage of bottom ash is sourced from the other wastewater streams and forms part of the integrated water cycle for the plant.
- Boiler water blowdown: expected to be less than 5% of the steam flow, meaning a contribution of 168 m^3/day to the plant´s effluents.
- Cooling tower: evaporation, drift and blowdown is a major requirement for process water when a wet cooling tower is used. This may contribute up to 2600 m^3/day to the demand, with about 160 m^3/day as blowdown appearing in the effluent stream.
- Closed loop cooling water: from various other equipment parts which require cooling (waste chute, grate and ash discharger) does not represent a significant loss of water.
- Sanitary waste water: from toilets, showers and cleaning is estimated at 10 m^3/day.
- Water Demand and Effluent from the Anaerobic Digestion Plant:
    - The AD plant is a net water producer and would have its own dedicated wastewater treatment plant.
    - The generation of waste water from the organic residue dewatering is 20 m^3/day.
    - The waste water is treated in membrane bioreactor type wastewater plant to meet CONAMA Resolution 357/05 requirements.

5.2.1.6 Jobs at the WTE Plant

5.2.1.6.1 Implementation Phase

The construction phase is expected to last from 30 to 36 months, including start up and commissioning.

The number of man hours for the entire construction project is approximately 4,800,000. This includes civil and building work, plus mechanical, electrical and installation of control equipment.

It is envisaged that a large Brazilian construction company would carry out the construction work.

5.2.1.6.2 Operation Phase

It is estimated that the Waste to Energy plant would require 46 full time staff. This would include power plant operators, crane drivers, mechanical and electrical maintenance trades, control technicians, general laborers and managers. The AD plant would require 3 full time plant operators.

Based on the proposed mass balance provided by COMLURB, the sorting and recycling facility would expand to operate two lines and the composting plant would also be substantially expanded. Due to the increased throughput, staffing levels at the sorting and composting facility are expected to increase is in the order of 50- 100 percent.

5.3 Social and Environmental Scenario of the Area of Interest

5.3.1 Physical Environment

5.3.1.1 Air quality

The level of air pollution is determined by quantifying the air pollutants. According to CONAMA Resolution No.3, of June 28, 1990, an air pollutant is:

> *"any kind of matter or energy with intensity, quantity, concentration, time or characteristics that do not comply with the established levels, and that make or can make the air inadequate, noxious or offensive to our health, inconvenient to public welfare, harmful to materials, fauna and flora, or even detrimental to safety, to property use and enjoyment, and to normal activities of the community*".

With regard to their origin, pollutants can be classified as:

- Primary: produced by emission sources directly;

- Secondary: formed in the atmosphere by chemical reactions between pollutants and/or natural atmospheric elements.

According to the current atmospheric conditions, the emitted pollutants can be dispersed and diluted, which makes their concentrations less noxious. Therefore, the actual concentration of pollutants in the atmosphere depends not only on their emission by pollution or removal sources, but also on climate conditions, dispersion mechanisms and local topography. The interaction between pollution sources and the atmosphere actually defines air quality in a given place.

Due to such factors, it can be observed how air quality is degrading with respect to carbon monoxide, particulates and sulfur dioxide during the winter – when climate conditions do not favor the dispersion of pollutants. Similarly, ozone exhibits higher concentrations during spring and summer, as it is a secondary pollutant that needs high sunlight levels to be formed (CETESB, 2009).

To determine the concentration of a pollutant in the atmosphere, the exposure level of recipients (human beings, other animals, plants, materials) is measured as the final result of the emission process of such pollutant to the atmosphere, considering its sources and interactions in the atmosphere, from the physical (dilution) and chemical (chemical reactions) standpoints. The whole system can be represented in the following way:

POLLUTION SOURCES	➔	ATMOSPHERIC PROCESSES	➔	RECIPIENTS
	(POLLUTANTS)		(DILUTION AND/OR CHEMICAL REACTIONS)	

5.3.1.1.1 Air quality standards

According to Art. 1 of CONAMA Resolution Nº. 03/1990:

> "Air quality standards are concentrations of atmospheric pollutants that can impair health, safety and welfare of the population when exceeded, and can damage the flora and fauna, materials and the environment in general".

This same resolution establishes two types of air quality standards:

- Primary air quality standards: pollutant concentrations that can affect the health of the population when exceeded. They can be understood as the maximum tolerable levels of air pollutant concentrations, and are short- to mid-term goals.

- Secondary air quality standards: pollutant concentrations below which a minimum adverse effect can be seen on population welfare, as well all minimum damage to flora and fauna, to materials and to the environment in general. They can be understood as desired levels of pollutant concentration, and are long-term goals.

Table 5.3-1 shows the primary and secondary standards for air quality, as established by CONAMA Resolution Nº 03/1990.

Table 5.3-1 - National Air Quality Standards (CONAMA Resolution Nº. 03/1990)

Pollutant	Sampling time	Primary standard (µg/m³)	Secondary standard (µg/m³)	Measurement method
Overall suspension particulates	24 hours (1) YGA (2)	240 80	150 60	High volume sampler
Sulfur dioxide	24 hours YAA (3)	365 80	100 40	Pararosaniline
Carbon monoxide	1 hour 8 hours	40,000 (35ppm) 10,000 (9ppm)	40,000 (35ppm) 10,000 (9ppm)	Non-dispersive infrared
Ozone	1 hour (1)	160	160	Chemiluminescence
Smoke	24 hours (1) MAA (3)	150 60	100 40	Reflectance
Inhalable particles	24 horas (1) MAA (3)	150 50	150 50	Inertial separation / Filtering
Nitrogen dioxide	1 hour (1) MAA (3)	320 100	190 100	Chemiluminescence

Source: CONAMA Resolution No. 03/90. (1) Cannot be exceeded more than once a year. (2) Yearly geometric average. (3) Yearly arithmetic average.

Air quality standards are indispensable tools to appraise air quality degradation, when compared to soil level concentrations – as determined by monitoring or mathematical modeling of the dispersion of pollutants produced by a given source or source group.

Consequently, if pollutant concentration in a given site exceeds the values of Table 5.3-1, the air will be considered inadequate.

Each pollutant has also fixed levels for the definition of critical air quality states: attention, alert and emergency levels (Table 5.3-2):

Table 5.3-2 - Criteria for Severe Air Pollution Scenarios (CONAMA Resolution Nº. 03/1990)

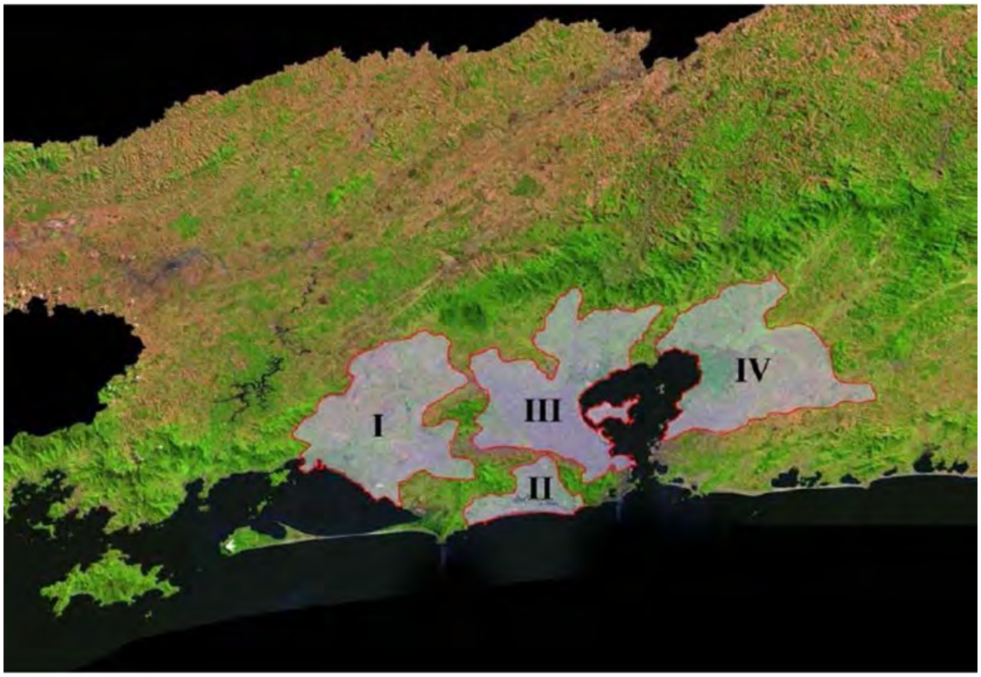
Parameters	Attention	Alert	Emergency
Overall suspension particulates (µg/m³) – 24h	375	625	875
Inhalable particles (µg/m³) – 24h	250	420	500
Smoke (µg/m³) – 24h	250	420	500
Sulfur dioxide (µg/mg/m³) – 24h	800	1,600	2,100
SO_2 X PTS (µg/m³) (µg/m³) – 24h	65,000	261,000	393,000
Nitrogen dioxide (µg/m³) – 1h	1,130	2,260	3,000
Carbon monoxide (ppm) – 8h	15	30	40
Ozone (µg/m³) – 1h	400	800	1,000

Source: INEA, Annual air quality report for Rio de Janeiro State, 2009.

5.3.1.2 Air Basins

Relief, land cover and climate characteristics of a region define homogeneous areas in terms of mechanisms that can disperse air pollutants. Such areas, delimited by topography and vertical / horizontal air spaces, compose an air basin (or sub-region). According to INEA, considering the influence of topography and meteorology in the capability of air pollutant dispersion in the Metropolitan Region of Rio de Janeiro (MRRJ), there are 4 air basins, which can be seen in Figure 5.3-1

Figure 5.3-1 - Delimitation of Air Basins in the Metropolitan Region of Rio de Janeiro (MRRJ).



Source: INEA, Annual air quality report for Rio de Janeiro State, 2009.

The air pollutant emission rates can be seen in Table 5.3-3, considering 2009 as the reference year (fixed sources).

Table 5.3-3- Pollutant Emission Rates for Each Air Basin (2009) for fixed sources

Emission rate (t/year) x 1000	Air pollutant				
	SO_2	NO_x	CO	HC	Inhalable particles – MP_{10}
Air basin I	21.48	14.55	0.92	0.31	5.90
Air basin II	0.01	0.14	0.13	0.74	0.36
Air basin III	29.41	13.30	2.80	24.44	2.50
Air basin IV	3.8	1.28	2.36	0.13	1.39
Overall value	55.76	30.27	6.38	25.85	10.58

Source: INEA, Annual air quality report for Rio de Janeiro State, 2009.
SO_2 – Sulfur dioxide; NO_X – Nitrogen oxides; CO – Carbon monoxide; HC – Hydrocarbons

The results show that Air basin III, where the area of interest of this enterprise is located, contains the fixed sources that most contribute to air pollutant emission.

5.3.1.2.1 Air Quality in the MRRJ

According to the Annual Air Quality Report (INEA, 2009), the metropolitan area of Rio de Janeiro is the country's most densely populated region, with nearly 2,100 inhabitants/km^2, and represents its second largest concentration of vehicles, industries and pollutant sources, which cause serious air pollution problems.

The city of Rio de Janeiro has a very irregular topography, with three mountain ranges: Gericinó, Tijuca and Pedra Branca. The last two, which are parallel to the seashore, create a physical barrier to winds from the sea – which makes more difficult the dispersion of pollutants in the communities located in the inland zone.

Besides, due to the intense solar radiation and high temperatures, and to the tropical climate that prevails in that region, the photochemical processes are escalated, and generate secondary pollutants (such as ozone, for instance).

With the action of high pressure systems that predominate in the region from May to September, it is usual for atmospheric stagnation to occur– which increases the pollution rates. Another factor that contributes to air quality degradation is the decrease of rainfall during the month of July, during the drought season.

According to INEA[17], air quality has been monitored since 1967 in Rio de Janeiro State, when the first monitoring stations were installed. According to the last annual report (2009), more than 62% of monitored areas exhibited yearly average values for long-term exposure to inhalable particles above the standard rates. The highest concentrations have been achieved at the north and east areas of the Metropolitan Region.

With regard to short-term exposure, 45% of monitored areas showed more than one violation of the daily standard limit of air quality, established by CONAMA Resolution Nº. 03/90.

Regarding sulfur dioxide, nitrogen dioxide and carbon monoxide the report showed values compliant with the standard limits of air quality in all locations.

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[17] Data available at: http://www.inea.rj.gov.br/fma/qualidade-ar.asp

5.3.1.2.2 Emission Sources at the MRRJ

Fixed Sources

The MRRJ has an ample variety of air pollution emission sources. According to the Inventory of air pollution sources in the metropolitan region of Rio de Janeiro (FEEMA, 2004), which surveyed fixed sources from several companies with different production processes, the industrial typologies with the most significant emissions per pollutant type can be seen in Table 5.3-4

Table 5.3-4 - Emission Rate According to Industrial Typology (x1000 tons/year)

Type of emission rate (tons/year)*1000	Pollutants				
	SO_2	NO_X	CO	HC	MP10
Chemical	0.87	0.98	0.29	2.19	0.50
Petrochemical	28.16	11.49	2.11	23.19	2.12
Metallurgy	0.29	0.60	0.18	0.03	0.64
Asphalt	0.22	0.19	0.61	0.18	0.12
Miscellaneous	0.13	0.17	0.02	0.01	0.02
Ceramics	2.66	0.60	2.14	0.03	1.27
Laundry	0.15	0.07	0.01	0.00	0.01
Textile	0.42	0.17	0.08	0.01	0.04
Food	1.32	0.78	0.25	0.04	0.17
Pharmaceutical	0.34	0.24	0.09	0.01	0.06
Cement	0.18	0.18	0.09	0.01	0.07
Paper	0.29	0.10	0.01	0.00	0.02
Tobacco	0.01	0.00	0.00	0.00	0.00
Glass	0.34	0.67	0.04	0.02	0.13
Naval	0.02	0.00	0.00	0.00	0.01
Power generation	20.37	14.02	0.47	0.12	5.40
Overall value	55.76	30.27	6.38	25.85	10.58

Source: FEEMA, Inventory of air pollution sources in the metropolitan area of Rio de Janeiro, 2004.

MP10 – Inhalable particulates; SO_2 – Sulfur dioxide; NO_X – Nitrogen oxides; CO – Carbon monoxide; HC – Hydrocarbons

As shown by the table above, the pollutants of fixed sources come from the petrochemical industry and power generation enterprises mainly. Regarding the volume of sulfur dioxide produced by fixed sources, nearly 87% comes from these two sectors (51% from petrochemical and 36% from power generation). As to the emission of nitrogen oxides, 46% are produced by the power generation sector and 38% by the petrochemical plants. With regard to hydrocarbons, the petrochemical sector contributes with roughly 90% of the overall emission value in the metropolitan region.

Movable Sources

Movable sources are those composed by air, sea and land transport means, particularly motor vehicles – which mostly contribute to air emissions in urban areas, due to their number and geographical distribution.

The Emission Inventory (FEEMA, 2004), took into account the main car traffic routes in the metropolitan region (187 routes), which have been properly segmented according to the respective paths or flows; 260 movable sources were then assessed, using average emission factors for the vehicles considered (Table 5.3-5).

Table 5.3-5 - Percent Contribution of the Main Traffic Routes for Pollutant Emission

Route name	MP_{10} (%)	SO_2 (%)	NOx (%)	CO (%)	HC (%)
Av. Brasil	22.9	30.0	33.4	25.3	25.2
Av. das Américas	5.7	9.6	7.9	12.2	12.3
Rod. Pres. Dutra	5.5	2.9	3.4	2.6	2.2
Linha Vermelha	3.1	3.4	3.8	2.8	2.8
Rod. Washington Luís	2.9	3.9	4.2	3.5	3.5
Ponte Rio - Niterói	1.9	3.2	2.7	3.9	3.9
Av. Ayrton Senna	*	2.2	1.8	2.9	2.9
Linha Amarela	*	1.9	1.9	2.5	2.5
Other routes	58.0	42.9	40.9	44.3	44.7

Source: FEEMA, Inventory of air pollution sources in the metropolitan area of Rio de Janeiro, 2004.

**Percentage included in other traffic routes; MP10 – Inhalable particulates; SO_2 –Sulfur dioxide; NO_X –Nitrogen oxides; CO – Carbon monoxides; HC – Hydrocarbons*

Avenida Brasil, due to its heavy car traffic, generates 25% to 30% of the overall air pollutants emitted by traffic routes in the metropolitan region of Rio de Janeiro.

Table 5.3-6 summarizes the achieved values according to source type and pollutant.

Table 5.3-6 - Emission Rates for Each Source Type at the MRRJ (x 1000 tons/year)

Source type	MP_{10}	SO_2	NO_X	CO	HC
Fixed	10.6	55.8	30.3	6.3	25.9
Movable	7.8	7.5	60.2	314.7	53.4
Total	18.4	63.3	90.5	321	79.3

Source: FEEMA, Inventory of air pollution sources in the metropolitan area of Rio de Janeiro, 2004.

The emissions of inhalable particulates and sulfur dioxide come mainly from fixed sources, responsible for 58% and 88% of overall emissions of these pollutants respectively. As to hydrocarbons and carbon monoxide, the contribution of movable sources is significantly higher (67% and 98% respectively). With regard to nitrogen oxides, movable sources are responsible for most emissions (66%), although the contribution of fixed sources is significant too (37%).

The data extracted from the inventory indicate that, in the whole of considered sources, movable sources contribute with 77% of the overall pollutant volume, while the fixed ones produce only 23%.

5.3.1.2.3 Emission Standards

More specifically, the limits of atmospheric emissions from thermal incinerators of solid wastes are established by CONAMA Resolution Nº. 316/2002. Such limits can be seen in Table 5.3-7

According to Operational Standard NOP-INEA-01, approved by CONAMA Resolution Nº. 26/2010, any potentially polluting activities must be linked to the Monitoring Program of the Emission of Fixed Sources to the Air (PROMON AR), which requires regular monitoring of emissions, with a frequency (no greater than six months) to be determined according to environmental licenses or any other formal documents from INEA. INEA can also require continuous monitoring, as long as the proper technology is available and internationally recognized.

Table 5.3-7 - Limits of Atmospheric Emissions (CONAMA Resolution Nº. 316/2002)

Parameter	CONAMA 316/02 (mg/Nm³ db 7% O_2)*
MP	70 mg/Nm³
NOx	560 mg/Nm³
SOx	280 mg/Nm³
CO	100 ppm
HCl	80 mg/Nm³ dry basis
	max. 1.8 kg/h
HF	5
TCDD	0.50 ng/Nm³ db 7%O_2
Cd	Metal series 1: 0.28
Hg	Metal series 1: 0.28 mg/Nm³
Pb	Metal series 3: 7.0 mg/Nm³

**mg/Nm³ on a dry basis corrected to 7% of 0_2 (Art 38, §2)*

Source: CONAMA Resolution Nº. 316/2002.

5.3.1.3 Water Quality

5.3.1.3.1 Regional Context

According to CERHI-RJ Resolution No. 18, of November 8, 2006, from the State Council of Water Resources, Rio de Janeiro State has been subdivided into 10 (ten) Hydrographic Regions (HRs) for the purposes of water resource management.

The area of interest is located at Hydrographic Region V, known as Guanabara Bay. HR V has an approximate area of 380 km², and includes nearly all metropolitan area of Rio de Janeiro City (Figure 5.3-2).

Figure 5.3-2 – Hydrographic Region of Guanabara Bay – RH V

Source: CERHI-R Resolution Nº. 18/2007 of the State Council of Water Resources, 2007.

Hydrographic Region V includes the entire cities of Niterói, São Gonçalo, Itaboraí, Tanguá, Guapimirim, Magé, Duque de Caxias, Belford Roxo, Mesquita, São João de Meriti, Nilópolis; and partially the cities of Maricá, Rio Bonito, Cachoeira de Macacu, Petrópolis, Nova Iguaçu and Rio de Janeiro.

5.3.1.3.2 Water Quality at the MRRJ

Water quality is represented by several features of chemical, physical and biological nature. Being a common resource to everyone, legal use restrictions have been created to protect the water bodies. Consequently, the physical and chemical characteristics of the water must be kept within certain limits – which are represented by standards or values that identify the quality of water, sediments and biota (CONAMA Resolutions Nº. 357/2005, Nº. 274, Nº. 344/2004, and Decree Nº. 518 of the Ministry of Health).

Due to the intense urban growth in that region, water quality at Guanabara Bay is impaired, because the waters from the contributing hydrographic basin receive a considerable load of effluents and residues.

Among the potential pollution sources of Guanabara Bay are several industrial topologies: shore terminals of oily products, two commercial ports, several shipyards and two oil refineries, in addition to other economic activities, not mentioning the improper management of sewers and urban solid wastes.

With regard to the rivers of that basin, according to INEA, those in the most critical situation are the tributaries from the Bay's west coast – where the area of interest is located – from Mangue Channel to Sarapuí Channel. They are mostly used for waste dilution.

INEA monitors Guanabara Bay every two months, with 13 sampling stations; the contributing basin is monitored with 38 sampling stations, with the purpose of tracking the key physical-chemical, biological and bacteriological indicators, along with sediment and biota quality.

According to Lima (2006), the area with the worst water quality of Guanabara Bay, with dissolved oxygen below 1 mg/l, Biological Oxygen Demand (BOD) up to 50 mg/l, and high rates of nutrients (nitrogen and phosphorus) and fecal coliforms is located at a channel between the Governador and Fundão islands and the continent, due to the significant discharge of raw or partially treated effluents from industrial and low-income residential areas at the north of Rio de Janeiro. This area of the Bay is adjacent to the proposed Caju site.

5.3.1.3.3 Effluent Discharge Standards

Regarding the effluent discharge standards on a countrywide basis, they have been established by CONAMA Resolutions Nº. 357/2005 and Nº. 397/2008, which indicate the conditions and standards for the discharge of any polluting effluents into bodies of water, in a direct or indirect way. For Rio de Janeiro State, however, there is a more strict regulation, as the Technical Norm of Criteria and Standards for Liquid Effluent Discharge (NT-202.R-10) must be observed. The Technical Norm was approved by deliberation Nº. 1007 of the State Commission for Environmental Control (CECA), of December 4, 1986.

The discharge conditions and parameters indicated by CONAMA Resolutions Nº. 357/2005 and Nº. 397/08, and by NT-202.R-10 can be seen in Table 5.3-8 and Table 5.3-9.

The criteria for the discharge of organic matter from industrial effluents are determined by the Guideline for Control of Organic Load in Liquid Effluents of Industrial Origin – DZ-205.R-6, approved by CECA Resolution Nº. 4887, of September 25, 2007. According to this guideline, the effluents from industries with a flow over 3.5 m^3/day can be discharged in bodies of water, directly or indirectly, only if they meet the Chemical Oxygen Demand (COD) limits established in Table 5.3-10.

Table 5.3-8– Effluent Discharge Conditions According to CONAMA Resolutions Nº. 357/2005 and Nº. 397/2008, and NT-202.R-10

Conditions	CONAMA Resolutions Nº. 357/2005 and Nº. 397/2008	NT-202.R-10
pH	Between 5 and 9	Between 5 and 9
Temperature	Lower than 40ºC; temperature variation in the recipient's body cannot exceed 3ºC at the mixing zone	Lower than 40 ºC
Sedimentable materials	Up to 1 ml/l with 1 hour test in an Imhoff cone. For discharge in lakes and ponds with virtually no circulation speed, there must be no sedimentable materials	Up to 1 ml/l with 1 hour test in an Imhoff Cone. No sedimentable materials after 1-hour test in an "Imnhoff Cone" for discharge in lakes, ponds, lagoons and reservoirs*
Floating materials	-	Virtually absent
Color	-	Virtually absent
Flow mode	Discharge mode with maximum flow up to 1.5 times the average flow period that corresponds to the daily activity of the polluting agent – except in cases allowed by the competent authority	-
Mineral oils	until 20mg/L	until 20mg/L
Vegetable oils and animal fats	until 50mg/L	until 30mg/L

Source: CONAMA Resolutions No. 357/05 and No. 397/08, and NT-202.R-10/86.

Table 5.3-9 – Discharge Standards According to CONAMA Resolutions Nº. 357/05 and Nº. 397/08, and NT-202.R-10

Parameters	Maximum allowed values	
	CONAMA Resolutions nº. 357/2005 and nº. 397/2008	NT-202.R-10
Aluminum (total)	-	3.0 mg/l Al
Arsenic (total)	0.5 mg/L As	0.1 mg/l As
Barium (total)	5.0 mg/L Ba	5.0 mg/L Ba
Boron (total)	5.0 mg/L B	5.0 mg/L B
Cadmium (total)	0.2mg/L Cd	0.1 mg/l Cd
Lead (total)	0.5 mg/L Pb	0.5 mg/L Pb
Cobalt (total)	-	1.0 mg/l Co
Cyanide (total)	1.0 mg/L CN	-
Free cyanide	0.2 mg/L CN	-
Cyanides	0.2 mg/l CN	-
Dissolved copper	1.0 mg/L Cu	-
Copper (total)	-	0.5 mg/l Cu
Hexavalent chromium	0.1 mg/L Cr^{6+}	-
Trivalent chromium	1.0 mg/L Cr^{3+}	-
Chromium (total)	-	0.5 mg/l Cr
Tin (total)	4.0 mg/L Sn	4.0 mg/l Sn
Dissolved iron	15.0 mg/L Fe	-
Soluble iron	-	15.0 mg/l Fe
Fluoride (total)	10.0 mg/L F	10.0 mg/l F
Dissolved manganese	1.0 mg/L Mn	-
Soluble manganese	1.0 mg/l Mn	-
Mercury (total)	0.01 mg/L Hg	0.01 mg/l Hg
Nickel (total)	2.0 mg/L Ni	1.0 mg.1 Ni
Ammoniacal nitrogen (total)	20.0 mg/L N	-
Silver (total)	0.1 mg/L Ag	0.1 mg/l Ag
Selenium (total)	0.3 mg/L Se	0.05 mg/l Se
Vanadium (total)	-	4.0 mg/l V
Sulfide	1.0 mg/L S	1.0 mg/l S

Parameters	Maximum allowed values	
	CONAMA Resolutions nº. 357/2005 and nº. 397/2008	**NT-202.R-10**
Sulfites	-	1.0 mg/l SO3
Zinc (total)	5.0 mg/L Zn	1.0 mg/l Zn
Ammonia	-	5.0 mg/l N
Active chlorine	-	5.0 mg/l Cl
Organophosphorous and carbamate pesticides	-	0.1 mg/l (per compound)
Overall organophosphorous and carbamate pesticides (summation of all pesticides analyzed on an individual basis)	-	1.0 mg/l
Aliphatic halogenated volatile hydrocarbons, such as: 1,1,1-trichloroethane; dichloromethane; trichloroethylene and tetrachloroethylene	-	0.1 mg/l (per compound)
Overall aliphatic halogenated volatile hydrocarbons	-	1.0 mg/l Cl
Halogenated hydrocarbons not listed above, such as: pesticides and phthalo-esters	-	0.05 mg/l (per compound)
Overall halogenated hydrocarbons, excluding aliphatic halogenated volatile hydrocarbons	-	0.5 mg/l Cl
Carbon sulfide	-	1.0 mg/l
Tensoactive substances that react with methylene blue	-	2.0 mg/l
Chloroform	1.0 mg/L	-
Dichloroethene (summation of 1.1 + 1.2 cis + 1.2 trans)	1.0 mg/L	-
Overall phenols (substances that react with 4 - aminoantipyrine)	0.5 mg/L C_6H_5OH	0.2 mg/L C_6H_5OH
Carbon tetrachloride	1.0 mg/L	-
Trichloroethene	1.0 mg/L	-

Source: CONAMA Resolutions Nº. 357/2005 and Nº. 397/2008, and NT-202.R-10/86.

Table 5.3-10 – DQO Limits Established by the DZ-205.R-6

INDUSTRIES	COD
Chemical and petrochemical industries; oil refineries	< 250 mg/l or 5.0 kg/day
Manufacturing of pharmaceutical and veterinary products, excluding antibiotic manufacturing units through fermentative process	< 150 mg/L or 3.0 kg/day
Antibiotic manufacturing through fermentative process	< 300 mg/L or 6.0 kg/ day
Beverage manufacturing – beers, soft drinks, wines, rum, excluding alcohol distilleries	< 150 mg/L or 3.0 kg/ day
Manufacturing of paints, varnishes, enamels, shellac, waterproofing substances, dryers and plastic resins / pastes	< 300 mg/L or 6.0 kg/ day
Tanneries and leather / hide processing	< 400 mg/L or 8.0 kg/ day
Individual operations for surface treatment made by industries of the following sectors: metallurgy, mechanical, transport materials, electric / electronic / communications materials, publishing / graphic, plastic materials, rubber, and phonographic / photographic / optical devices, instruments and materials	< 200 mg/L or 4.0 kg/ day
Food industries, excluding fisheries	< 400 mg/L or 8.0 kg/ day
Fisheries	< 500 mg/L or 10 kg/ day
Manufacturing of cigarettes and cigars; tobacco preparation	< 450 mg/L or 9.0 kg/ day
Textile industries	< 200 mg/L or 4.0 kg/d day
Metallurgic industries	
- Coke works, carbochemical and blast furnaces	< 200 mg/L
- Steel works and rolling	< 150 mg/L
- Other units, excluding the surface treatment sector	< 100 mg/L
Paper and cellulose	< 200 mg/L or 4.0 kg/ day
Outsourced stations for liquid effluent treatment	< 250 mg/L or 5.0 kg/ day
Percolate of industrial landfills	< 200 mg/L

Source: CECA, DZ-205.R-6, 2007.

According to the Guideline for Control of Organic Biodegradable Charge in Liquid Effluents of Sanitary Origin – DZ-215.R-4, approved by CECA Resolution Nº. 4886, of September 25, 2007, the industrial effluents of sanitary origin with overall organic charge lower than 5 kg BOD/day, equivalent to an average of 200 employees, can be discharged in the sewer system after a treatment with minimal efficiency of 30% BOD removal. In this case, the concentration of BOD and TSS (Total Suspended Solids) in the effluents cannot exceed the maximum value of 180 mg/L.

As to the monitoring of effluent discharge, according to the Guideline for Liquid Effluent Self-Control Program - PROCON ÁGUA - DZ-942.R-7, the companies that carry out polluting activities must inform INEA regularly, by means of a Liquid Effluent Tracking Report (RAE), about the qualitative and quantitative characteristics of their liquid effluents. The sampling frequency varies according to daily flow (m^3/day) and the analyzed parameter; ranging from daily, weekly, twice a week, fortnightly or monthly basis.

5.3.1.4 Noise, Smells and Dusts

CONAMA Resolution Nº. 01/1990 identifies any noises that exceed the values acceptable by the NBR 10152 standard – Noise Evaluation in Inhabited Areas, as harmful to health and public tranquility. The standard is issued by the Brazilian Association of Technical Standards (ABNT) to establish the acoustic comfort levels in residential, commercial and service areas, and must also be observed during building or renovation activities.

The noise generated by industries is inspected by entities like INEA and the Ministry of Labor, and must be limited to levels defined by ABNT's NBR 10151/2000 standard for industrial regions – which are 70 dB(A) for daytime and 60 dB(A) for nighttime; or by the NR 15 standard, which establishes the maximum sound pressure level at 85 dB(A) for 8-hour daily exposure of workers.

Since the intended implementation area contains the existing Caju Transfer Station, where recyclable materials from MSW are separated and the organic fraction of such wastes are composted, there exists some smell emission in the vicinities; however, there is no regulations that impose limits to this kind of emission.

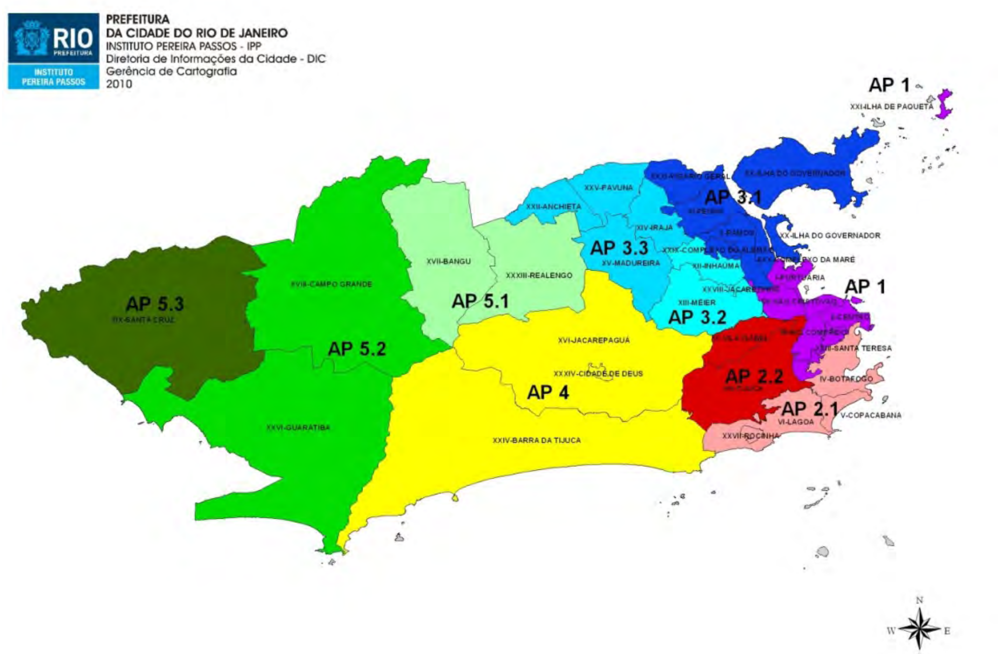
With regard to dust emission, the main adverse cause that can affect the population is the emission of inhalable particles, mentioned in a previous item about air quality.

5.3.2 Social-Economic Medium

5.3.2.1 Local Context

The city of Rio de Janeiro, capital of the State with the same name, lies in an area of 1,255.3 km², including the islands and continental waters. Its territory has been divided into 5 Planning Areas (APs), 33 Administrative Regions (RAs) and 160 Districts (ALEM, 2010)[18], as shown by Figure 5.3-3.

Figure 5.3-3 – Summary Map of Planning Areas for the City of Rio de Janeiro



Source: IPP, "Database" (Armazém de Dados). Available at: http://www.armazemdedados.rio.rj.gov.br/arquivos/2905_aps_%C3%ADndice.JPG. Access Dec 2011.

18 ALEM, Adriano. Brief report on the formation of administrative regions of the city of Rio de Janeiro: 1961 to 2010. In: Coleção Estudos Cariocas, No. 20100501, May 2010. http://portalgeo.rio.rj.gov.br/estudoscariocas. Accessed on December 2011.

The city is one of the largest urban areas in the world, but grew around a large green lung – the Tijuca Forest; it is the largest urban forest in the world, with important remains of its original ecosystems (IPP, accessed in 2011)[19].

With a population of 6,320,446 inhabitants (IBGE, 2010)[20], among which 1.393.314 are living in subnormal zones[21] (IBGE, 2010), the illiteracy rate was 2.8% in 2010 – well below the national average of 9%. The infant mortality rate was 12.8 per 1000 live births in 2010 (Armazém de Dados <http://www.armazemdedados.rio.rj.gov.br/> accessed on December/2011)

The number of homes in 2010 was 2,144,445, of which 91% were connected to the sewer system, 98% were connected to the water supply system, and 85% were served by the local garbage collection service (IBGE, 2010).

The city is Brazil's largest oil producer, including important entities and research centers. It is also the main culture and art region of the country, and main tourist destination. It contains 5 industrial districts and the largest Brazilian metallurgy center (RIO NEGÓCIOS <http://rio-negocios.com/> accessed on December 2011).

The GDP of the city of Rio de Janeiro, R$ 175,739,349 (current prices – R$ 1,000) was 49.6% of the State's GDP in 2009. The service sector was the key one, with 84.9% of the GDP during that year. The GDP per capita was R$ 28,405 (IBGE, 2009)[22]

In 2000, the Economically Active Population (EAP)[23] was composed of 2,791,262 individuals, employed by the service sector mainly – which represented 48% of all

19 IPP – Pereira Passos Urbanism Municipal Institute (Instituto Municipal de Urbanismo Pereira Passos). History of Rio (História do Rio). Available at: http://www.rio.rj.gov.br/web/ipp/exibeconteudo?article-id=87129. Accessed on December 2011.

20 IBGE, 2010 Demographic Census. Available at: http://www.ibge.gov.br. Accessed on December 2011.

21 According to IBGE (2010), the subnormal zones include slums and similar regions. They are assemblies composed by 51 homes at least (houses, shacks, etc.) that occupy (or was occupying) public or private properties. They are disposed, in general, in a dense and disorderly way and most of them lack public utilities.

22 IBGE, Cities Gross Domestic Product - GDP 2005-2009. Available at: http://www.ibge.gov.br/home/estatistica/economia/pibmunicipios/2005_2009/defaulttab.shtm. Acesso em Janeiro/2012.

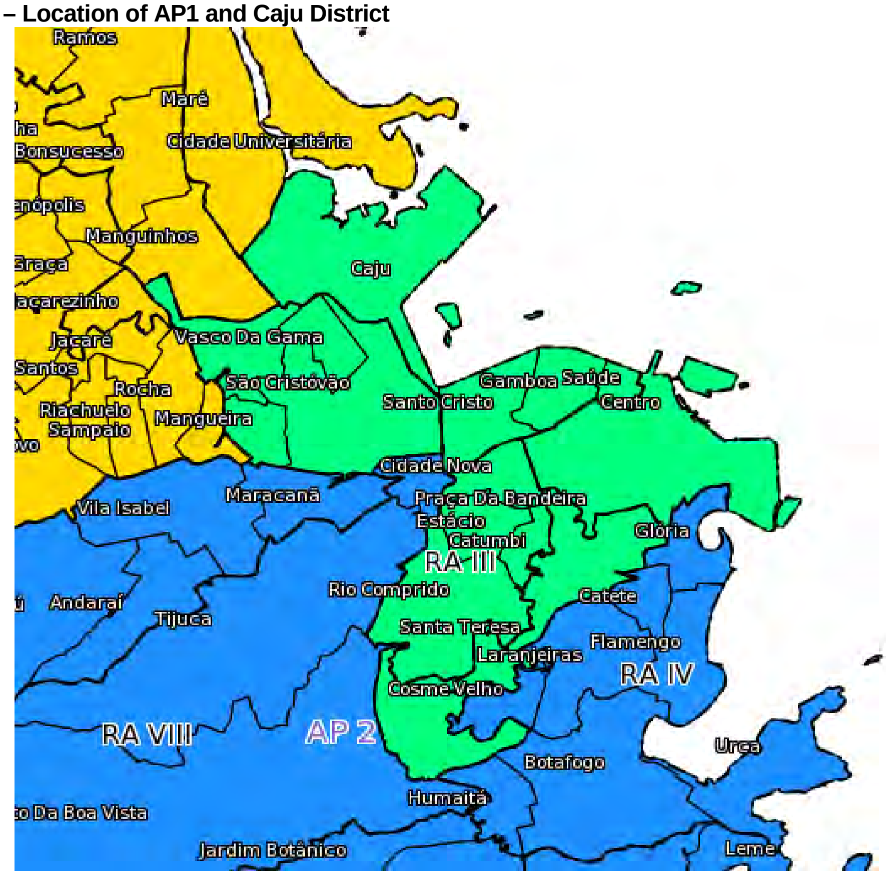
23 EAP includes the potential labor for the productive sector, considering employed and unemployed population (Source, IBGE, Accessed on January, 2012).

formal jobs in that year. The rate of formal jobs in relation to the EAP was 62%. In 2008, the EAP grew to 3,163,737, an annual growth of 1.58%, the rate of formal jobs reached 64%, with highlight for the service sector.[24]

5.3.2.2 Planning Area 1 – AP1

The Caju Transfer Station is located at Planning Area 1 (AP1), with 6 Administrative Regions (RAs), including the Port RA – containing Caju District (Figure 5.3-4).

Figure 5.3-4 – Location of AP1 and Caju District



24 Source: IBGE, 2010 Demographic Census. Available at: http://www.censo2010.ibge.gov.br/. Access in December/2011; Rio´s Boroughs "Database" (Armazém de Dados - Bairros Cariocas). Available at: http://www.armazemdedados.rio.rj.gov.br/. Accessed on December, 2011.

Source: Mayorship of Rio de Janeiro. Available at: http://mapas.rio.rj.gov.br/#. Accessed on December 2011.

The AP1 includes the city's oldest urban space, corresponding to the historic center and group of districts that were urbanized in the first half of the 19th century. The area has been heavily transformed, due to the implementation of new urban traffic systems[25] (IPP, 2005). The AP1 population decreased 27% between 1970 and 2000. It is worth mentioning, however, the allure power of the central business area, daily destination of nearly 1 million people.

In a general way, the AP1 is characterized by: main city center; ancient occupation area (historic center); diversity of equipment and entities (transportation, sport and leisure, culture, health, education, shops and services, etc); great complexes of the High Social Interest Areas; deactivated / underused building and urban gaps; metropolitan traffic network with structuring elements for the city; and diversity in occupation patterns (from old areas to structural intervention areas, such as subway and tunnels, slum expansion – which caused an exodus of the population and economic activities; and life style diversity).

The population at AP1 grew 1.06% between 2000 and 2010, from 268,280 to 297,976 inhabitants). The AAP at AP1, considering the population between 10 and 69 years, was composed of 241,921 people[26]. In this work, the AAP of 2010 was considered, as the EAP data from the 2010 census had not been disclosed yet. It is worth noting, from this total (AAP - 241,921 people), retired and pensioned people, students, and other dependents who are not economically active must be disregarded. Due to the nature of that area, characterized by miscellaneous uses (institutional, commercial, service provision, etc.), the number of formal jobs was 801,789 in 2010 – or nearly 34% of formal jobs in the city of Rio de Janeiro (IBGE, 2010).

5.3.2.3 Caju District

Caju is a low income district located at the northern border of AP1, including the complex of Caju slums and industrial / port activities. The port activities started when

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[25] Traffic and transport infrastructure

[26] This corresponds to the group of all people that can carry out an economic activity, being composed by the population with more than 10 years of age, and subdivided into: Economically Active Population and Non-Economically Active Population (IBGE, accessed on Dec. 2011).

the Portuguese court arrived at Rio de Janeiro, and increased in intensity during the 20th century, with the growth of the coffee sector (Nacif & Machado, 2009)[27].
The Rio Ouro Railway was built in the 20th century, with its initial station at the Caju district. With access to the sea, an excellent pier, proximity to the commercial center, and the construction of Avenida Brasil, its industrial occupation was favorable. With the creation of other districts, Caju lost its residential features and was transformed into a predominantly industrial district (Nacif & Machado, 2009).
Most of population that currently lives in the Caju district is composed of people who, starting on the fifties, occupied low value areas – which now compose Caju's slum complex. The growing slumming process dates back to the seventies, with the arrival of migrants. Initially employed for civil works during the construction period of large shipyards, such population was later excluded from the formal production process, thus enlarging the number of unemployed or sub-employed people (Nacif & Machado, 2009).

The slums have been built in the middle of nearly abandoned industrial structures, cemeteries, landfills, etc. The district suffers with air pollution caused by the industries and streets, and with the pollution caused by the smell from the composting plant and local cemeteries (Nacif & Machado, 2009).

In 2000, the district had a population of 17,679 inhabitants, 11,958 of whom in subnormal groups. Table 5.3-11 shows the several groups located in that district. Nearly 68% of inhabitants of the Caju district had settled in subnormal groups during 2000.

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[27] NACIF, C. L.; MACHADO, M.; Gilson Dimenstein Koatz; Eliane Baptista Alves. Territorialidades e Conflitos em Bairros Cariocas: Caju e Jardim Botânico. In: 12 Encuentro de Geógrafos de America Latina - Caminando en una America Latina en transformación, 2009, Montevideo. 12 Encuentro de Geógrafos de America Latina. Montevideo, 2009, Uruguay. 12 Encuentro de Geógrafos de America Latina, 2009. v. 1. p. 1-12., 2009. Available at: observatoriogeograficoamericalatina.org.mx/egal12/Geografiasocioeconomica/geofrafiaespacial/37.pdf. Accessed December 2011.

Table 5.3-11– Subnormal Groups in Caju District (2000).

Subnormal group	Inhabitants	Homes	Types	Existing equipment in the settlements
Quinta do Caju	2,046	641	Quinta do Caju Local Nursery	Urbanized community
Ladeira dos Funcionários	660	186	Healthcare unit: CMS Caju	Urbanized community
Parque São Sebastião	1,396	359	No resources	Urbanized community
Parque Nossa Sra. Da Penha	1,178	306	No resources	Slum
Parque Alegria	3,895	1,101	No resources	Slum – Complex
Parque da Boa Esperança	1,801	486	Senninha Local Nursery	Urbanized community
Parque Conquista	982	265	No resources	Urbanized community
TOTAL	11,958	3,344	...	...

Source: SABREN – Low Income Settlement System.

Two other subnormal groups have been settled after 2000: Via Presidente João Goulart slum, with 59 inhabitants in 17 houses, and Vila do Mexicano, with 322 inhabitants in 92 houses. There is no urban equipment in both groups.

The district's population reached 20,477 inhabitants in 2010, with a growth rate of 1.48% per year (between 2000 and 2010). If the same growth rate of the overall population is applied to the inhabitants of the subnormal groups, an approximate percentage of 86% is achieved for the people of that district who live in such areas.

The district's AAP is 16,282 inhabitants between 10 to 69 years. With regard to formal jobs, 5,643 of them have been recorded in the district. Considering a relationship between the active age population and formal jobs (records of the Caju district), a low job rate can be noticed (around 35%). The service sector is also the main employer in the Caju district, with 47% of the jobs, followed by manufacturing industry – which provides 37% of formal jobs in the district, thus indicating its industrial trend.

As to income, in 48% of homes the nominal monthly wages varied, during 2010, from half minimum salary to 2 times minimum salary (R$ 272.50 to R$ 1,090 on November 2011)[28]. Another 35% of homes exhibited wages from 2 to 5 times minimum salary (R$

[28] Assuming a minimum salary of R$ 545.00 from November 2011. Source DIEESE. Available at: http://www.dieese.org.br/rel/rac/salminMenu09-05.xml. Accessed on January,2012.

1090.00 to R$ 2725.00 on November 2011). Considering the minimum required income (as estimated by DIEESE) of R$ R$ 2,349.26, the district can be considered as a low income region.

Nearly 99% of homes are served by the sewer system, almost 100% are served by the water supply system, and only 64% are served by the garbage collection service.

Regarding the human development indicators, the district exhibits an infant mortality rate of 28.40 deaths for every 1,000 live births – a fairly high rate in relation to the whole city, which is 12.8 deaths for every 1,000 live births; it was the 8th highest rate in the city on 2006. The illiteracy rate was 6.2% on 2010, higher than the 2.8% of the city as a whole.

5.3.2.4 Land Use in the Vicinity

The Caju district lies in an area focused mainly on industrial use and port activities. According to Decree No. 322, of March 3, 1976, the district has been divided into two zones: ZI1 (Industrial Zone 1) and ZP (Port Zone). Any activities that do not pose risks to the population are allowed in Industrial Zone 1.

In the Caju district, the Directive Plan (Complementary Law No. 111, of February 2, 2011) defined two special areas of interest: the Urban Special Interest Area, intended for specific projects of urban structuring or restructuring, renovation and revitalization; and the Social Special Interest Area (AEIS), intended for Social Interest Household Programs – which will be aimed to families with an income equal to or higher than 6 minimum salaries. Such area will also admit shops, community education and health facilities and sport / leisure areas. The latter area will be divided into two distinct modes. Caju Transfer Station is located at the Urban Interest Area.

With regard to use, the industrial sector started to settle in that district during the 19th century. The implementation of several embankments enabled the construction of many important port facilities, such as the Air Force's Electronic Material Park (PAME), and the Ishikawajima, Caneco, Fronape and Portobras shipyards. During the eighties, starting mainly with the Brazilian shipbuilding crisis, the disorderly occupation and the slumming process of that district occurred at a faster pace, due to the closure of shipyards.

The district contains some commercial and industrial enterprises, and its population is mainly composed of low income communities living in slums. Currently characterized as a Complex, it includes slums, low middle class homes, industries and industrial enterprises that support naval activities, port terminals, military units, bus garages, cemeteries (ALVES, 2007)[29], Alegria Sewer Treatment Station, and Caju Transfer Station – which receives part of the wastes collected in the city; such wastes go then to Gramacho landfill, in the town of Duque de Caxias.

In a general way, the vicinity of Caju Station is characterized mainly by port and industrial use. The nearest population group is located to the southwest, with a regular occupation group and Parque Boa Esperança slum. Parque Conquista slum is at the southeast of that area. It is worth mentioning that those groups do not have borders with the area of interest.

5.3.2.5 Characterization of the Local Road Infrastructure

The road system in the area occupied by Caju district is composed by important connection streets between the city of Rio de Janeiro and other cities in Rio de Janeiro's metropolitan area, such as Avenida Brasil and Linha Vermelha.

Avenida Brasil is a federal road under local administration, and is part of the BR-101 highway, connecting the Presidente Costa e Silva Bridge (Rio-Niterói Bridge), Washington Luis Highway (Rio-Petrópolis Highway), the BR-040 or Presidente Dutra Highway (Rio-São Paulo Highway), the BR-116 Highway and the Rio-Santos Highway (BR-101)[30]. Starting at the port area, Avenida Brasil has one of the highest Average Daily Volumes (VDM) of vehicles in the city of Rio de Janeiro. The VDM of Avenida Brasil in the area of interest is 229,778 vehicles, a section with the heaviest traffic in the entire avenue.

Linha Vermelha is another important connection road between the city of Rio de Janeiro and other cities of the metropolitan area and the State. This is the popular

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[29] ALVES, Eliane Baptista. Borough of Caju: The construction of a poor outskirts (O bairro do Caju: a construção de uma periferia empobrecida). Masters dissertation (Dissertação de Mestrado). Rio de Janeiro, UFRJ, 2007. Available at: http://www.dominiopublico.gov.br/pesquisa/DetalheObraForm.do?select_action=&co_obra=151382. Accessed on December 2011.

[30] Source: Secretaria Municipal de Transportes. Gerência de Áreas Especiais da CET-Rio. Available at: http://www0.rio.rj.gov.br/smtr/smtr/hp_cve_brasil.htm. Accessed on December 2011.

name of the RJ-071 State Highway, whose official name is Via Expressa Presidente João Goulart. The road connects the city of Rio de Janeiro to the town of São João de Meriti, crossing the town of Duque de Caxias

The VDM[31] rate at km 3, in Caju district, lies around 139,674 vehicles/day. Linha Vermelha is the main access path to Gramacho Landfill, in the town of Duque de Caxias. Other important traffic paths in the district are Avenida Monsenhor Manoel Gomes, Rua Carlos Seidl and Rua Carlos Seixas, where the area of interest is located (Caju Transfer Station).

5.3.2.6 Characterization of Solid Waste Collection and Destination in the City of Rio de Janeiro

Collection, transport and final destination of solid wastes and the urban cleaning service are the responsibility of the Municipal Urban Cleaning Company (COMLURB – Companhia Municipal de Limpeza Urbana). It has adopted a selective collection program since 1993, initially based on the implementation of district cooperatives. The next step was the implementation of door-to-door selective collection in the city's South Zone and in part of its North Zone, and selective collection through voluntary delivery points at the city's West Zone.

The city of Rio de Janeiro is served by the following landfills:

- Gericinó: located at the Bangu region, it has been operated since 2002 by Delta Construções and receives all wastes from AP5 (West Zone);

- Gramacho: located at the town of Duque de Caxias. Part of the wastes intended for this landfill go to the Caju Transfer Station first, and another part is sent there directly. Caju Transfer Station receives an average of 2,800 tons/day of local solid wastes – which are then transferred to Gramacho landfill. There are plans to close it two years from now. The station includes a recycling center and a composting plant, who's operations would be expanded as a result of the proposed enterprise. Nowadays, this landfill is the main destination for urban solid wastes from the city

[31] Mean Daily Volume of vehicles

of Rio de Janeiro and also from the cities of the metropolitan region, especially Duque de Caxias, Nilópolis, São João de Meriti e Queimados.[32]

- Nova Iguaçu: located at the town of Nova Iguaçu.

Beside these landfills, the Seropédica Waste Treatment Center (WTC) was scheduled to begin operation in April, 2012, and was developed under an agreement with COMLURB. This WTC is located at the city of Seropédica and it will manage large amounts of urban domestic solid waste and the remains of tree trimmings from the city of Rio de Janeiro and from Seropédica and Itaquaí. This Center consists of a bioenergetic landfill and auxiliary waste treatment units. The WTC will gradually receive the waste that is destined for the Gramacho landfill, which will then be shut down.

In its first phase, around 1,000 tons/day of waste shall be transported to the WTC by 9 trucks making five trips each, totaling 45 trips/day. This amount of waste will come initially from the Jacarepaguá Transfer Station that supports Barra da Tijuca, Recreio and Jacarepaguá boroughs.[33]

Rio de Janeiro's planning areas produce 1.3 to 3.3 kg of all kinds of garbage per capita per day on average, with a city-wide average of around 1.6 kg per capita every day.

5.3.2.6.1 Characteristics and Flow of Municipal Solid Waste

Local collected solid wastes are classified according to the following types: domestic, from municipal entities, large garbage producers, building wastes, from public cleaning, hospital waste and others.

As shown, solid wastes produced in the city of Rio de Janeiro are sent to Gramacho, Gericinó and Nova Iguaçu landfills. Part of the wastes intended for Gramacho or Nova Iguaçu are sent there directly, while another part arrive there after being processed by

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[32] COMLURB. Gramacho Landfill. Available at: http://comlurb.rio.rj.gov.br/serv_atgramacho.htm. Accessed on January,2012.

33 Information obtained at CTR Technical report (Ficha Técnica do CTR). Available at: www.ciclusambiental.com.br/ciclus_ctr.php. Accessed on January,2012; and "Jornal do Brasil" newspaper. Seropédica Waste Treatment Center strats to operate (Central de Tratamento de Resíduos de Seropédica começa a operar). Available at: http://www.jb.com.br/rio/noticias/2011/04/20/central-de-tratamento-de-residuos-de-seropedica-comeca-a-operar/. Accessed on January,2012.

the Caju, Jacarepaguá and Irajá Transfer Stations. All wastes intended for Gericinó are transported to such landfill directly, without the use of transfer stations.

Table 5.3-12 shows data on waste flow in the city of Rio de Janeiro and their final destination (data from October 2010). The landfills that receive most of the waste flow are: Gramacho (direct destination and through Caju transfer station) and Gericinó (direct destination).

Table 5.3-12 – Waste Flow According to Type and Destination

Transfer station / Landfill	Mass flow of residues according to type (mtpd)								
	A	B	C	D	E	F	G	Total	%
Caju	1,490	1,130	0	0	0	10	170	2,800	26%
Jacarepaguá	580	300	0	0	0	5	65	950	9%
Irajá	300	0	0	0	0	0		300	3%
Missões (building wastes only)	0	10	0	0	620	0	60	690	6%
Direct to Gramacho	620	350	0	1,540	630	10	120	3,270	30%
Total intended for Gramacho	**2,990**	**1,790**	**0**	**1,540**	**1,250**	**25**	**415**	**8,010**	**73%**
Direct to Gericinó	1,330	1,140	0	0	80	0	40	2,590	24%
Total intended for Gericinó	**1,330**	**1,140**	**0**	**0**	**80**	**0**	**40**	**2,590**	**24%**
Caju	0	0	120	0	0	0	0	120	1%
Jacarepaguá	0	0	30	0	0	0	0	30	0%
Direct to Nova Iguaçu	0	0	149	0	0	0	0	149	1%
Total intended for Nova Iguaçu	**0**	**0**	**299**	**0**	**0**	**0**	**0**	**299**	**3%**
Total	**4,320**	**2,930**	**299**	**1,540**	**1,330**	**25**	**455**	**10,899**	**100%**

Source: COMLURB. Waste Flow (Fluxo do Lixo). October 2010. Legend: A= Home wastes / B= Public cleaning / C= Large waste generators / D= Waste from mayorship / E= Building wastes / F= Hospital wastes / G= Others

As to the expectation of future waste generation growth, this work follows COMLURB's guideline, adopting an annual growth rate of 2% throughout project lifetime (25 years). Note that the waste flow required for the proposed enterprise is 1700 mtpd, considerably less than the current waste flow to Caju which is 2800 mtpd.

Table 5.3-13 shows the mass flow of overall wastes produced in each planning area.

Table 5.3-13 – Mass flow of all Waste Types, in Each Planning Area (2009)

Planning area	Mass of wastes (mtpd)	Population	Production rate (kg/day/person)
AP1	747	228,549	3,268
AP2	1,484	919,685	1,614
AP3	3,512	2,253,958	1,558
AP4	1,438	807,750	1,780
AP5	2,224	1,714,894	1,297
Total/Ave	9,405	5,924,836	1,587

Source: COMLURB.

Planning Area 3 is responsible for the largest amount of waste (3512 mtpd) produced in the city. It is worth mentioning that it is the AP with the largest population count. On the other hand, AP1 produces the lowest volume of waste, as it is the city's least populated area; however, it is also the AP with the highest production rate per capita per day (2009 data).

According to COMLURB data for one year period starting on September 2010, there is a waste production peak in December, and a decrease during February, relative to the annual average. Seasonal variations reflect fluctuations in AP1, AP2 and AP3. AP4 and AP5 did not show any significant variation. Such seasonal variation is a normal factor in waste production and composition, due to the following: tourist season, holidays, popular events, rainfall periods, etc. This variation is important for the power recovery process in the WTE plant.

Regarding waste composition, the humidity content of waste collected in the city of Rio de Janeiro between 2005 and 2008 varied from 50% to 65%. Generally, wastes are mainly composed by organic matter (56% to 61%). There is a trend of growth for paper and plastic in waste composition. The planning areas with the highest volumes of paper and plastic in waste composition are: AP2.1, AP3.1 and AP4. These areas exhibit wastes with the highest heating value. Several studies indicate that high heating value wastes are associated to high incomes and commercial activity.

5.3.2.7 Characterization of Electric Power Infrastructure in the City of Rio de Janeiro[34]

The generation, transmission and distribution of electric power in all 31 cities of Rio de Janeiro State (including the capital) are the responsibility of Light Serviços de

34 Light Energy (Light Energia). Available at: http://www.lightenergia.com.br/parque-gerador/. Accessed on December 2011.

Eletricidade S.A., a company of the Light Group. Light's granting area includes 3 large regional branches: Metropolitan Region, Grande Rio and Vale do Paraíba.

Light Rio company, through Light Energia S.A., has a structure composed of five hydroelectric power plants with an installed capacity of 852 MW: Fonte Nova, Nilo Peçanha, and Pereira Passos, located in the hydroelectric complex of Lajes; Ilha dos Pombos, in the municipality of Carmo; and Santa Branca, located in the municipality of the same name. Light, nonetheless, does not produce all the power that it distributes, and needs to purchase additional power from other generating systems such as the nuclear complex of Angra dos Reis, Furnas Centrais Hidrelétricas, and Itaipu[35]

Light´s Power System is composed of 196 substations, a grid with over two thousand kilometers of sub-transmission network, and over 55 thousand km of distribution. [36]

Near Caju district, there are two Power Substations from FURNAS System (Sistema FURNAS): Grajaú Substation, and Jacarepaguá Substation, which transfer the power received from FURNAS System to the substation lines of Light which, in turn, distributes the power throughout the boroughs of the city of Rio de Janeiro.

Grajaú Substation, located in the district of Grajaú, is an integral part of FURNAS transmission system, responsible for supplying around 60% of the power consumed in Rio de Janeiro.[37] It receives two 500 kV lines coming from the Substations of Adrianópolis and Angra dos Reis, both belonging to FURNAS System, and located in Rio de Janeiro State. The power received is transferred over sixteen 138 kV lines used to supply power to the substations of Light.

Jacarepaguá substation, located in the borough of the same name, interconnects to the Light system in order to meet the demand for power in the boroughs of Cascadura, Mato Alto, Jardim Botânico, Padre Miguel, Cosmos, Ari Franco, Senador Camará, Esperança, Palmares, Vila Valqueire, Grajaú, São Conrado, Barra da Tijuca, Recreio

35 Wikipedia. Available at: http://pt.wikipedia.org/wiki/Light_%28Rio_de_Janeiro%29. Accessed on January,2012.

36 LIGHT – Social-environmental responsibility report – 2007. Available at: http://www.agendasustentavel.com.br/images/pdf/001535.pdf. Accessed on January,2012.

37 Substations – Grajaú Substation. FURNAS magazine Year XXXI, nº 324, September/2005. Available at: http://www.furnas.com.br/arqtrab/ddppg/revistaonline/linhadireta/rf324_grajau.pdf. Accessed on January,2012.

dos Bandeirantes and Jacarepaguá (Taquara, Freguesia and Curicica). It became commercially operational in 1967 to supply power to the municipality of Rio de Janeiro by using power from Santa Cruz Thermoelectric Power Plant provided through the interconnection with various Light substations.[38]

The area provided for Jacarepaguá Substation also includes Rio Regional Center Station (Centro Regional Rio) whose main function is to coordinate maneuvers and normalize the electric system after possible disturbances. Its field of responsibility includes the power supply trunks of Rio de Janeiro and Espírito Santo States.[39]

Light substations located nearest to the WTE site at Caju include[40]:

- Substation located in Rua Carneiro da Rocha, in the borough of Higienópolis, next to Abrigo Cristo Redentor (Christ the Redeemer Shelter);
- Substation located in Rua Conselheiro Mayrink, in the borough of Jacaré, close to Subway Station Triagem;
- Substation located in Avenida Itaoca, in the borough of Inhaúma, Favela (Slum) Nova Brasília;
- Mackenzie Substation and Camerino substation, located in Rua Alexandre Mackenzie, Center of the City.

With this existing power infrastructure for transmission and distribution of energy in the city of Rio de Janeiro, and, specially, in the surroundings of Caju Transfer Station site, the interconnection between the WTE Plant and the existing system seems possible.

38 Substations – Jacarepaguá Substation. FURNAS Magazine Year XXXIII nº 340, May/2007. Available at: http://www.furnas.com.br/arqtrab/ddppg/revistaonline/linhadireta/rf340_subjac.pdf. Accessed on January,2012.

39 Furnas Systems. Available at: http://www.furnas.com.br/hotsites/sistemaFurnas/sist_transm.asp. Accessed on January,2012.

40 Information obtained at Wikimapia, available at: http://wikimapia.org/#lat=-22.901424&lon=-43.1866765&z=19&l=9&m=b&v=8&search=subesta%C3%A7%C3%A3o%20da%20light; and Google Maps, available at: http://maps.google.com.br/maps?hl=pt-BR&tab=wl. Accessed on January,2012.

However, the implementation of a substation and a transmission line to interconnect the Plant to the existing system could result in social and environmental impacts. Since Caju Transfer Station is located in a consolidated and densely occupied urban area, the interferences may occur predominantly in the socio-economic aspect (relocation of population and economic activities, for example), so studies would need to be carried out for the environmental licensing of these structures. In addition to the socio-economic impacts expected, the implementation of this power transmission would contribute to increased project costs.

In relation to energy consumption, the monthly electric power consumption in the city of Rio de Janeiro increased slightly during the 2002-2010 period, at a rate of 0.69% per year. The city's main consumption class is residential, with a consumption of 5,988,844 MWh per year. Public lighting had a significant increase of 35.52% per year, while the industrial sector decreased 12.10% per year (Table 5.3-14).

Table 5.3-14– Annual Power Consumption According to Electric Power Consumption Classes – Growth Rate

Consumption classes (MWh)	2002	2010	Growth rate
Residential	4,603,194	5,988,844	3,34%
Industrial	3,133,454	1,116,469	-12.10%
Commercial	4,272,515	5,023,741	2.05%
Rural	2,344	2,240	-0.56%
Public entities	941,905	1,245,823	3.56%
Public lighting	38,903	442,477	35.52%
Public service	689,626	624,072	-1.24%
Individual consumption	57,123	68,201	2.24%
Total	13,739,063	14,511,867	0.69%

Source: "Database" – Statictics, Infrastructure ("Armazém de Dados", Estatísticas, Infraestrutura). Available at: http://www.armazemdedados.rio.rj.gov.br/. Accessed on December 2011.

Table 5.3-15 shows the annual average consumption, the average monthly consumption and the daily consumption of power per inhabitant during 2010.

Table 5.3-15– Total Annual, Monthly and Daily Consumption of Electric Power per Inhabitant (2010)

Consumption	2010
Total (MWh)	14,511,867
Annual (MWh/capita)	2.3
Monthly – average (KWh/capita)	191.3
Daily (KWh/capita)	6.3

Source: Armazém de Dados. Estatísticas. Infraestrutura. Available at: http://www.armazemdedados.rio.rj.gov.br/. Accessed on December 2011.

It is important to stress the relevance of Rio de Janeiro in power generation and energy research. Within such context, the state government created, through its Secretariat of Economic Development, Power, Industry and Services, the **Rio Capital da Energia** program, with the purpose of making that State a reference in rationalization, technological innovation and environmental sustainability in the energy area, through partnerships with private/public companies and entities. Such programs established the following actions:

- Covenant with Ampla[41] and Light to decrease power consumption is schools, hospitals and units of the Pacifying Police;
- Tax reduction for solar and wind generators;
- Investment in science and technology with FAPERJ[42] resources;

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41 AMPLA Energia e Serviços is an electric power distributing concessionary that provides power service to approximately 2.5 million residential, commercial and industrial clients in 66 municipalities of Rio de Janeiro Stat, covering 73% of the territory. (Available at: http://novoportal.ampla.com/a-ampla/conhe%C3%A7a.aspx. Accessed on January/2012).

42FAPERJ – Fundação Carlos Chagas Filho de Amparo à Pesquisa do Estado do Rio de Janeiro (Foundation Carlos Chagas Filho for Research support in the state of Rio de Janeiro). A Rio de Janeiro State agency that foments science, technology, and innovation. Working with the Secretary of State for Science and Technology, its purpose is to encourage the activities in the scientific and technological areas, and support comprehensively projects and programs of academic institutions and research based in Rio de Janeiro State. This is accomplished by means of granting scholarships and providing assistance to

- Financing lines from the Promotion Agency of Rio de Janeiro State (Investe Rio).

The Strategic Committee of the program is composed of Petrobrás, Eletrobras Furnas[43], Light, Firjan[44], UERJ[45], UFRJ[46], UTE[47] and Neoenergia, among others.

Rio de Janeiro produces 85% of Brazil's oil, who's industry made Rio de Janeiro a focus for research in that sector, with emphasis for the Fundão Technological Complex (Fundão Island, where UFRJ is located). Rio de Janeiro houses the headquarters of entities like Petrobrás, along with other Brazilian and foreign oil companies and their key representative entities. In the case of electric power, for instance, Furnas Centrais Hidrelétricas, Eletrobrás and EPE are represented.[48]

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researches and institutions. Available at: http://www.faperj.br/interna.phtml?ctx_cod=1.1. Accessed on January/2012.

43 A power generation and transmission joint capital company, subsidiary of Centrais Elétricas Brasileiras S.A. - Eletrobras, working with the Ministry of Mines and Energy. Available at: http://www.furnas.com.br/memoria_apresentacao.asp. Accessed on January/2012.

44 FIRJAN System (Sistema FIRJAN) is an important state company partner in the search of development, and composed of 5 organizations that offer solutions and services capable of multiplying the productivity of the companies and improve the quality of the employee life. The organizations are: FIRJAN (Rio de Janeiro Industry Federation), CIRJ (Rio de Janeiro Industrial Center), SESI (Industrial Social Service), SENAI (National Service for the Industrial Training) and IEL (Euvaldo Lodi Institute). Available at: http://www.firjan.org.br/data/pages/2C908CE9215B0DC401216AFC0AD551E3.htm. Accessed on January/2012.

45 UERJ – State University of Rio de Janeiro.

46 UFRJ – Federal University of Rio de Janeiro.

47 UTE Norte Fluminense: Power generation company created in 1990 which utilizes natural gas as fuel from Bacia dos Campos. The UTE is part of the EDF Group (Eletricité de France), but 10% of its capital belongs to PETROBRAS. Its installed capacity is 780 MW. Available at: http://www.utenortefluminense.com.br/br/empresaApresentacao.php. Accessed on January/2012.

48 Information on the "Rio Capital da Energia" Program can be found at: Secretariat of Economic Development, Power, Industry and Services. Projects and Programs (Projetos e Programas). Available at:http://www.rj.gov.br/web/sedeis/exibeconteudo?article-id=610437. Accessed on December, 2011.

5.4 Impact Forecast and Assessment

It is understood that the analysis of social-environmental impact involves the functional correlation between the growth dynamics of a given enterprise and its location – which, in turn, exhibits potentialities, fragilities and conflicts. Under such conditions, the social-environmental impacts can be identified, according to the applicable environmental laws.

The National Environmental Council (CONAMA), in its Resolution No. 001/1986, which regulates environmental licensing, defines environmental impact as “any change in the physical, chemical or biological properties of the environment, caused by any form of matter or energy as a result of human activities, which can affect on a direct or indirect basis: health, safety and welfare of the population; social and economic activities; the biota; aesthetic and sanitary conditions of the environment; and the quality of environmental resources”.

Therefore, the social-environmental impact (or simply Environmental Impact) involves a relevant change in a given aspect of the biophysical, social-economic, cultural and institutional areas, which must be identified and evaluated in the context of influence areas, and timed according to the construction phases or expansion / operation works of the enterprise (or any other required consideration).

In the case of a WTE plant in the Caju district, in the capital city of Rio de Janeiro, a preliminary identification of probable impacts was possible, through the enterprise’s key characteristics, indicating as the most relevant impacts those related to the physical and social-economic areas. The following can be stressed for the physical area: atmospheric, liquid effluent, noise, smell and dust emissions and for the social-economic area: job creation and technology transfer to that region.

Such relevant impacts have been analyzed by associating the enterprise’s key aspects with social-environmental factors that would undergo change, taking into account the local conditions. In case of negative impacts, prevention, mitigation, compensation, control or monitoring actions have been suggested. On the other hand, leveraging actions have been introduced for beneficial impacts that can result from the WTE implementation.

The identification and assessment of impacts have the purpose of forecasting which environmental conditions must be checked at the enterprise’s intervention and influence area, both after its deployment and during its operation. In this case, the assessment has been carried out by means of tools that show a qualitative and quantitative scenario for previously stipulated impacts.

See below the methodology adopted for impact classification and assessment.

5.4.1 Support Methodology

In the impact identification and assessment procedure, the effects of the proposed enterprise on the Caju district and its influence areas have been located and evaluated, and control actions have been proposed (mitigation, compensation, monitoring or leveraging / development).

Impacts on the environment were identified according to the following attributes and magnitudes:

Attributes	
Nature – positive in the sense of bringing benefits for the influence areas; negative when causing adverse effects.	POSITIVE NEGATIVE
Probability – sure event (C), with 100% of occurrence probability; or probable (P), associated to some level of probability.	P – PROBABLE C – SURE
Reversibility – reversible in the sense that the impacted medium can return to a given balance situation (when the impact ceases), similar to the one present without any impact occurrence; or irreversible when the medium retains the impact effects in spite of control actions for environmental aspects and/or impact mitigation – thus characterizing impacts that cannot be mitigated on a partial or full basis.	R – REVERSIBLE IR – IRREVERSIBLE
Duration – temporary when its occurrence has a certain foreseen duration; or continuous when it lasts for the entire enterprise lifetime.	P – PERMANENT T – TEMPORARY
Magnitude	
Quantitative measure used in situations that can be estimated with a proper indicator; whenever possible, its result can be evaluated in relation to its particular universe.	USEFUL INDICATOR TO EXPRESS IMPACT MAGNITUDE
Qualitative measure used in those situations that enable assigning a size parameter – such as large, mid and small magnitude.	SMALL MID LARGE

Preparation: ARCADIS Logos.

In the current project development phase, preliminary suggestions of control, mitigation, compensation and monitoring actions (in case of negative impacts) or leverage / development actions (in case of beneficial ones) were possible – which can be adopted according to a given schedule.

The solution level of these actions indicated the chances to decrease, eliminate or leverage the intensity of a specific impact.

5.4.1.1 Considered Environmental Factors

a) Physical Environment

- Quality of surface waters: indicates the quality standards and physical-chemical / biological characteristics of surface waters;
- Air quality: indicates air quality standards, considering atmospheric emissions.
- Noise, smell and dust levels: indicate the acceptable levels of noises, smells and dust that can affect in some way the quality of life of possible recipients.

b) Social-Economic Environment

- Resident population, economically active population, active age population;
- Local and regional economy: indicates the occurrence of economic activities, in the several economy sectors, on a local and municipal basis;
- Jobs and income: job characteristics related to its distribution in activity sectors and employment level;
- Road infrastructure: a factor considered on a local and regional basis, related to the traffic of garbage collection trucks to Gramacho landfill, in the town of Duque de Caxias;
- Power infrastructure: electric power generation and consumption.

5.4.2 Assessment of Environmental Impacts

The foreseen environmental impacts have been assessed according to the previously mentioned criteria, and from an interaction between enterprise aspects and environmental factors.

5.4.2.1 Physical Environment

A. Air Quality Degradation at Caju District due to Atmospheric Emissions

As shown previously, the enterprise's area of interest is located at the MRRJ, within Air Basin III, which contains the fixed sources that most contribute to pollutant emission to the atmosphere. According to the Annual Air Quality Report (INEA, 2009), the manual sampling network indicated a critical situation in 2009, due to the concentration of inhalable particles in the entire MRRJ.

Although there are no specific sampling data for Caju district, it is a densely populated area, with the presence of petrochemical industries and heavy vehicle traffic, mainly due to its proximity to the port area – which can mean an environment with high emission levels of sulfur dioxide, nitrogen oxides, hydrocarbons and particulates.

The key pollutants produced during the thermal use of urban solid wastes, with regard to the generated volume, are nitrogen oxides, sulfur dioxide, carbon monoxide, particulates and acid gases (HCl and HF). Mercury, cadmium, lead, dioxins and furans are produced in smaller volumes.

If produced in volumes that exceed the dispersion and depuration capacity of the atmospheric basin, such pollutants can increase their concentrations up to levels that are harmful to human health, thus causing public health problems. Even though they are produced in smaller volumes, dioxins and furans are the most dangerous pollutants, because they are organic persistent pollutants.

Organic persistent pollutants have toxic properties, are resistant to degradation, undergo bioaccumulation, and are transported by air, water and migratory species through international borders, and are deposited far from their emission place – where they accumulate in land and water ecosystems.

Considering the residual atmospheric emissions sampled in the exhaust stack of a project similar to the one planned for Caju district, provided with similar pollution control equipment, the estimated emissions for the Caju WTE facility can be seen in Table 5.4-1, compared with the values prescribed by CONAMA Resolution No. 316/02 – which indicates procedures and criteria for the operation of thermal waste treatment systems.

Table 5.4-1 – Estimated Values of Pollutant Emissions for the Caju WTE facility and Comparison with the Limits Defined by CONAMA Resolution Nº. 316/02

	NO_x	SO_2	CO	PM_{10}	Pb	Cd	Hg	HCl	HF	Dioxins / Furans
Estimated emissions	215 mg/Nm^3	21.5 mg/Nm^3	60 ppm	12.2 mg/Nm^3	21.5 $\mu g/Nm^3$	1.2 $\mu g/Nm^3$	2.4 $\mu g/Nm^3$	8.1 mg/Nm^3	3.1 mg/Nm^3	0.02 ng/Nm^3 (TEQ)
CONAMA No. 316/02[(1)]	560 mg/Nm^3	280 mg/Nm^3	100 ppm	70 mg/Nm^3	7.0 mg/Nm^3 (Total Metals Cl 3)	0.28 mg/Nm^3 (Total Metals Cl 1)	0.28 mg/Nm^3 (Total Metals Cl 1)	80 mg/Nm^3	5 mg/Nm^3	0.5 ng/Nm^3 (TEQ)*

Source: Malcolm Pirnie, 2011.

Although the thermal treatment of urban solid wastes produces pollutant emissions, the above table shows that the estimated emission rates are below the limits established by CONAMA Resolution No. 316/02 with the use of proper pollution control equipment. On a state basis, in spite of the lack of laws that define emission compensation in saturated air basins, some stricter requirements may be made at the environmental licensing before the plant can be deployed, taking into account the local conditions. For a better assessment of the interaction of such emissions with local atmospheric processes an atmospheric dispersion study may be requested.

Therefore, this can be classified as a negative impact, with sure probability of occurrence, continuous for enterprise lifetime, reversible and mid magnitude, considering the atmospheric conditions at the MRRJ.

Suggested Actions

- An atmospheric dispersion study must be conducted, in order to better evaluate the influence of pollutants on the atmosphere;
- The best available technologies for pollution control equipment must be evaluated. For example, the typical plant which is used above for comparison purposes, does not include selective catalytic reduction (SCR) for post combustion treatment of NO_x, which would significantly reduce predicted emissions
- The atmospheric emissions must be monitored, in order to appraise the system and assure the efficiency of control devices, in compliance with the NOP-INEA-01 standard and CONAMA Resolution No. 382/2006.

B. Water Quality Degradation in Nearby Bodies of Water Due to the Discharge of Polluting Sources

The intended project would produce the following estimated process effluent flows:

- 168 m^3/day (from WTE boiler blowdown)
- 160 m^3/day (from WTE wet cooling tower blowdown).

The main characteristics of such effluents are high dissolved inorganic salts and high suspended solids. These effluents would be reused as appropriate in the integrated process water system so the net effluent flow cannot be determined at this preliminary stage. An on-site wastewater treatment plant would accept all non-reusable effluents and treat them to below the limits defined by CONAMA Resolution Nº. 357/05.

- 20 m^3/day of residual waters from the dewatering of AD residues

The main characteristics of such effluents are the high load of organic matter and suspended solids. A suitable on-site wastewater treatment plant would be provided to treat this effluent to below the limits defined by CONAMA Resolution Nº. 357/05. This can be accomplished with a biological treatment process that is designed for both BOD_5 removal and ammonia oxidation (nitrification).

In addition, the following estimated sanitary effluent flow

- 10 m^3/day of domestic effluents from toilets and changing rooms.

The main characteristics of such effluents are the heavy load of organic matter.

Located in the district of Caju, in the vicinities of Caju Transfer Station, ETE Alegria is the largest sewage plant operated by CEDAE (Rio de Janeiro State Company for Water and *Sewage*), able to receive and treat 2,500 liters of sewage by second and, in the future, 5,000 liters of sewage per second, providing service for 1.5 million people. ETE carries out the treatment of sewage collected in the Center of the City, boroughs of Tijuca, São Cristóvão, Benfica and Caju, eliminating therefore the sewages discharging in the Guanabara Bay and in the rivers and water channels existing in the surrounding area. In the future it will be able to collect sewage from: Manguinhos, Faria-Timbó and Cidade Nova (http://www.cedae.com.br/). The borough of Caju is serviced by the domestic sewage collecting system, and the effluents are routed to treatment in ETE Alegria

The potential impact of decomposition process of organic matter if discharged in bodies of water implies the consumption of oxygen in such media, thus killing any existing organisms. Besides, the release of nutrients favors the growth of algae and superior plants, causing the eutrophication of the bodies of water and impairing the several uses of such bodies.

As previously mentioned, these processes are already intense in Guanabara Bay, particularly between the Governador and Fundão islands and the continent – where the enterprise would be installed. Due to the discharge of effluents from industrial areas and low income homes, the self-depuration capacity of that region was already exceeded; a strict control is then needed for the additional discharge.

Although the quality situation of water resources in the area of interest is really critical, the plant's hydric balance would be designed to maximize the reuse of residual waters within the plant and minimize water demand and, consequently, the effluent discharge. For any residual waters that cannot be reused in the process, a proper treatment station would be installed for those pollutants and discharge patterns. Additionally, the urban solid wastes, boiler ashes and gas washing residues would be stored in sheltered places, to prevent rainwater from carrying such materials to bodies of water.

Therefore, the negative impact can be considered of sure occurrence, reversible, continuous for enterprise lifetime and mid magnitude, taking into account the situation of the water bodies in the area in question.

Suggested Actions

In order to mitigate or diminish this potential impact the following suggested actions are proposed:

- If the sanitary effluents are to be delivered to the sewer system, it would be advisable to observe the Guideline for the Control of Biodegradable Organic Loads in Liquid Effluents of Sanitary Origin – DZ-215.R-4, approved by CECA Resolution No. 4886, of September 25, 2007 – which establishes that industrial effluents of sanitary origin with overall organic load lower than 5 kg BOD/day (equivalent to an average of 200 employees) can be discharged in the sewer system after a treatment with minimum removal efficiency of 30% of the BOD. In this case, the concentration of BOD and TSS in the effluents cannot exceed the maximum value of 180mg/l.

- A regular monitoring of produced effluents is also advisable, according to Guideline DZ-942.R-7.

- The quality and efficiency of effluent treatment must be assured, according to the Guideline of Organic Load Control in Liquid Effluent of Industrial Origin - DZ-205.R-6/2007 and the Technical Standard for Criteria and Patterns to Control Toxicity in Industrial Liquid Effluents - NT-213.R-4/1990, in addition to CONAMA Resolution No. 357/05.

C. Discomfort to the Population Due to the Generation of Noise, Smells and Dust

During enterprise deployment, the transport and assembly of equipment and the motion of machines and civil works would increase the level of noise and dust in the vicinity of the area of interest. During enterprise operation, noise and dust would also be produced due to machine and equipment operation.

The site where the enterprise would be deployed has high emission levels of noise and dust already, due to its proximity to the port area, industries and heavy local traffic. The main impact of dust generation can be associated with inhalable particles, which are mentioned in the assessment of the impact of air quality degradation.

As to smells, the handling of urban solid wastes (and their combustion) can produce disagreeable smells; however, the plant's pollution control equipment would remove combustion and products associated odors with the stack emissions. As to smells associated with raw waste handling, the flow of waste and its storage would not increase with regard to the current situation, considering the operation of the Caju Transfer Station, which already separates and composts wastes.

Suggested Actions

- Some background noise measurements must be made before the enterprise deployment.

- The noise produced during the civil works and enterprise operation must be monitored, and then compared to the background values and to the limits defined by the NBR 10.152 standard.

- Individual Protection Equipment (IPE) must be mandatory for those employees that may be exposed to higher noise levels.

- If the population feels discomfort due to smell generation, physical, chemical or biochemical methods may be used to reduce such smells.

5.4.2.2 Social-Economic Environment

A. Interferences in the Urban Infrastructure

a) Interference in the Road System

A daily waste load of 1,700 tons would be required to operate the integrated WTE facility. Currently, Caju Transfer Station receives 2,800 tons of wastes every day, and it is not foreseen that such flow will change in a significant way. The required volume to operate the plant would be taken from the existing waste flow.

Therefore, from the daily 2,800 tons that arrive at Caju Station, 1,700 tons would be deviated to the plant and the remaining load (1,100 tons/day) would be forwarded to Gramacho landfill. In other words, from the overall waste load that arrives at Caju Station, 60.7% would be treated, and will not be sent to Gramacho landfill.

This diversion of waste represents: a 60.7% reduction of waste processed by Caju Station, intended for Gramacho landfill; a 21.2% reduction of overall waste sent to Gramacho landfill; and 16% reduction of overall waste delivered to landfills by the City of Rio de Janeiro.

With such reduction of wastes taken to Gramacho landfill, a significant decrease in the number of trucks is expected along this route. Considering that the trucks must use roads like Linha Vermelha to arrive at that landfill, one with the heaviest traffic in the city of Rio de Janeiro, having a daily average volume of 139,674 vehicles near the Caju district, the decrease of truck trips would contribute to:

- Reduced atmospheric emissions;
- Reduced number of vehicles on roads with heavy traffic, thus interfering in a positive way to the traffic of that region;
- Reduced pavement wear;
- Reduced possibility of accidents.

This impact can be classified as positive, sure, reversible and continuous, with small magnitude.

b) Interference in the Power Infrastructure

In full operation, the WTE plant would generate 30 MW of power every day, which would be sold through ANEEL biddings. There may be the need to expand the existing distribution infrastructure to distribute such power; however, considering that the plant would be deployed close to power consumer centers, in an area with base infrastructure, only a minor expansion is expected.

This impact can be classified as positive, sure, irreversible and continuous. It has small magnitude, however, due to the relatively small contribution of generated power when compared to the overall consumed power of the city. It is worth mentioning that the enterprise would contribute to diversify the power matrix, and at the same time to decrease the volume of wastes sent to landfills.

To the extent that the additional electrical power replaces fossil fired power generation, the project would reduce the emission of greenhouse gases. This impact can be classified as positive, probable, irreversible, but with a small magnitude.

B. Socio-economic impacts and increase of project costs due to energy production and transmission

Despite the city of Rio de Janeiro being provided with a large electric power transmission and distribution infrastructure, and the likely possibility of having an interconnection between the WTE to the existing system, the implementation of a substation and a transmission line could be necessary. With the implementation of this transmission infrastructure, socio-economic impacts related to this type of enterprise are expected.

Since Caju Transfer Station is located in a consolidated urban area, and densely occupied, the interferences should occur predominantly in the socio-economic aspect (relocation of population and economic activities, for example), so studies would need to be carried out for the environmental licensing of these structures. In addition to the socio-economic impacts expected, the implementation of this power transmission structure should contribute to the increase of this project costs

This impact could be classified as negative, probable, irreversible, and of large magnitude, due to the occurrence of social and environmental impacts and increase of project costs.

As measures to reduce and mitigate the impact the following is suggested:

- The preparation of a power infrastructure diagnosis for the city of Rio de Janeiro;
- The registration of the WTE Plant with ANEEL as an electric power generator;
- The preparation of the design, based on the closest transmission network for the interconnection;
- The preparation of a specific Environmental Impact Assessment including location alternatives study, so as to identify the best alternative capable of preventing and reducing socio-economic impacts.

C. Market-Oriented Reform

The proposed enterprise meets the requirements of the current National Policy for Urban Solid Residues (Federal Law No. 12.305/2010); one of the purposes of this law is to stimulate the development of environmental and entrepreneurial management systems focused on the improvement of production processes and the reuse of solid wastes – including energy recovery and reuse (Art. 7). According to Art. 8, scientific and technological research is one of the tools encouraged by such policy.

Paragraph 1 of Art. 9 mentions the possibility of using energy recovery technologies for urban solid wastes, as long as their technical and environmental feasibility can be proved, and a monitoring program for toxic gas emission is implemented, with the approval of an environmental entity.

According to Art. 44, each government level (Federation, Federal District, States and Cities) can create norms to provide tax reduction and financial / credit incentives, but always within the limits of the Fiscal Responsibility Law (Complementary Law No. 101, of May 4, 2000).

The existing and acknowledged energy recovery technology in Brazil involves the generation of power by means of biogas from landfills, which is already regulated by law. The thermal treatment of wastes has already been regulated by CONAMA Resolution No. 316/02, which regulates the thermal treatment of wastes and corpses – by establishing operating procedures, emission limits, and criteria for performance, control, treatment and final disposition of effluents, in order to minimize any impacts to the environment and public health as a result of such activities. That resolution, however, does not address power generation from wastes specifically.

Although most of the population and civil organizations (particularly the associations and cooperatives of garbage collectors) still resist to the deployment of units for thermal treatment of wastes in Brazil, there are already initiatives of similar enterprises in progress (such as WTE São Bernardo do Campo and WTE São José dos Campos) – which are stimulating discussions on the subject and contributing to the evolution of corresponding laws, regulations and policies, driven mainly by the urgent need of innovative solutions for the sanitary issues of large urban centers in Brazil, along with the interest of investors and the scientific community.

The proposed enterprise holds strategic value for the city or Rio de Janeiro. The city of Rio de Janeiro houses the headquarters of Petrobrás, branches of companies like Furnas Centrais Hidrelétricas and Empresa Brasileira de Energia, in addition to advanced power research centers. The intended enterprise complies with the Rio Capital da Energia program, which intends to make the state of Rio de Janeiro a reference in rationalization, technological innovation and environmental sustainability in the power sector, through partnerships with private / public companies and entities. This confirms the existence of a market trend towards alternative power sources, mainly in the area of interest.

In such context, the deployment of a WTE plant in Caju district can contribute to accelerate all regulations for this technology, and to the expected developments over coming years in the power sector, with regard to alternative power generation sources.

This impact can be classified as positive, with sure occurrence. Considering the existence of other similar initiatives and the real trends for the adoption of such technology, a mid magnitude impact is expected. Additionally, the changes would be irreversible and permanent after the enterprise is deployed.

D. Employment Growth

a) Employment Growth During the Construction Phase

A civil works company must be contracted for the plant's deployment works; it would be responsible for hiring workers, for their safety and, at the end, for their dismissal or effective hiring in other works. In this process, however, the entrepreneur would be co-responsible.

According to estimates, approximately 500 workers would be required for these works. This number was achieved by relating the overall number of hours during the works (considering 36 months, 30 days per month and 8 work hours per day) to the number of man-hours (4,800,000 man-hours).

In the city-wide context the creation of 500 construction jobs has a very minor impact, representing only 0.05% of EAP that is not formally employed (1,138,956 persons). It is worth reminding, in this case, the high rate of formal jobs in the city of Rio de Janeiro (64% on 2008).

At the level of this planning area (AP1), when appraised in terms of Active Age Population (AAP) in 2010, the impact of these 500 new jobs can be also considered of little relevance, as they correspond to nearly 0.23% of the population in working conditions[49].

At the district level, the relation between possible jobs and the population in working conditions (16,282 persons) is more relevant, with 3.41% of the AAP.

In addition to the possible increase of direct jobs (workers hired for the works directly), a leverage action of the local economy is expected, because:

- Indirect and induced impacts are expected, in relation to the civil works – that is, jobs created by service providers, shops and other support activities for the works;
- An increase in local taxes is also expected, from the purchase of local goods associated with the works;
- An increase in support companies for civil works is expected too.

As reported by the Brazilian Chamber of the Building Sector (CBIC), for every 100 new direct jobs, 21 indirect jobs and 47 induced jobs are created; therefore, the creation of the following jobs can be estimated:

- 500 direct jobs
- 105 indirect jobs

[49] At this analysis level (AP1), and at the district level (Caju), AAP data of 2010 have been considered, as 2011 data are not available yet.

- 249 induced jobs[50] (created from the income change of workers as consumers)

Consequently, the overall number of direct, indirect and induced jobs that can be created with the works (854 jobs) would be still very low with regard to the city's AAP (only 0.08% of that total). Relevance would be also low at the planning area (0.38%), but considerably higher at the district level (5.74% of AAP in 2010).

This can be considered a positive, sure, reversible and temporary impact, ending after work completion. Its magnitude can be considered small in the city context, but mid-sized in the district context.

Suggested Actions

As possible actions to leverage this impact, workers from the district in question can be hired whenever possible, along with the purchase of products and services from the enterprise region and from the city. The job creation impact at the city-wide level is of minor impact, however, the impact increases substantially if the workers are hired from the local district where possible. Note that the Caju district has a low job rate of 35 % of the EAP.

b) Employment Growth During the Operation Phase

According to estimates, at least 49 full-time workers would be needed to operate the new facilities included in the enterprise including the WTE and AD plants. Positions would include plant operators, hoist operators, mechanics, electrical maintenance personnel, control technicians, and workers / managers in general.

The hiring of workers to operate the plant would be, as in the construction work period, of minor impact within the city context. With regard to the district, the relation between these jobs and active age persons is 0.28%, which can be considered very low.

It is worth mentioning, however, that the hired workers would have the benefit of a better quality of life, due to a higher income and the qualification to operate the

50 CBIC – Brazilian Chamber of the Building Sector. Employment generation in the building sector (Geração de emprego no setor da construção civil). Available at: www.cbicdados.com.br/files/textos/026.pdf. Accessed on December 2011.

enterprise – which would contribute to a certain stimulation of local economy, thanks to higher consumption capability, with the new indirect and induced jobs.

The impact is then positive, sure, reversible and permanent. Its magnitude can be considered low both in the city and the district contexts.

As possible actions to leverage this impact, workers from the district in question can be hired whenever possible, investing in their training and qualification.

In terms of the workers of the recycling cooperative existing in Caju Transfer Station, it is worth mentioning that they would be kept in place, because the enterprise operation would not use the total residues that arrives daily at the location as indicated in the diagnosis. Therefore, it can be observed that the work of waste pickers is still of major importance to the collection system and destination of urban solid residues.

c) Other Opportunities Associated with the Enterprise

Other opportunities associated to the enterprise may potentially include:

- Jobs created by renovations (law, regulation and policy changes)
- Jobs created by indirect impacts from the development of a new infrastructure
- Job opportunities due to qualification programs or investments made in technology transfer, by increasing the number of researchers at the scientific research centers

Although the above opportunities have positive impacts, none are considered certain or any more than minor impact.

E. Technology Transfer and Productivity Enhancement

There are not any active WTE plants in Brazil; however, some initiatives are being taken. In the state of São Paulo, for instance, CETESB is stimulating the cities to search and adopt solutions and new technologies for waste treatment with power recovery. Some examples can be mentioned: projects in progress for the towns of São Bernardo do Campo and São José dos Campos, both located at the state of São Paulo.

The project intended for São José dos Campos is now in a public consultation phase for bidding purposes, and will combine the following technologies: mechanical separation of garbage, biodigestion of organic wastes and burning of non-recyclable materials to generate power (Mayorship of São José dos Campos, accessed on December 2011)[51]. On the other hand, the project for São Bernardo is already in the bidding phase, to establish a public-private partnership for the deployment and management of that enterprise. It is expected that the works begin on January 2014, with burning tests starting after June[52]. Other initiatives are also in progress at the areas of Barueri and Baixada Santista (SP) and the town of Maringá (PR).

Considering that these are pioneer initiatives, a technology transfer for garbage treatment with power recovery is expected, with benefits related to waste treatment and power matrix diversification.

This is positive impact, with sure occurrence. It would be irreversible and permanent. It has a significant magnitude in such context, as it is integral part of pioneer initiatives for garbage treatment and power generation.

Suggested Actions

As there is no technology transfer without qualified people to absorb it, partnerships with Universities and Research Centers are suggested for an effective transfer (VARGAS, undated)[53]. Technology transfer must also occur with the transfer of scientific knowledge. Actions from the local government are important in this process.

It is worth stressing that the country and the city of Rio de Janeiro are well ahead in this context, with regard to research and the use of alternative power generation solutions. Brazil has important entities involved in such research, with a qualified technical staff to properly interact with the technology transfer process.

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51 Available at: http://servicos.sjc.sp.gov.br//downloads/mpri339.pdf.

52 Urban Infrastructure Magazine (Revista Infraestrutura Urbana), issue 09, December 2011. Available at: http://www.infraestruturaurbana.com.br/solucoes-tecnicas/5/artigo224674-1.asp; Accessed on December 2011.

53 VARGAS, José Israel. Tecnology Transfer Mechanisms for 3º World Countries (Mecanismos de Transferência de Tecnologia para Países do Terceiro Mundo). IEA – Advanced Studies Institute at São Paulo University (Instituto de Estudos Avançados da Universidade de São Paulo). Available at: www.iea.usp.br/artigos. Accessed on December 2011.

6 Task 6 – Legal, Regulatory and Institutional Review

6.1 Preface

Task 6 includes a review the regulatory framework relevant to implementation of the project, including waste and energy sector laws, incentives for renewable energy, and environmental permitting.

The balance of this report includes the following sections:

- Overview of environmental policy
- Environmental Permits – covering federal and state legislation relevant to the proposed facility
- Specific water and air quality national and state standards
- Specific solid waste and thermal energy legislation.
- Incentives and regulatory charges for Independent Power Producers (IPP) with emphasis on generation of power from municipal waste.
- Government programs to encourage use of alternative sources of electrical energy.

6.2 Environmental Policy

Pursuant to the Brazilian Constitution, which dedicates a special chapter to the environment, all citizens have the right to a balanced environment. Therefore, Article 225 of the Brazilian Constitution imposes on public authorities and society, as a whole, a general obligation to protect and preserve the environment for present and future generations.

In furtherance of this obligation, Article 23 appoints the Federal Government, the states, the Federal District and the municipalities to be in charge of environmental protection, to guard against pollution in any form, and to preserve Brazilian fauna and flora. The authority to promulgate legislation with respect to matters involving the environment (such as the protection of fauna, flora, soil and natural resources in general, as well as pollution control) is granted jointly only to the Federal Government, the states and the Federal District (Article 24); the municipalities may legislate only with respect to matters of local interest or on a supplementary basis to the federal and state laws (Article 30, Items I and II).

The Brazilian legislative framework of environmental protection is comprised of many stringent federal, state and local environmental laws and regulations. One of the most relevant Brazilian environmental laws is Federal Law 6.938/1981, which created the Brazilian Environmental Policy and establishes its purposes, formulation and enforcement mechanisms. Such formulation and enforcement mechanisms include, among others, the imposition of environmental licensing requirements for certain plants and activities.

Federal Law 6.938/1981 also established the organic structure of the Brazilian System for the Environment, which is comprised of all federal, state and local environmental agencies and entities. The Ministry of the Environment performs the coordination of the Brazilian Environmental Policy.

The Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) is responsible for the implementation and enforcement of Brazilian environmental policy and its directives at the federal level. The Brazilian Council for the Environment (CONAMA) has authority to enact resolutions establishing environmental standards with national approach.

Federal Law 6.938/1981, which established the National Environmental Policy, gives CONAMA - the National Environmental Council, within SISNAMA - National Environmental System, the power to issue rules, criteria and standards related to environmental quality control, for the purpose of ensuring rational use of environmental resources, especially those related to water. Based on the powers granted by Federal Law 6.938/1981, CONAMA has been issuing various regulations in an ongoing process to ensure comprehensive environmental regulation.[54]

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[54] This course of action has been the subject of heated debate. Some legal scholars believe that CONAMA is acting outside the powers conferred to it by law. According to these scholars, the adoption of this type of regulation by CONAMA, which belongs to the executive branch of government, represents an incursion into the legislative branch of government. Even though this issue has not been fully resolved in the Brazilian system, the regulations issued by CONAMA are widely accepted and recognized, which reflects the CONAMA's credibility in the field of environmental protection. Because of such intricacies, Brazilian environmental legislation and regulation is dispersed over various levels of government and, for that reason, is difficult to compile and summarize.

States and several municipalities also maintain special agencies and entities that have the authority to establish, control and enforce, respectively, state and local environmental policies. In the State of Rio de Janeiro, the agency responsible for environmental policy is INEA (State Institute of the Environment).

The Brazilian federal, state and local environmental agencies/bodies have the police power to control and enforce environmental laws and regulations. The implementation of such police power; however, very often exposes conflicts of authority, due to the decentralized federative system adopted in Brazil. Such conflicts of authority involve not only the definition of which agency/body must perform environmental control and impose administrative penalties, but also the authority to issue environmental permits. At the present moment, the criteria adopted are basically focused on the predominant interest involved (for instance, for an undertaking or activity that causes impacts to an asset of federal domain, IBAMA shall have the authority to perform the police power).

6.2.1 Liabilities

In Brazil, environmental legislation is comprised by various federal, state and municipal laws and regulations. The non-compliance with such laws and regulations may subject the violator to administrative and criminal sanctions, in addition to the obligation to repair or to indemnify damages caused to the environment and third parties.

6.2.1.1 Criminal Law

In 1998, the Brazilian government approved an environmental crimes law (Federal Law 9.605/1998), which imposes administrative and criminal penalties on corporations and individuals committing environmental violations. Individuals (including corporate officers and directors) may be imprisoned for up to five years for environmental crimes. In the criminal sphere, penalties against corporations include fines, community service and certain other restrictions, including the cancellation of credit lines with official entities. At the administrative level, individuals or corporations found to be violating environmental laws can be fined up to R$50 million, have their operations suspended, be barred from entering into certain types of government contracts and be required to forfeit tax benefits and incentives.

Defenses adopted against criminal and administrative environmental liabilities usually focus on the absence of culpability of the defendant, the non-commitment of a violation as it is described by the law and the lack of a casualty linkage between the conduct of the defendant and the environmental damage.[55]

Criminal sanctions can also be imposed against directors and officers, to the extension of their respective culpability, if they knew about the offence of the company and did nothing to impede consummation or continuing of the environmental crime. No insurance policies cover criminal environmental liabilities.

The non-compliance of requirements established by environmental agencies as specific requirements for the issuance of environmental permits/authorizations may result in the cancellation of the relevant permit/authorizations.

6.2.1.2 Civil Law

Brazilian environmental laws adopt the strict liability regime. In this case, defenses are usually based on the non-existence of the environmental damage or the absence of a casualty linkage between the environmental damage and the conduct of the defendant.

Pursuant to Brazilian laws, if the environmental damage was caused, either directly or indirectly, by more than one polluter, all polluters can be held jointly and severally liable for the recovery of the environment.

Moreover, Federal Law 9.605/1998 expressly recognizes that the piercing of the corporate veil of a company may occur in order to ensure enough financial resources to the recovery of damages caused against the environment. Therefore, the personal assets of directors and officers of a corporation can be affected if the relevant company does not have sufficient assets to bear the environmental recovery cost.

Acts of God and Acts of Nature may not be accepted as exemptions from civil environmental liability, as the Brazilian Civil Code (Federal Law 10.406/2002) recognizes the risk of the activity as one of the sources of civil liability.

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[55] At the administrative level; however, due to the fact that applicable laws do not clearly address culpability as a requirement for the imposition of penalties in all cases, environmental agencies and part of the Brazilian legal doctrine understand that strict liability should be adopted. Such understanding is still controversial and there is no jurisprudence on this matter.

Directors and officers may get special insurance in order to protect their personal assets from indemnities involving environmental damages. However, insurance protection or any other contractual exemptions of liability will not hinder public authorities to adopt legal measures against directors and officers. Such protective means can be used by directors and officers to recover potential asset losses.

The existence of a valid environmental license and the compliance with permit limits do not protect an operator from civil liabilities, if the operator has effectively caused an environmental damage. In addition, the environmental agencies themselves might be held jointly and severally liable with the operator, if the relevant permitted limits cause environmental damages.

6.3 Environmental Permits

Brazilian environmental laws require the obtaining of environmental permits prior to the construction, installation, expansion, modification or operation of any facility or activity that uses natural resources, causes or has the potential to cause degradation or environmental pollution on Brazilian territory.

Environmental licenses are for a specific term and are issued by an administrative act, by which the relevant environmental authority establishes the conditions, restrictions and means for environmental management to be observed by the respective applicant, whether an individual or legal entity. The environmental licensing process consists of three distinct stages, which correspond to the phase of the project, and is carried out by federal, state or municipal environmental agencies, as follows:

- **Preliminary Permit -** The preliminary permit is evidence of the environmental feasibility of a facility or activity and establishes the basic requirements and environmental conditions to be satisfied during subsequent implementation stages.

- **Installation Permit**- The installation permit authorizes the construction of a facility and establishes the control measures and other environmental conditions to be fulfilled before the operation phase can begin. Proof of the implementation of the conditions under the preliminary permit, as well as the preparation of a basic environmental project and its relevant environmental programs, are pre-requisites to the issuance of an installation permit.

- **Operating Permit**- The operating permit authorizes the operation of a facility or activity for the period established in the permit, which may be renewed. The applicant must seek the permit from the relevant environmental agency prior to completion of the construction, by providing evidence of the implementation of the basic environmental project and compliance with the environmental conditions of the installation permit.

Since the object of the environmental permit is the facility or activity itself, in general, it is possible to transfer the license from one person to another. The transfer usually requires the conduction of a formal procedure with the competent environmental agency. The competent environmental agency has the power to decline an environmental permit or to establish specific conditions to the maintenance of its validity.

The performance of an environmental impact assessment may be a requirement for the issuance of a preliminary permit. If the relevant facility or activity is deemed to have a potential for causing significant environmental degradation or pollution, an environmental impact assessment and the corresponding report on the impact to the environment must be prepared and submitted for analysis through public hearings in the affected communities by the relevant competent environmental agency.

The competent environmental agency has the authority to suspend or cancel environmental permits if the holder of the permit does not comply with specific conditions established for the maintenance of the permit, or as an administrative penalty against environmental administrative offences. If cancellation or suspension of the permit is established by the relevant environmental agency, the operator of the facility/activity can present an administrative defense against the decision of the agency. If the defense is not successful, the operator can file an administrative appeal to the competent upper level body.

6.3.1 Environmental Impact Study and Environmental impact Report – EIA/RIMA

Article 225 of the Federal Constitution provides that a prior environmental impact study is required for any undertaking or activity that could potentially cause significant environmental degradation.

In addition, CONAMA Resolution 01/1986 lists all the activities for which the EIA/RIMA is compulsory, and establishes the guidelines for performing the study and preparing the report. The proposed Rio waste to energy facility constitutes thermal destruction of waste, and as such is considered a high impact activity requiring an Environmental Impact Assessment (EIA) for the implementation of this project.

The EIA must provide the following information: (i) technological alternatives and alternative locations; (ii) identification of the areas of direct and indirect impact, and evaluation of the impact caused by installation and operation of the project; (iii) analysis of the project's compatibility with government programs for the area; and (iv) the mechanisms required for environmental protection.

Associated with the EIA is the Environmental Impact Report (RIMA), its main requirements are to set out: (i) the objectives and reasons for the project; (ii) a complete description of the project, its alternatives and impacts; (iii) the environmental diagnosis of the area; (iv) a description of the measures to be taken to minimize negative impacts; and (v) a description of the monitoring program.

Under CONAMA Resolution 09/1987, a public hearing may be called by the environmental authority or the public prosecutors, or at the request of any civil entity or group of at least 50 citizens for purposes of discussing the EIA/RIMA. The hearing must be opened to public so that anyone in the community can take part in the discussion of the project.

Another important aspect of the licensing of undertakings with significant environmental impact is found at Law 9965 of 2000. One of the requirements to be met for obtaining environmental licenses is the creation of a state-owned conservation unit, as a form of reparation for the environmental damage that may be caused by the project. The expenses associated with the establishment and operation of the conservation unit must be proportional to the environmental changes and damages caused by the undertaking and must be within 0.5% of the total forecast cost of implementing the undertaking. The EIA/RIMA for the undertaking must also present proposals, plans or possible alternatives for compliance with the determinations of applicable law.

6.3.2 Environmental Permit at Rio de Janeiro

The State of Rio de Janeiro has specific legislation for the environmental licensing process for thermal destruction of waste, which was established by Determination CECA/CN nº 2968 of September 14, 1993.

The legislation requires a program of burning tests to be performed and approved prior to operation of a waste thermal destructions facility. The burning test program consists of three phases, namely:

I. Presentation of the test burn plan;
II. Preparation of test burns with technical monitoring by INEA, with each condition tested at least three times; and

III. Presentation of the report to INEA based on the results of the assessment of plant performance, control equipment, and including charts, tables, reports and required analysis.

There is also an obligation to meet the operating conditions established in the project presented to INEA upon request for an existing license or upon renewal of operating license. These conditions include implementation of continuous monitoring for the control of oxygen, carbon monoxide, temperature, waste feed rate, a minimum temperature of the combustion chamber exhaust, and the minimum temperature of flue gas output, among other conditions.

6.4 Water

Water pollution is defined under Federal Decree 50.877/61 as anything that alters water's properties, causing damage to the population or compromising its social or economic use. Federal Law 9.433/1997 established the National Water Resources Policy, administered by the Federal Water Agency - ANA, and created riverbed committees to implement policies and rules within their respective jurisdictions.

The National Water Resources Policy also establishes rules governing water rights. The federal and state authorities that form part of the National Water Resources Management System - SNGRH are responsible for granting the rights to use water resources. A water rights' grant is required for: (i) collection of water for final consumption, public supply or industrial input; (ii) extraction of water from underground aquifers for final consumption or industrial input; (iii) discharge of wastewater into bodies of water; (iv) use of water for hydroelectric purposes; and (v) any use that may cause changes in the flow, quantity or quality of the water. Water use rights are subject to the priorities established in the Water Resources Plans and cannot be granted for a period of more than 35 years.

The National Water Resources Policy also determines that payment must be made for water use and effluent discharge to water bodies. Although the Policy establishes the criteria for water use charges, a fee system has not been fully implemented. Some States already have an operational fee system, but the national system is still under implementation. Funds collected through water use fees shall be used for financing studies, programs, projects or construction works, as well as for paying administrative costs of the agencies and entities that form part of the National Water Resources Management System.

Furthermore, penalties can be imposed on users who pollute water resources. A grant of water rights can also be suspended, temporarily or permanently, for reasons such as: (i) failure to comply with the terms of the grant; (ii) failure to use the water rights granted for three consecutive years; (iii) urgent need of water to attend to catastrophic situations, including those resulting from adverse climatic conditions; (iv) prevention or remediation of serious environmental degradation; (v) overriding priorities for water use, in the collective interest, when there are no alternative sources available; and (vi) ensuring that the water body remains navigable.

In Brazil, the discharge of effluents is controlled by either the federal or the state governments, and it is forbidden to discharge effluents into ground water. The governments also have the power to determine how water streams may be used. CONAMA Resolution 357/2005 establishes maximum discharge levels for a large range of substances found in effluents, as well as water quality standards. The States can establish supplementary rules and in case of conflict, the more restrictive rule applies. Depending on the case, the local environmental agency can establish even stricter standards for specific activities.

The environmental agencies have jurisdiction to apply CONAMA Resolution 357/2005, monitoring water use and pollution and applying legal penalties, including, in the worse cases, the suspension of polluting industrial activities.

Recently there was the publication of a new Resolution CONAMA nº 430/2011 which complements the CONAMA Resolution nº 357/2005, thus setting new conditions and standards for effluent discharge of any pollutant source. This resolution includes specific standards that establish the maximum load for the release of polluting substances are present or substances likely to be formed in the production process so as not to compromise a defined receptor. The resolution also outlines requirements for regular monitoring of effluents discharged into receiving bodies by the polluting sources of water resources, over the license period of the activity.

Specifically in the State of Rio de Janeiro, intended for local installations there is a Determination CECA/CN nº 4.887 of September 25, 2007. This standard sets out specific rules in relation to effluent reduction, including the following topics:

- biodegradable organic matter from industry,
- non-biodegradable organic matter from industry,
- industrial organic compounds that interfere with the ecological mechanisms of water bodies
- operating biological treatment systems deployed by industry

- operators of sewer services,
- industrial wastewater and the sewage generated by industry

6.5 Air Quality and Emission Standards

Air quality and emissions standards are established by federal and state regulations in order to prevent a concentration of pollutants in the atmosphere that could negatively affect the human, animal or plant populations. The Environmental Crimes Law expressly makes pollution of the atmosphere a pollution crime, defined as any pollution that results or may result in damage to human health, the mortality of animals or significant destruction of flora. If the air pollution causes the evacuation, even for short periods, of the inhabitants of the affected areas, or causes effective damage to people's health, harsher penalties apply.

The over-arching federal legislative goals for air quality and emission standards are established by CONAMA Resolution 05/1989, which created the National Air Quality Monitoring Program (PRONAR). This Program establishes a primary and a secondary air quality standard and three different classes of regions: (i) Class I regions should not have any air quality impact; (ii) Class II regions should conform to a secondary standard; and (iii) Class III regions should conform to a primary standard. CONAMA Resolution 03/1990 complements the Resolution 05/89, providing air quality standards for several pollutants as well as methods of analysis.

Also in 1990, CONAMA Resolution nº 08 set emission ceilings for air pollutants in combustion processes to external fixed-source pollution. Specifically for heat treatment systems for waste, CONAMA Resolution 316/2002 sets emission standards, which are reviewed in the following section.

The States have authority to monitor compliance with the air emission standards and control atmospheric emissions caused by potentially polluting activities undertaken in that State. In the State of Rio de Janeiro, the Determination CECA nº 21, March 15, 1978, establishes the standards of air quality, setting limits for each pollutant that should be observed for enterprises located in the state of Rio de Janeiro.

Table 6.5-1 shows the standards that must be followed for the above parameters in accordance with this resolution.

Table 6.5-1 - Rio De Janeiro CECA no 21 - Air Quality Standard			
Pollutant	**Long Term**	**Short Term**	**Reference Method**
Sulphur Oxides (SO_2)	80 µg/m3 Annual Arithmetic Mean	365 µg/m3 Max Concentration in 24 hr samples	MF-605
Particles in Suspension	80 µg/m3 Annual Geometric Mean	240 µg/m3 Max Concentration in 24 hr samples	MF-606
Carbon Monoxide (CO)	10 mg/m3 Max Concentration in 8 hr samples	40 mg/m3 Max Concentration in 1 hr samples	MF-Non Dispersed Infrared Spectroscopy
Photochemical Oxidants	Not Applicable	160 µg/m3 Max Concentration in 1 hr samples	MF-608
Particle Settling	1.0 mg/cm2 per 30 days (industrial area) 0.5 mg/cm2 per 30 days (other areas)	Not Applicable	MF-609

Moreover, there is also Determination CECA No. 935 of 1986 which created the Program of Emissions Self-Control to Atmosphere (PROCON – AR) and Resolution CONAMA No. 26 of 2010, which refers to the Program for Monitoring of Fixed Source Emissions to Atmosphere (PROMON AR). Those responsible for these activities must regularly report to the environmental agency of the State of Rio de Janeiro (INEA), the results of periodic and continuous sampling in chimney and air quality carried out under defined conditions in other regulations.

The main purpose of those programs is the compliance verification to emission standards, the design control requirements, and the allowance of the establishment of standards and emission factors appropriate to the State of Rio de Janeiro.

The State of Rio de Janeiro has also established the following rules for specific technical procedures for air emissions monitoring:

- **Determination CECA-RJ-956-1986 (MF-0515.R-3)** – This rule requires, in chimneys, the concentration of particles in the gas and it is used as reference methods: determination of points for sampling in chimneys and ducts of stationary sources; determination of the gas average speed in chimneys; determination of the concentration of CO2 in the air excess and of the molecular weight of dry gas in chimneys; and determination of gas moisture in chimneys.

- **Determination CECA-RJ-663-1985 (MF-0520.R-4)** – This rule establishes the method for visual determination of blackening degree of smoke from stationary sources.

- **Determination CECA-RJ-1949-1981 (MF-511.R-4)** – This rule determines the points for sampling in chimneys and ducts of stationary sources, which applies to ducts and chimneys are larger than 0.30 m and cross section greater than 0.07 m^2.

- **Determination CECA-RJ-192-1984 (MF-512.R-1)** – This rule determines the gas average speed in chimneys and consequent volumetric flow, to determine the concentration or emission of pollutants from stationary sources.

- **Determination CECA-RJ-168-1981 (MF-0516.R-1)** – This rule establishes the method for visual determination of emissions opacity from stationary sources, which must be preceded by qualified and trained observer.

- **Determination CECA-168-RJ-1981 (MF-513.R-2)** – This rule establishes the method of analysis that allow for determining concentrations of CO2, air excess and the molecular weight of a flow in the chimney, to determine the percentage of CO, CO2, O2 and N2.

- **Determination CECA-RJ-168-1987 (MF-0514.R-1)** – This rule defines the method for determining the moisture content in exhaust gases from a chimney.

- **Determination CECA-RJ-311-1978 (IT-802.R.1)** – Establishes conditions for submission the projects of system emission control of air contaminants.

- **Determination CECA-RJ-27-1978 (MF-606.R-3)** – This rule establishes the method of the high volume sampler (HI-VOL) for determination of particle in suspension in ambient air, to be adopted in the control activities of pollution in ambient air.

6.5.1 Protection of the Ozone Layer

Protection of the ozone layer is essential to avoid physical alterations in the environment caused by climatic changes resulting from the greater penetration of harmful radiation through the Earth's atmosphere. Thus, both international treaties and federal determinations were incorporated into the environmental protection system, seeking to protect the ozone layer.

The Vienna Convention and the Montreal Protocol, signed by Brazil and promulgated by Federal Decree 99.280/1990, establish measures for the protection of the ozone layer. The Rio/92 Declaration also contemplates the adoption of preventive measures for this matter.

The main Brazilian regulations on this matter are: (i) CONAMA Resolution 13/1995, which prohibits the use of a series of ozone depleting substances, in accordance with the Montreal Protocol; and (ii) the Brazilian Program for the Elimination of Production and Consumption of Substances that Destroy the Ozone Layer (PBCO), carried out by PROZON, a Joint Ministerial Executive Committee created by an Executive Decree of September 1995.

6.5.2 Air Pollutants Specific to Thermal Treatment of Solid Waste

The CONAMA Resolution No. 316 of 2002 describes the procedures for operation of industries that perform thermal treatments of waste, including emission limits for air pollutants from such industries. Refer to Section 6.1 of this report for further information on requirements and specific emission limits.

Pursuant to Brazilian Technical Rule (NBR) No. 10,004:2004, solid waste is defined as any solid or semi-solid waste resulting from industrial, domestic, hospital, agriculture, services and sweeping activities. Such definition includes the sludge generated by water treatment systems and by pollution control facilities and equipment, as well as certain liquids that, due to specific characteristics, must not be released into the public sewage collection system or into water bodies

Pursuant to the same technical rule, waste is classified in two classes, as follows: class I - hazardous; and class II - non-hazardous. Non-hazardous waste is also divided in two subclasses: class II A - non-inert; and class II B - inert.

All hazardous wastes are subject to special management requirements, including its temporary storage, transportation, treatment and final destination. In several States, the final disposal of hazardous waste requires the obtaining of a special authorization from the relevant state environmental pollution control agency.

Certain types of wastes are subject to specific regulations, such as batteries and accumulators, used tires, useless fluorescent lamps, health services waste, construction waste, pesticide packaging and radioactive waste.

In principle, both the temporary storage and final disposal of waste on the site where it was produced can be done as long as the producer complies with specific environmental permitting and technical requirements, which include the use of appropriate storage and disposal facilities and the adoption of adequate environmental procedures.

However, depending on the area where the facility is located (for instance, the proximity to water sources or residential areas), the competent environmental agency may decide not to issue an environmental permit for the temporary storage or final disposal of waste in situ.

As Federal Law 6.938/1981 expressly contemplates the concept of indirect polluter, the transfer of waste to another person for disposal/treatment off-site will not exempt the producer of the waste from environmental liabilities. In Brazil, several civil and criminal lawsuits have already been filed against producers due to environmental damages caused directly by third parties that were retained to perform waste treatment services off-site. In most of these cases, in the civil sphere, joint and several liabilities between the producer and the third party are being claimed.

Transportation of wastes also requires approval by environmental agencies. The main regulations on this matter are Federal Decree 96.044/1988 and Resolution 420/2004 of the National Land Transport Agency, which establish technical safety requirements.

The Federal Law nº 12.305 of August 2, 2010, established the National Policy on Solid Waste, which sets out several principles that are guiding the implementation of its provisions. For the purposes of this policy, the law defines a priority order of waste management, aiming to reduce the impacts of waste on the environment:

- No generation,
- Reduction,
- Reuse,
- Recycling,
- Waste treatment and disposal of environmentally sound waste.

This means that only those wastes for which there is no means of recycling may receive environmentally appropriate disposal.

The policy was regulated by Federal Decree nº 7.404 published on 23 December 2010, which established rules for the implementation of the principles described therein. The policy aims to establish control systems for waste generated, including:

i. solid waste plans,
ii. inventories and the system declaratory annual solid waste,
iii. the selective collection, the reverse logistic systems and other tools related to implementing the shared responsibility for the lifecycle of products,
iv. The National System of Information on Solid Waste Management (SINIR), and
v. The National Registry of Operators of Dangerous Waste.

6.5.3 CONAMA Resolution No. 316 of 2002 – Thermal Treatment of Waste

The CONAMA Resolution No. 316 of 2002 describes the procedures for operation of industries that perform thermal treatments of waste. It establishes the form of operation, the emission limits, performance criteria, control, treatment and final disposal of effluents aiming always to minimize impact to the environment and public health. The procedures described in this resolution are applicable to the operation of thermal treatment at, or above eight hundred degrees Celsius.
This resolution also mandates, prior to installation, an analytical study of alternative technologies that demonstrates that the proposed plant is in accordance with the concept of the best available technology.

The rate of destruction and removal efficiency to achieve the thermal treatment of industrial waste should be greater than or equal to ninety-nine and nine tenths percent for the main dangerous organic compound (POP) defined in the burning test. In the case of polychlorinated biphenyls (PCBs) the rate of destruction efficiency must be the same or greater.

All thermal treatment facilities must maintain records of transportation, storage, identification, date, and the analysis of waste that form the load that will supply the system, preserving representative samples for six months for any evidence required by the competent environmental agency.

To obtain an operations permit for a waste thermal treatment facility, the following documents must be prepared and approved:

- Basic and Detailed Project description
- Environmental Impact Study (EIA – RIMA)
- Risk analysis
- Burning Test Plan
- Emergency Plan

The operating permit issued by the competent environmental agency will be valid for five years.

Table 6.5-2 lists the maximum emission limits of air pollutants which should not be exceeded in accordance with the provisions of this resolution.

Table 6.5-2 Brazil CONAMA 316/2002 - Emission Standard

Component	Standard
NO_x	560 mg/Nm^3
SO_2	280 mg/Nm^3
CO	100 ppm
HCl[1]	80 mg/Nm^3
HF[2]	5 mg/Nm^3
Dioxins/Furans[3]	0.5 ng/Nm3 (TEQ)
PM_{10}	70 mg/Nm3
Class 1 Substances (Cd, Hg, Tl and their compounds)	0.280 mg/Nm^3 (Total Metals Class 1)
Class 2 Substances (As, Co, Ni, Te, Se and their compounds)	1.4 mg/Nm^3 (Total Metals Class 2)
Class 3 Substances (Sb, Pb, Cr, CN, Cu. Sn, F, Mn, Pt, Pd, Rh, V and their compounds)	7.0 mg/Nm^3 (Total Metals Class 3)

1. Total inorganic chlorinated compounds expressed as HCl
2. Total inorganic fluorinated compounds expressed as HF
3. Expressed in TEQ (toxic equivalent quantity) of 2, 3, 7, 8 TCDD (tetrachloro-dibenzo-para-dioxin)

The measured parameters should be corrected by the oxygen content in the mixture of combustion gases from the discharge point to seven percent on a dry basis. It is important to remember that the competent environmental agency may restrict the limits set forth herein depending on the location and patterns of air quality in the region.

6.6 Regulation of Energy Sales

It is important to review local regulation of the power sector relevant to a Waste to Energy (WTE) facility. The following items highlight incentives and some specific charges for a WTE generation unit in Brazil. The main incentive is the wire fee exemption, which will have a great impact especially for those consumers supplied in lower voltages, whose wire fees can represent up to R$100/MWh.

6.6.1 Incentives in Wire Rate for Municipal Solid Waste

The wire rate is the tax paid for the use of the distribution system (TUSD) and for the use of the Transmission system (TUST). Resolution 271 of ANEEL (National Agency of Electrical Energy – Appendix 6-A1) assures the right to a 100% reduction, focusing on the production and consumption of energy marketed by enterprises whose capacity is less than or equal to 30 MW, and use at least 50% biomass as energy input.

Biomass in this context includes

- Urban solid waste
- Sanitary landfill
- Digesters of vegetal or animal waste
- Sewage sludge treatment plants

6.6.2 Incentives for On-Site and Remotely Connected Units

There are specific conditions for back-up supply to cover forced and planed outages of the Independent Power Producer (IPP) at on-site facilities that are directly connected to the network through an exclusive connection. The network capacity to be contracted is called capacity reserve and follows Resolution #304 (Appendix 6A-2) that changes provisions of ANEEL Resolution #371 of 1999. These resolutions establish that IPPs will have transmission fees determined by the usage rate and not fixed and based on capacity as are regular units.

For remotely connected facilities that take part in a generation consortium or are owned by the generator, meaning self-consumed power, there is an exemption of sector charges such as CDE (Development Account), CCC (Non connected systems fuel bills), PROINFA (Program for alternative fuels), ERR (Reserve Energy Bill) and ESS (System Security Bill).

6.6.3 Generation Charges

Concerning generation system costs, on top of transmission charges, there are others that should be addressed as listed below.

Research and Development: generators must apply 1% of the net operating revenue in R&D, according to Law #9991/2000, Law #11465/2007 and Law #12212/2010. Generators can be exempted from this payment if they generate exclusively from small hydroelectric systems, biomass, qualified co-generation, wind or solar units.

Independent Power Generators also pay for services of the national regulator and inspection agency (ANEEL). The fee is the TFSEE, and is calculated annually by orders of ANEEL. An example follows in Appendix 6A-3 (Order #4080, of December 27, 2010).

Another fee that IPP's are required to pay is the fee to support the national operator for power dispatch, the ONS rate. The value is defined annually by ONS and approved by ANEEL according to Law #9648/1998 and Decree #2335.

6.6.4 Special Program of Incentives for the Development of Infrastructure (REIDI)

Power Plants can qualify for this special program and get a reduction in federal tax, denominated PIS/COFINS. Ordinance #319, of September 26, 2008 (Appendix 6A-4) establishes the approval procedure for projects of generation, transmission and distribution of electrical energy.

The Special Incentive Scheme for the Development of Infrastructure (REIDI), set by Law #11488, of June 15th, 2007, and regulated by Decree #6144, of July 3rd, 2007 provides additional procedures. The entity that is eligible for the exemption is the one that owns the assets or participates in the generation consortium. The formulas for calculating the reduction on PIS/COFINS are presented in the ordinance for each case.

6.7 Specific Regulations for Generation from Municipal Waste

The Solid Waste National Policy is regulated by the provisions of Decree #7404/10. The decree resulted in the creation of the Inter-Ministry Committee of the Solid Waste National Policy, which supports the structuring and implementation of the policy through governmental institutions and entities. The Committee aims to elaborate on the Solid Waste National Plan which includes goals for solid waste reduction, reuse, recycling, energy recovery, and phasing out of landfills. Simultaneously, the Solid Waste National Plan is to be implemented in states, municipalities and municipal consortiums.

Features of the legislation include:

- The law covers individuals and public or private entities, who either generate solid waste or who develop actions related to integrated solid waste management.

- According to the law, the following solid waste management order of priority must be observed:

    1. no generation
    2. reduced generation
    3. reuse
    4. recycling
    5. solid waste treatment, and
    6. final disposition of environmentally sound waste.

- Technologies aiming at energy recovery of urban solid waste may be used, as long as their technical and environmental feasibility have been proven, and the implementation of a program for monitoring the emission of toxic gases is approved by the environmental agency.

- In the decree, the energy recovery from solid wastes directly, including co-processing shall follow the rules established by competent agencies.

- According to the decree, the energy recovery of the urban solid wastes, referred to in § 1 of article 9 of Law #12305, 2010 (qualified according to Article 13, Item I, paragraph "c", of that Law) must be disciplined in a specific manner, in a joint act of the Ministries of Environment, Mining, Energy and of the Cities

6.8 Program to Encourage Alternative Resources of Electrical Energy (PROINFA)

The Program was instituted by Law #10438 in 2002 with the goal of increasing the participation by enterprises producing electricity based on wind resources, small hydroelectric systems (SHP) and biomass in the Brazilian interconnected system.

The Program predicted the implementation of 144 plants with a total of 3299MW of installed capacity (1191MW from 63 SHPs, 1423 MW from wind plants and 685MW from 27 plants based on biomass). All this power has a 20-year guarantee by Centrais Elétricas Brasileiras S.A. (Eletrobrás).

6.8.1 Main Goals

- Diversification of the national power matrix, by installing 3300 MW of generation capacity from renewable resources, equally distributed by type of resource (wind, biomass and SHP);

- Within 20 years, 10 percent of the consumption of electrical energy in the country generated from resources of wind, SHP and biomass.

- Hiring of power from ELETROBRÁS, for 20 years.

- Guarantee a minimum of 70 percent of the contractual revenue during the duration of the enterprise financing contract, to be restored every time there is a positive balance or after its termination.

- Liquidation in the short-term market of the difference between the contracted power and the produced power reflected on the gravity center of the system.

6.8.2 Program of Financial Support to Investments in Alternative Sources of Electrical Energy within PROINFA

BNDES provides support to investments in generation projects using alternative resources within PROINFA, in accordance with Law #10438/02 modified by Law #10762/03.

6.8.2.1 Recipients

Recipients must be generating electrical energy and have signed the Contract of Purchase and Sale of Power (*Contrato de Compra e Venda de Energia – CCVE*) with Eletrobrás under PROINFA (Law #10438/02 of April 26th, 2002 and Law #10762/03, of November 11th, 2003).

In case of SHP and of wind energy, the companies applying to financial support from BNDES must be Societies of Specific Purpose (*Sociedades de Propósito Específico – SPEs*) and constituted in the form of Anonymous Societies.

6.8.2.2 Contemplated Technologies

Plants with installed power greater than 1 MW and up to 30 MW that meet the requisites of the specific regulations of the National Agency of Electrical Energy (ANEEL) are contemplated for financial support.

7 Task 7 – Financial Market Options Review

7.1 Preface

Task 7 aims is to assist MPX arrange suitable finance for the project by obtaining expressions of interest from potential donors and lenders, and to outline any terms and conditions of the potential lenders.

A survey of lending organizations was conducted, targeting the major US, Brazilian and international sources of finance for sanitary solid waste and renewable energy projects. A Request for expressions of interest was provided to each of the organizations, in addition to phone interviews and meetings. The responses from lending organizations are documented, resulting in a summary of finance options.

7.2 Survey of Lending Institutions

This survey provides a current assessment of the lending institutions that encourage the development of power generation facilities and have demonstrated to have the ability to fund the required resources of such facilities. Lending institutions were selected upon past commitments to objectives that support projects such as waste to energy and carbon credit financing.

Additional information on the lending organizations and their past projects are found in the references listed in Section 7.5.

7.2.1 Multilateral Development Banks

Multilateral Development Banks (MDBs) are international institutions that provide financial assistance, typically in the form of loans and grants, to developing countries in order to promote economic and social development. The term MDB typically refers to the World Bank and other smaller regional development banks including the Inter-American Development Bank (IDB).

Project loans include large infrastructure projects, such as highways, power plants, port facilities, and dams, as well as social projects, including health and education initiatives.

The International Monetary Fund (IMF), whose mandate is to ensure international financial stability, is not an MDB.

7.2.1.1 IFC/World Bank Group

The World Bank Group is composed of five separate institutions:

- International Bank for Reconstruction and Development (IBRD)
- International Development Association (IDA)
- International Finance Corporation (IFC)
- Multilateral Investment Guarantee Agency (MIGA)
- International Centre for Settlement of Investment Disputes

Each agency is owned and operated as a cooperative by its respective member countries, which in most cases overlap.

Together, the IBRD and the IDA are commonly referred to as the World Bank. As of 2012, the Bank's five largest shareholders out of its 187 members were France, Germany, Japan, the UK, and the United States. The role of the World Bank is to alleviate poverty in developing countries with financial support to sustainable projects that yield cost-effective innovations.

The IFC's specific role among the other members of the World Bank Group is to promote private sector developments. Their target clients are private companies in World Bank member countries. The IFC business model includes financing solid waste projects, from the generation of waste, collection and transport, separation and processing (composting/recycling), waste disposal and energy recovery.

Table 7.2-1 indicates several global solid waste projects financed by the IFC.

Table 7.2-1:Solid Waste IFC Financed Projects

Project Country	Project Description	IFC Investment	Year
Infrastructure			
Thailand/Indonesia	Waste collection/transport/ recycle/treat/dispose	US$15 mm (corporate finance)	2004
India	MSW, hazardous industrial, bio-medical waste treatment	US$15 mm (corporate finance)	2005
Mexico	Plastic recycling	US$24.5mm (project finance)	2007
Brazil*	Sanitary landfills/waste treatment	Approx. US$24.5mm (corporate finance)	2009
Advisory/Financial Markets			

Project Country	Project Description	IFC Investment	Year
Vietnam	Recycle car batteries - Establish Regs and run recycle pilot program	Advisory Services	2010
Maldives	Waste collection/transport/ recycle/treat/dispose	Conduct PPP Process 20 yr BOT	2011

Source: Ref [56]

*This loan was made to Estre Ambiental, a leading privately-owned solid waste management company in Brazil. The project will allow Estre to expand waste operations, thus reducing greenhouse gas emissions and potential impacts from current waste disposal practices.

7.2.1.2 Inter-American Development Bank (IDB)

The Inter-American Development Bank has headquarters in Washington, DC and country offices in 26 borrowing countries with regional offices in Asia and Europe to accommodate non–borrowing countries. Since 1959, the IDB has approved $207 billion for projects, mobilizing more than $438 billion in investments according the bank's website. The IDB lends to central governments, provinces, municipalities, private firms and non-governmental organizations.

IDB has a proven history[57] in supporting Brazilian governments through funding integrated solid waste management plans for urban waste, with a focus on efforts to reduce the garbage dumpsites in municipalities.

In addition, the IDB has a record of funding energy projects, notably the construction of a coal-fired thermal power plant in 2011. The Pecem Plant was designed for MPX Energia S.A. in the State of Ceara, northeast Brazil. The project was part of the Programa de Aceleracao do Crescimento, a federal government program intended to increase the country's growth through investments in infrastructure and tax incentives.

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[56] 15th Annual LMOP Conference and Project Expo - Jim Michelsen, Carbon Business Group, IFC Baltimore, MD – January 18, 2012

[57] http://www.iadb.org/en/projects

7.2.1.3 MIGA (World Bank –Multilateral Investment Guarantee Agency)

MIGA is a member of the World Bank Group. Their mission is to promote foreign direct investment into developing countries to help support economic growth, reduce poverty, and improve people's lives.

MIGA's operational strategy is to attract investors and private insurers into difficult operating environments. They tend to focus on insuring investments in areas where the greatest difference is possible, such as:

- Countries eligible for assistance from the International Development Association (the world's poorest countries)
- Conflict-affected environments
- Complex deals in infrastructure and extractive industries, especially those involving project finance and environmental and social considerations
- South-South investments (from one developing country to another)

MIGA offers a number of products and aims to restore and shape the business community's confidence by collaboration with the public and private insurance markets. These efforts work to increase the amount of insurance available to investors.

As a multilateral development agency, MIGA supports investments that are developmentally sound and meet high social and environmental standards. MIGA applies a comprehensive set of social and environmental performance standards to all projects and offers extensive expertise in working with investors to ensure compliance to these standards.

Projects similar to the Rio waste to energy facility have been funded in part by MIGA[58]. These include the Beijing Gao Antun Waste to Energy Co. Ltd project in 2007 which involved expansion of a1600 mtpd waste to energy plant in Beijing. MIGA issued guarantees totaling $24.96 million to Golden State Waste Management Corporation for its equity investment and shareholder loan to the Beijing Gaoantun Waste to Energy Co. Ltd. The coverage, for a period of up to 20 years, is against the risk of expropriation

[58] http://www.miga.org/projects/index.cfm?pid=720

7.2.2 US Government Agencies

7.2.2.1 EX-IM (US Export- Import Bank)

EX-IM is an independent agency of the U.S. government established in 1934 to finance the export sales of U.S. made goods and services. They provide loan guarantees, export credit insurance, working capital guarantees, and direct loans. The Export-Import Bank of the United States (Ex-Im Bank) is the official export credit agency of the United States. Ex-Im Bank's mission is to assist in financing the export of U.S. goods and services to international markets.

Ex-Im Bank seeks to enable U.S. companies, large and small to turn export opportunities into real sales that help to maintain and create U.S. jobs and contribute to a stronger national economy. Ex-Im Bank does not compete with private sector lenders but provides export financing products that fill gaps in trade financing. Ex-Im Bank assumes credit and country risks that the private sector is unable or unwilling to accept. They aim to help to level the playing field for U.S. exporters by matching the financing that other governments provide to their exporters.

Ex-Im Bank provides working capital guarantees (pre-export financing); export credit insurance; and loan guarantees and direct loans (buyer financing). They maintain transactions with a variety of scope, carrying large and small projects. Ex-Im Bank has supported more than $456 billion of U.S. exports, primarily to developing markets worldwide. Due to its charter Ex-Im Bank loan conditions include limits on foreign (non US) content; however, foreign manufactured goods ordered as part of a US supplier contract may be financed, depending on eligibility rules.

In May, 2012 it was reported that Ex-Im Bank provided $48.6 million in financing for US green technology exports to Brazil[59]. The exporter is FirmGreen, a US firm based in Newport Beach, California supplying Gas Verde S.A. with equipment and services for the development of Novo Gramacho biogas in Brazil. The plant will convert landfill gas into usable methane gas supplied to a nearby Petrobras refinery.

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[59] http://www.waste-management-world.com/index/display/article-display/6542206728/articles/waste-management-world/landfill/2012/05/U_S__Loan_for_Huge_Brazilian_Landfill_Gas_Project_Pays_Dividends.html

7.2.2.2 Overseas Private Investment Corporation (OPIC)

OPIC is the U.S. Government's development finance institution. It mobilizes private capital to help solve critical world challenges and in doing so, advances U.S. foreign policy. OPIC works with the U.S. private sector and helps U.S. businesses gain footholds in emerging markets, supporting revenues, jobs and growth opportunities both at home and abroad. OPIC achieves its mission by providing investors with financing, guarantees, political risk insurance, and support for private equity investment funds.

Established as an agency of the U.S. Government in 1971, OPIC operates on a self-sustaining basis at no net cost to American taxpayers. OPIC services are available for new and expanding business enterprises in more than 150 countries worldwide. To date, OPIC projects have generated $74 billion in U.S. exports and supported more than 275,000 American jobs.

Recently, OPIC's board of directors has approved $125 million in financing for Alternative and Renewable Technologies Partners (TPG ART)[60]. TPG will invest in companies that have the best renewable technologies from the United States for markets in Latin America and Southeast Asia. One of OPIC investment goals is to fund design projects that can convert biomass to high-value products as reported in a press release June 19, 2012.

7.2.3 The Brazilian Economic and Social Development Bank (BNDES)

The Brazilian Economic and Social Development Bank (BNDES) is backed by the federal government and was formed in 1982 as a result of growing social concerns and a new financial policy. The bank encouraged Brazilian companies to compete with imported products in its domestic market and increase national exports. Moving forward, BNDES today has established a sustained commitment to promoting and generating local and regional developments, highlighting social and environmental improvements, innovation, and removal of inequalities. The BNDES is the largest source of credit for companies in Brazil and can offer below-market interest rates for its loans due to risk-free funding from the Brazilian Treasury through access to the

[60] http://www.opic.gov/node/411

TJLP[61]. On June 18, 2012 the Brazilian Finance Minister announced the TJLP would be reduced from 6.0% to 5.5%.

BNDES is the financial agent for reimbursing resources for the National Climate Change Fund, one of the instruments of the National Climate Change Policy (PNMC). In 2011, operational rules were established together with the Ministry of Environment that led to the creation of the Climate Fund Program. Renewable energy and solid waste processing with energy reuse topped the list of primary objectives of the Climate Fund Program.

Of particular interest, BNDES has approved R$ 33.9 million in financing for investments in environmental sanitation, to be performed by Estre Ambiental, a Brazilian company that operates in the solid waste management sector, specializing in the treatment of degraded areas[62]. The project will include the implementation of a waste processing plant with an annual production capacity for 450 tons of refuse-derived fuel (RDF). This new project aims to transform urban garbage into energy using RDF, a fuel in the form of flakes that can be used to stoke industrial boilers and furnaces.

Due to its mission, BNDES has limitations on the foreign content of projects under its funding. Should the Rio WTE project proceed based on US or European combustion grate technology, it is possible that partial funding may be required from commercial or foreign investment sources.

[61] http://en.mercopress.com/2012/06/28/mantega-insists-brazil-economy-picks-up-in-second-half-and-reaches-2.5-annual-growth

[62] http://www.projectfinancemagazine.com/Article/2740159/Estre-Ambiental-receives-waste-to-energy-BNDES-loan.html

7.2.4 **Regional** Development Banks

CAF (Development Bank of Latin America)

CAF is a Multilateral Development Bank currently owned by 18 countries in Latin America, the Caribbean and Europe as well as 14 private banks from the Andean region. CAF's objective is to support sustainable development and regional integration within Latin America in order to make its economies more diversified, competitive and responsive to social needs.

CAF is the main source of multilateral financing for infrastructure in Latin America. It has been operating for more than 40 years in the region and has financed projects that contribute to build an integrated and economically viable region. The institution supports projects in areas such as energy, transport, water and sanitation, telecommunication and information technology, private sector development and environment.

In March 2012, the German development bank (kfW) announced it has granted CAF a $US 195M line of credit for projects contributing to climate change mitigation[63]. Eligible projects include those related to renewable energy generation, such as waste to energy.

7.2.5 **Commercial** Banks

7.2.5.1 ING

The ING Group is a global financial institution offering retail banking, direct banking, commercial banking, investment banking, asset management, and insurance services. ING is an abbreviation for Internationale Nederlanden Groep (English: International Netherlands Group).

ING started its banking operation in Brazil in 1983 and provides a comprehensive range of financial services for corporate and institutional clients. Services offered include financial markets, investment banking and structured finance.

Globally ING offers structured finance services, including a division specializing in carbon credit eligible projects under the United Nations clean development

[63] http://www.caf.com/view/index.asp?ms=19&pageMs=69892&new_id=80208

mechanism[64]. Projects funded so far include hydro power, wind farms, waste heat utilization and energy efficiency.

7.2.5.2 CAIXA

CAIXA or CEF, is one of the largest banks in Brazil by assets, and is the largest government-owned financial institution in Latin America. Caixa has more than 32 million accounts, with liabilities worth more than R$ 148 billion in savings or investment. Together with government pension funds and other governmental resources, Caixa controls more than R$ 386 billion, and is seen as a tool for public investment and expansion of access to financial services to the Brazilian public.

The Bank promotes the improvement of public health and quality of life, through integrated projects of urban and rural sanitation by means of ventures financed to the public and private sector. Caixa has financed several environmental projects including:

- Water Supply
- Sanitary Sewage
- Institutional Development
- Integrated Sanitation
- Management of Pluvial Waters
- Preservation and restoration of watersheds
- Management of Solid Waste and Construction and demolition waste – RCD
- Studies and Projects.

More specifically, Caxia has been involved in developing new solid waste management projects[65]. Caxia helps fund projects that are set up to fulfill legislation within the Brazilian Solid Waste Policy created in 2010. Together with the World Bank Caxia creates loans for an Integrated Solid Waste Management and Carbon Finance

[64] http://www.ingcommercialbanking.com/eCache/ENG/1/479

[65] Presentation “Programa Saneamento Para Todos” at the 3rd Forum for Residual Solids by Rogerio Tavares of Caixa, Brazil

Program. The programs have provided funds for the construction of sanitary landfills and beneficial use of landfill gas.

7.3 Responses from Lending Institutions

The various institutions outlined above were sent a request for expressions of interest, outlining the basis of the feasibility study and a technical and economic summary of the facility, based on previous tasks. The details provided are shown in Appendix 7A. The following sections summarize the discussions and responses from each of the finance institutions contacted for this report.

7.3.1 World Bank/IFC

The Rio WTE project was discussed with IFC's investment unit in Brazil which covers the solid waste industry. Typically IFC's advisory unit would be hired by the government to structure the project, set up a Public/Private Partnership (PPP) and prepare the bid documents. Successful bidders, typically a consortium of engineering, construction and finance entities are then able to negotiate financing with IFC's investment unit. IFC does not participate in open bids for project finance.

The IFC is active in this sector and would be interested in participating in the Rio WTE project. However at this preliminary stage they have declined to provide any indicative terms.

7.3.2 Inter-American Development Bank (IDB)

MPX is well known to the IDB through their activities in Brazil. The Rio WTE project was discussed with senior staff from the Washington DC office.
Typically for a private developer, they would offer a non-sovereign guarantee product providing up to 25% of the project cost and partner with a commercial bank from the host country for remainder of the money. IDB may also partner with a technology vendor, which may be appropriate for the Rio WTE project.

The investment strategy would include minimizing technical and environmental risks so they would not generally be interested in novel or unproven waste treatment or waste conversion technologies.

The IDB have been in contact with MPX and since this project is in feasibility stage, the bank declined to offer a letter of interest or indicative terms. IDB would be open to further discussions when the project moves closer to implementation.

7.3.3 MIGA (World Bank –Multilateral Investment Guarantee Agency)

MIGA's office in Washington DC was contacted for this report. They would typically provide insurance for investors in the project from outside of the host country, based on an annual premium for up to 20 years. They take several risk factors into account including power purchase agreement, source of tipping fees and whether these are backed by the federal or municipal government.

MIGA is not a source of direct finance for projects of this nature, however may become relevant should the project require investment from the US.

7.3.4 US Export- Import Bank (EX-IM)

Ex-Im's Director for Renewable Energy & Environmental Exports was contacted for this report and provided several facts sheets on their program. Ex-Im Bank finances only U.S.-made goods and services, and looks for a reasonable assurance of repayment for any export financing it provides. The repayment term on a waste-to-energy project is likely 12 years maximum and the current direct loan interest rate for a 12-year loan is 2.08%.

Ex-Im Bank is not a source of direct finance for projects of this nature. They may be helpful if the technology is being provided from a US manufacturer or contractor.

7.3.5 Overseas Private Investment Corporation (OPIC)

OPIC's Office in Washington DC was contacted for this report. At this preliminary stage, they are not able to issue a letter of interest for the project; however, they provided information on financing terms and conditions.

To be eligible for OPIC financing at least 25% of the equity ownership of the project must come from a US citizen or US-owned company. OPIC can provide debt for up to 75% of the total project cost, up to $250 million per project. OPIC rates are based on long-term US Treasury rates plus an OPIC spread, and loan tenors can be up to 20 years.

OPIC financing may to be suitable for this project, but only if a US company emerges as the preferred WTE technology provider and becomes an equity partner.

7.3.6 Brazil National Development Bank (BNDES)

BNDES representatives in Rio have been discussing this project and joined on a phone conference with ARCADIS/Malcolm Pirnie and MPX. They expressed strong interest in the project and outlined the main conditions applied to the project as follows:

1) BNDES financing is available to companies, individual entrepreneurs, associations, foundations and corporations with headquarters and administration in Brazil.

2) Waste management projects, including WTE, are classified fall under BNDES "Environmental Sanitation and Water Resources" financing line and are subject to the following main conditions (for operations directly held with BNDES, with no intermediate financial institution):

    e) Interest rate: TJLP (currently at 5.5%) + BNDES Basic Spread (0.9%) + BNDES Risk Spread (maximum of 3.57% depending on the company's credit rating at BNDES)
    f) BNDES financing: maximum of 90% of the entitled investments

    g) Duration: approximately 10 years, but may vary depending on the project analysis.

3) BNDES financing may cover investments in new machinery and equipment, (including industrial systems) accredited by BNDES with a minimum domestic content of 60% in value and weight.

7.3.7 CAF (Development Bank of Latin America)

CAF have expressed some interest in the Rio WTE project. Discussions are ongoing. At this stage, possible loan terms and conditions are not known.

7.3.8 ING Brazil

ARCADIS/Malcolm Pirnie has discussed the project with ING's Commercial Banking / Project Finance Division in Sao Paulo. They expect this project would likely be financed by BNDES because of its access to TJLP funding, while commercial banks may be involved by assuming credit risk either for a pre-specified period or for the entire duration of the loan. They added that financing using funds from commercial banks would not allow very long tenors in BRL and financing in USD is not advisable unless there is a dollar component in the cash flow, which doesn't seem likely in this case.

Loan tenors would likely be limited by the Power Purchase Agreement (PPA) minus a few years. ING would be interested in analyzing the project financing at the appropriate time.

7.3.9 CAIXA

Caixa has expressed some interest in the Rio WTE project. They provided a detailed presentation in Portuguese outlining their carbon finance business model that combines the CERs as an ancillary finance guarantee. It is understood this model has been applied to the landfill gas and biogas sectors in Brazil.

At this stage, possible loan terms and conditions for the Rio WTE project are not known.

7.4 Summary

Based on the responses above and discussions with MPX, it appears likely that direct project funding would be from BNDES. The reason is BNDES' historical role in providing long term finance for infrastructure and social projects in Brazil and its access to the lower TJLP interest rates, not available to private banks.

Commercial banks active in Brazil may also be interested, primarily as a partner to BNDES. Notably, Caixa has an agreement with World Bank's Carbon Finance Unit (CFU) for commercialization of Certified Emission Reductions (CERs) generated from projects.

For the procurement strategy outlined in Task 3, it appears that BNDES would be the most competitive option. As noted above, BNDES' mission limits them to financing projects with at least 60% local content. Based on the construction cost estimate presented in Task 3, approximately $US120 M of imported equipment would be purchased, representing 38% of the project's total direct cost. On this basis the project appears to meet the local content rules for BNDES funding.

Note that an approximation of the BNDES lending rate (9.5%) was used in the economic analysis presented Task 4, were a large negative NPV for the project was calculated, namely ($US 250M). Unfortunately, the findings of this report support the economic analysis of Task 4, as this appears to be the lowest cost of capital available for this project.

For other procurement strategies that exceed BNDES' foreign content rules or include a foreign equity partner, other options should be considered. Multilateral Development Banks (IFC and IDB) are available to provide direct project funding or structured finance. In the case of IDB the funding would be provided in conjunction with a Brazilian commercial bank. Several US government agencies (OPIC, EX-IM Bank), and World Bank's MIGA may offer financial services to the project if a US entity is taking an equity position or supplying equipment for the facility.

7.5 References

7.5.1 References:

1. 15th Annual LMOP Conference and Project Expo Jim Michelsen, Carbon Business Group, IFC Baltimore, MD – January 18, 2012

2. IDB website:
http://www.iadb.org/en/projects

3. MIGA website:
http://www.miga.org/projects/index.cfm?pid=720

4. Waste Management World Magazine:
http://www.waste-management-world.com/index/display/article-display/6542206728/articles/waste-management-world/landfill/2012/05/U_S__Loan_for_Huge_Brazilian_Landfill_Gas_Project_Pays_Dividends.html

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9. ING website:
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10. Presentation “Programa Saneamento Para Todos” at the 3rd Forum for Residual Solids by Rogerio Tavares of Caixa, Brazil

7.5.2 Further Reading:

1. Nelson, R. (2012) Multilateral Development Banks: *Overview and Issues for Congress, Analyst in International Trade and Finance.* Congressional Research Service. 7-5700.
http://www.fas.org/sgp/crs/row/R41170.pdf

2. UNFCCC's CDM:
http://cdm.unfccc.int/index.html

3. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 5:
http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

4. World Bank’s Carbon Finance Unit:
www.carbonfinance.org

5. World Bank’s Urban Solid Waste Management:
http://go.worldbank.org/A5TFX56L50

Appendix 1-A
Global Context to Waste and Characteristics

Appendix 1-A:

Global Context - Waste Generation and Characteristics

Global Context - Waste Generation
The following paragraphs and charts are presented for informational purposes to provide a perspective of waste generation and waste characteristics in developing countries globally. The country Gross Domestic Product (GDP) is considered an important indicator of waste generation rate. Currently, the official GDP (2010 estimate) is 10,500 $US/capita/year, which places Brazil at the rank of 104 in the world, among the 229 countries for which there is reliable GDP data[1].

Average annual generation of all types of waste across planning areas in Rio ranges from 1.3 to 3.3 kg/capita/day, and averages about 1.6 kg/capita/day citywide

The chart below in Figure 1 was developed from dozens of detailed master plans done by the Japanese International Cooperation Agency (JICA) in developing countries. These charts were compiled within a global study conducted on holistic decision modeling of solid waste systems.[2] The chart shows the GDP at the time of the individual nation study and is not expressed in a consistent year's value. Comparing Brazil (1.6 kg/capita/day; $10,500 US GDP (2010)) to other nations supports the trend of higher waste generation with increasing GDP. The consistency is more evident with respect to data available for other nations in Latin and Central America.

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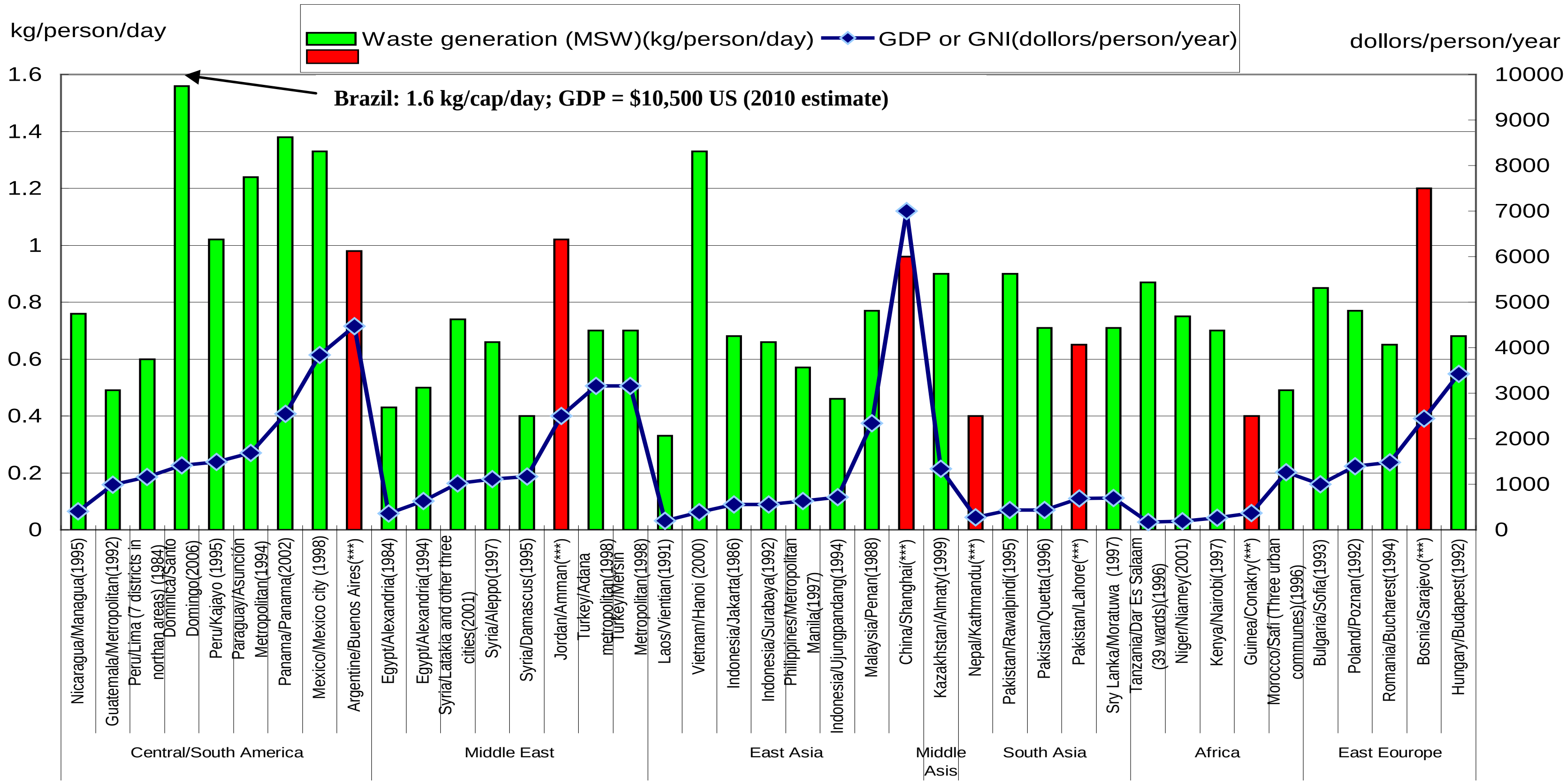
[1] CIA Factbook, https://www.cia.gov/library/publications/the-world-factbook/rankorder/2004rank.html?countryName=Brazil&countryCode=br&regionCode=sa&rank=104#br
[2] Cointreau, Project Manager; Nippon Koei and Research Triangle Institute, project consultants, Global study on holistic decision modeling of solid waste technologies, conducted from 2007-2009, for the World Bank and financed by Japanese trust funds. For the main report and appendices, see www.sandracointreau.com/civilengineering.htm

Figure 1 Waste Generation Rate and National GDP for Selected Cities



MPX Energia SA

Task 1 - Assessment of Municipal Solid Waste and Technology

APP 1-A

Global Context - Waste Characteristics

The effects of developing country waste collection practices on subsequent waste characteristics are many. Low income level leads to low levels of packaging material and low levels of paper and cardboard waste. Lack of waste containment during arid dry climates can result in waste that is too dry for biological conversion by anaerobic digestion. Uncontained waste during wet season can result in moisture levels that make the waste too wet for combustion. Lack of waste containment prior to collection and unpaved walkways and streets can lead to high levels of soil in the waste; and solid cooking and heating fuels can increase ash content. Soil and ash can significantly affect the cost of waste handling, equipment maintenance and energy production.
The World Bank report on holistic decision modeling noted above summarized the waste compositions found in dozens of JICA master plans. Figure 2 below shows compostable or biodegradable waste composition relative to income levels (i.e., GDP at the time of each study). In addition the report included combustibles (i.e., all organics) and recyclables (i.e., paper, plastic, metal, and textile). Waste composition in terms of combustibles is shown in Figure 2 below. Some components, such as food waste, are both compostable and combustible. Some components, such as metals, are recyclable only. Items that do not fall into these categories, such as miscellaneous inerts of glass and ceramic bits, stones, soil, rubble, etc., are not shown in the charts.

Based on Brazil's economic placement in Latin America it would appear likely that large Brazilian cities would have combustibles content between 70-90% of the total waste weight, and a biodegradable content between 40-60% of the total waste weight. The data provided by COMLURB for Rio de Janeiro shows this fits well within the global context. For comparison, the year-by-year results for combustibles and biodegradables (putrescible organics) from the COMLURB data are:

- 2005: biodegradables 54.6%, combustibles 91.6%.
- 2006: biodegradables 57.4%, combustibles 90.9%.
- 2007: biodegradables 54.6%, combustibles 89.9%.
- 2008: biodegradables 51.2%, combustibles 90.9%.

Figure 2. Waste Composition (kitchen waste and grass) with GDP of Selected Countries

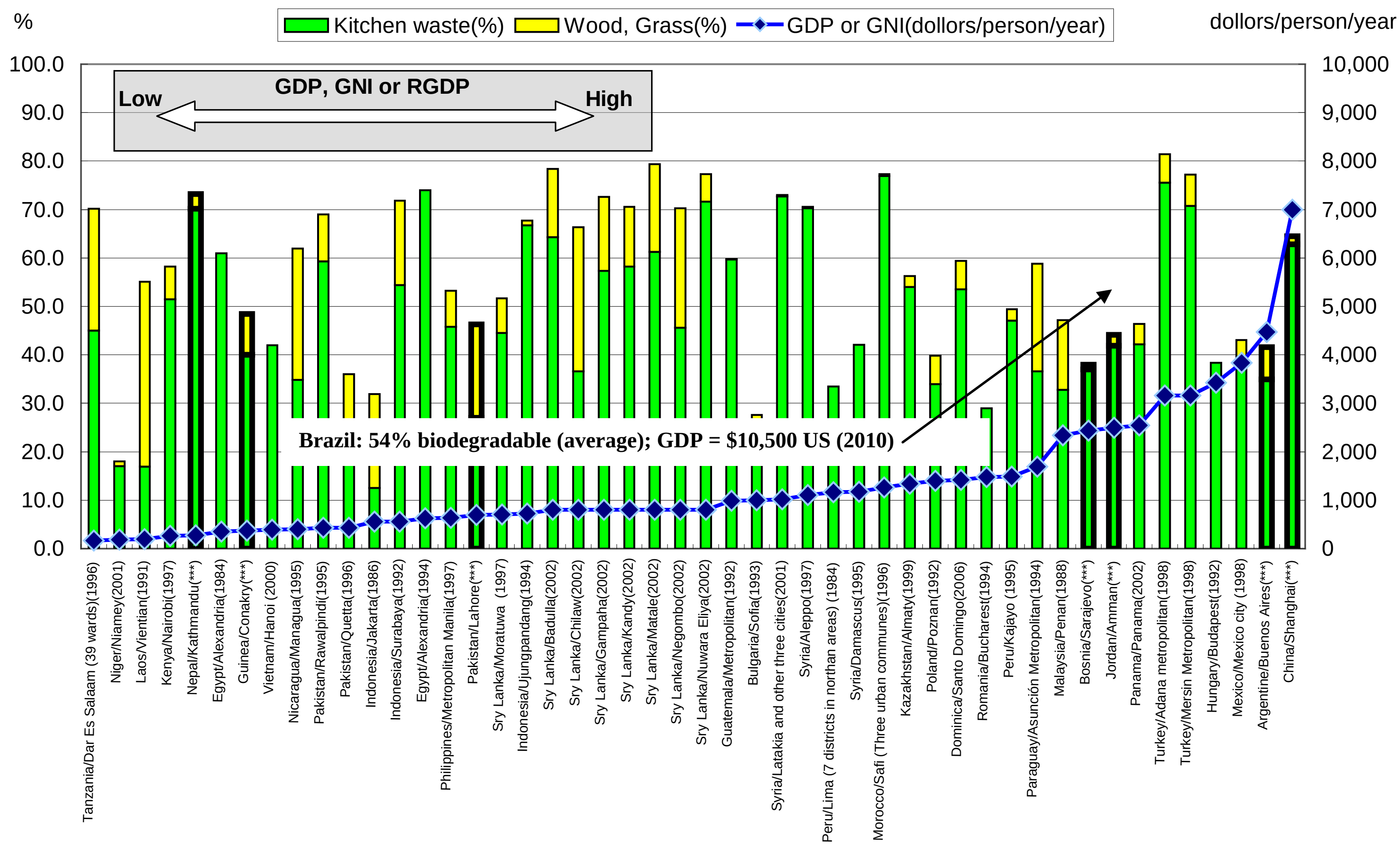
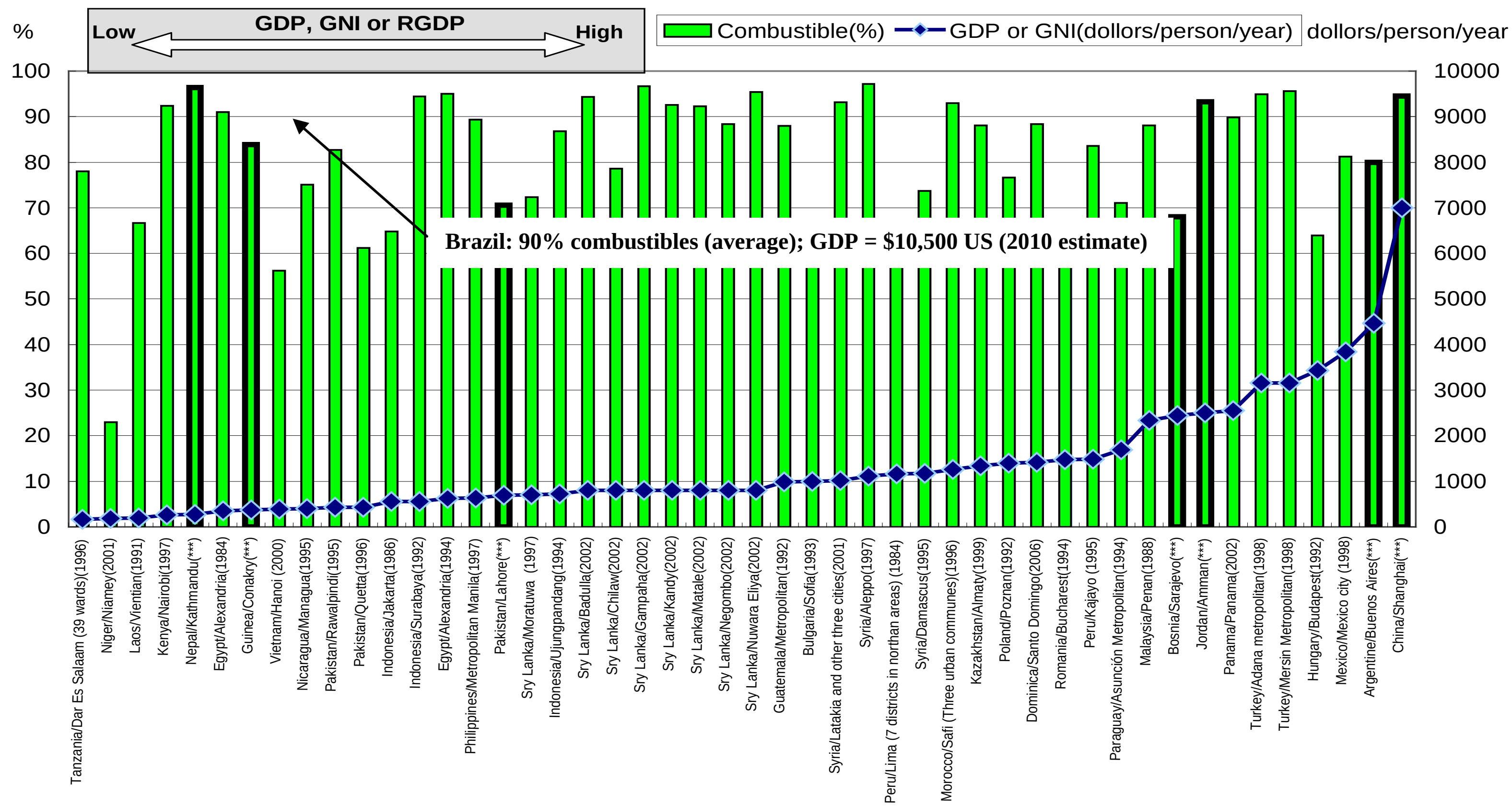
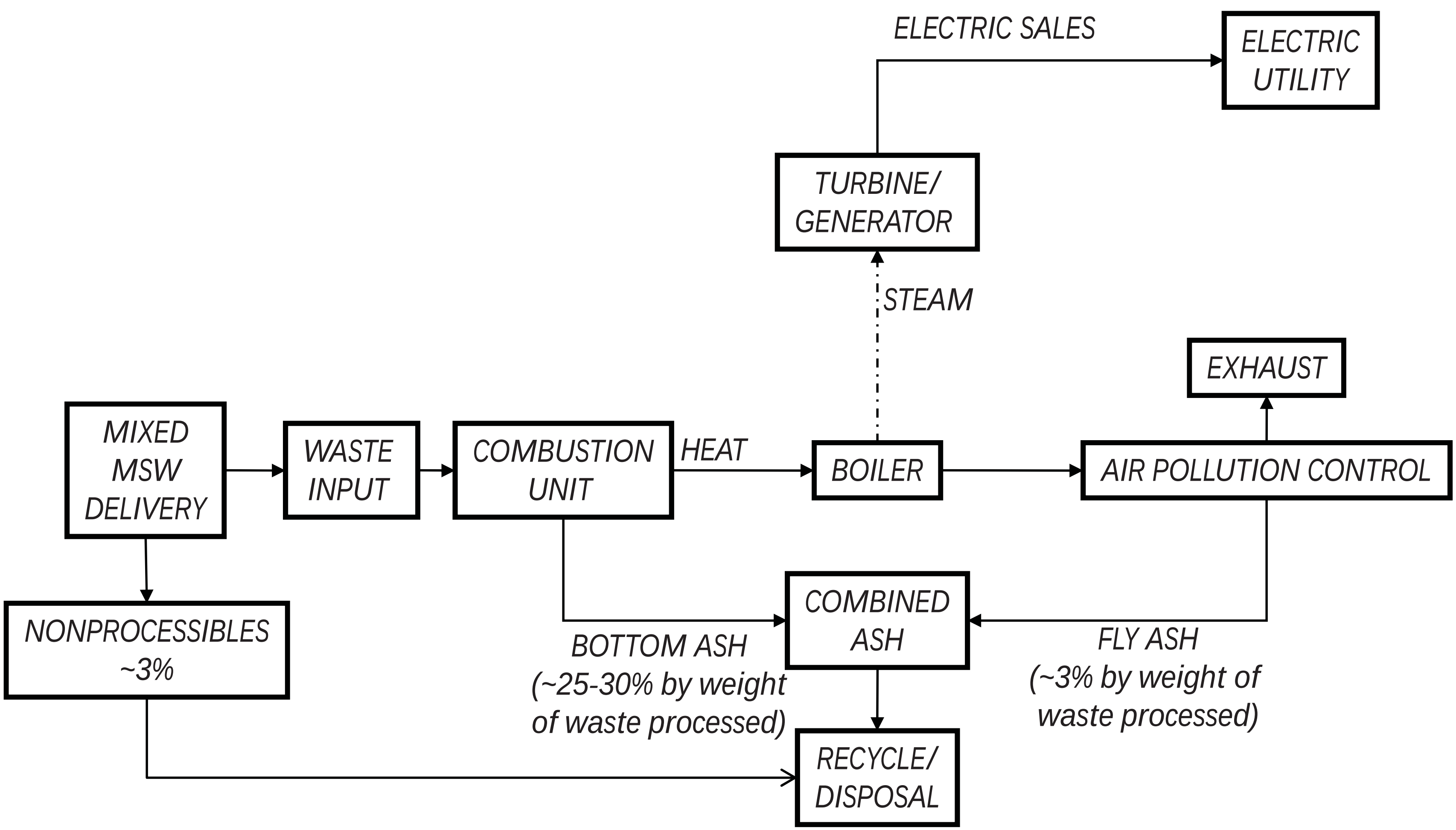


Figure 3. Waste Composition (combustibles) with GDP of Selected Countries

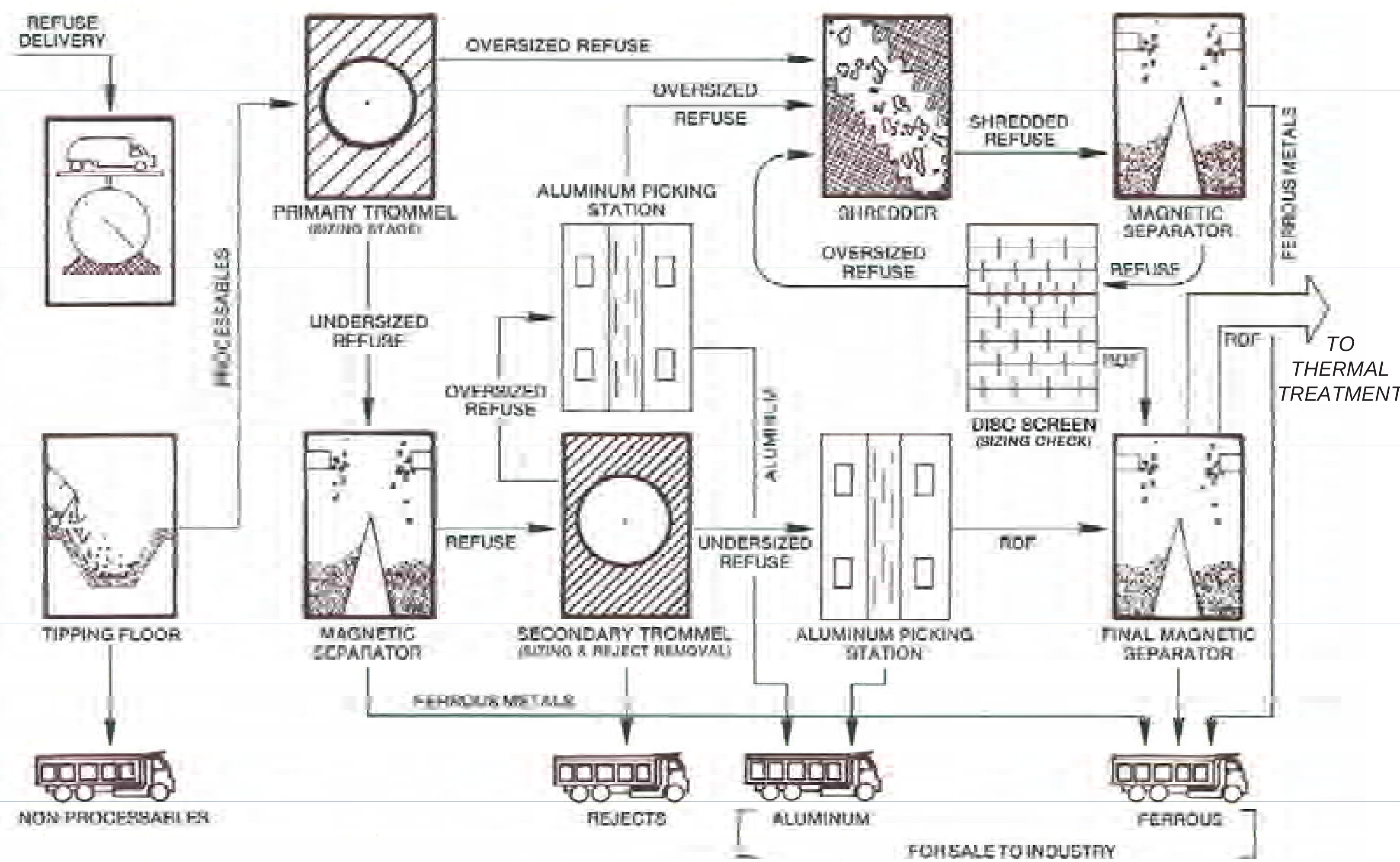


Appendix 1-B
Waste to Energy Process Schematics

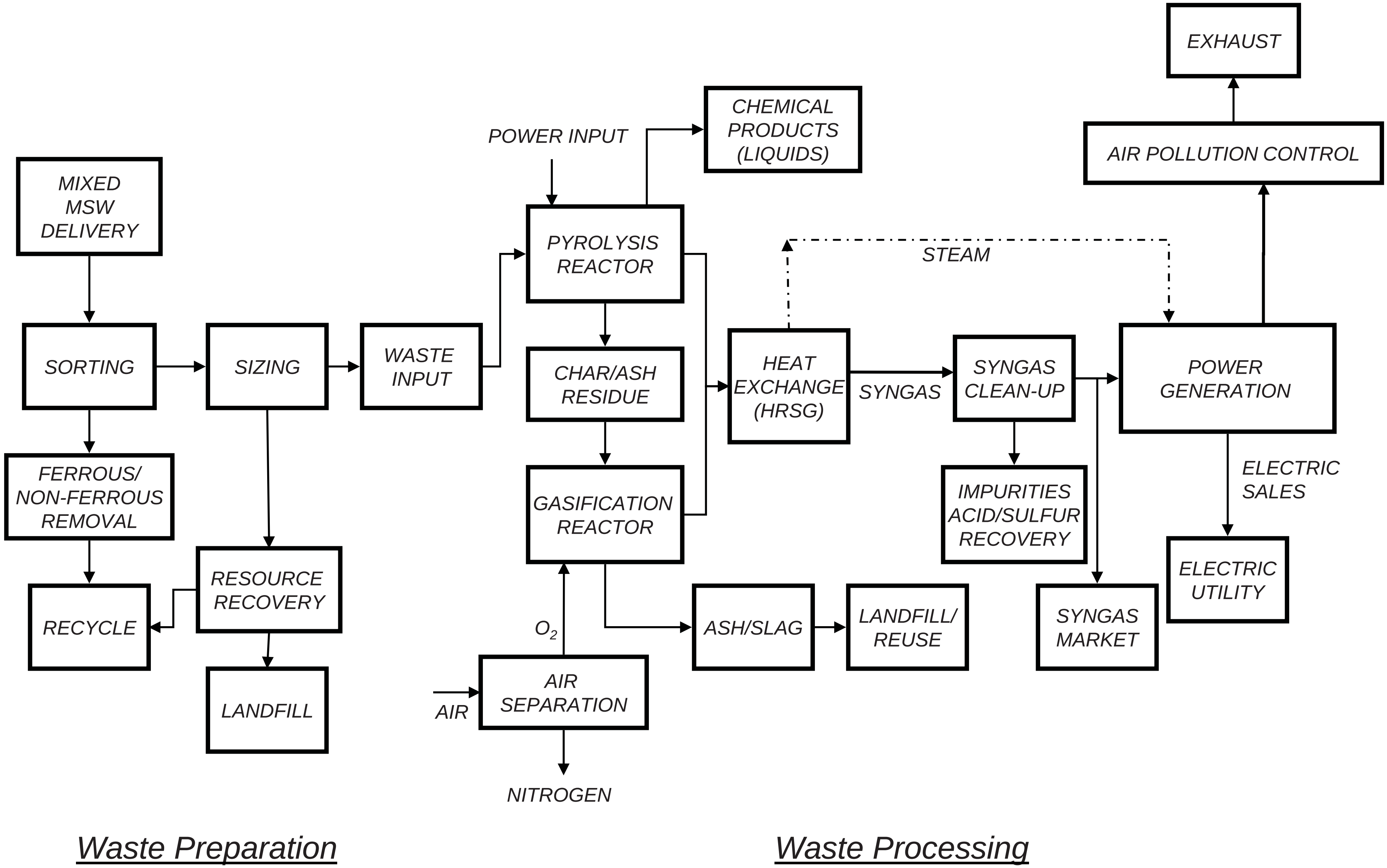
Combustion - Mass Burn



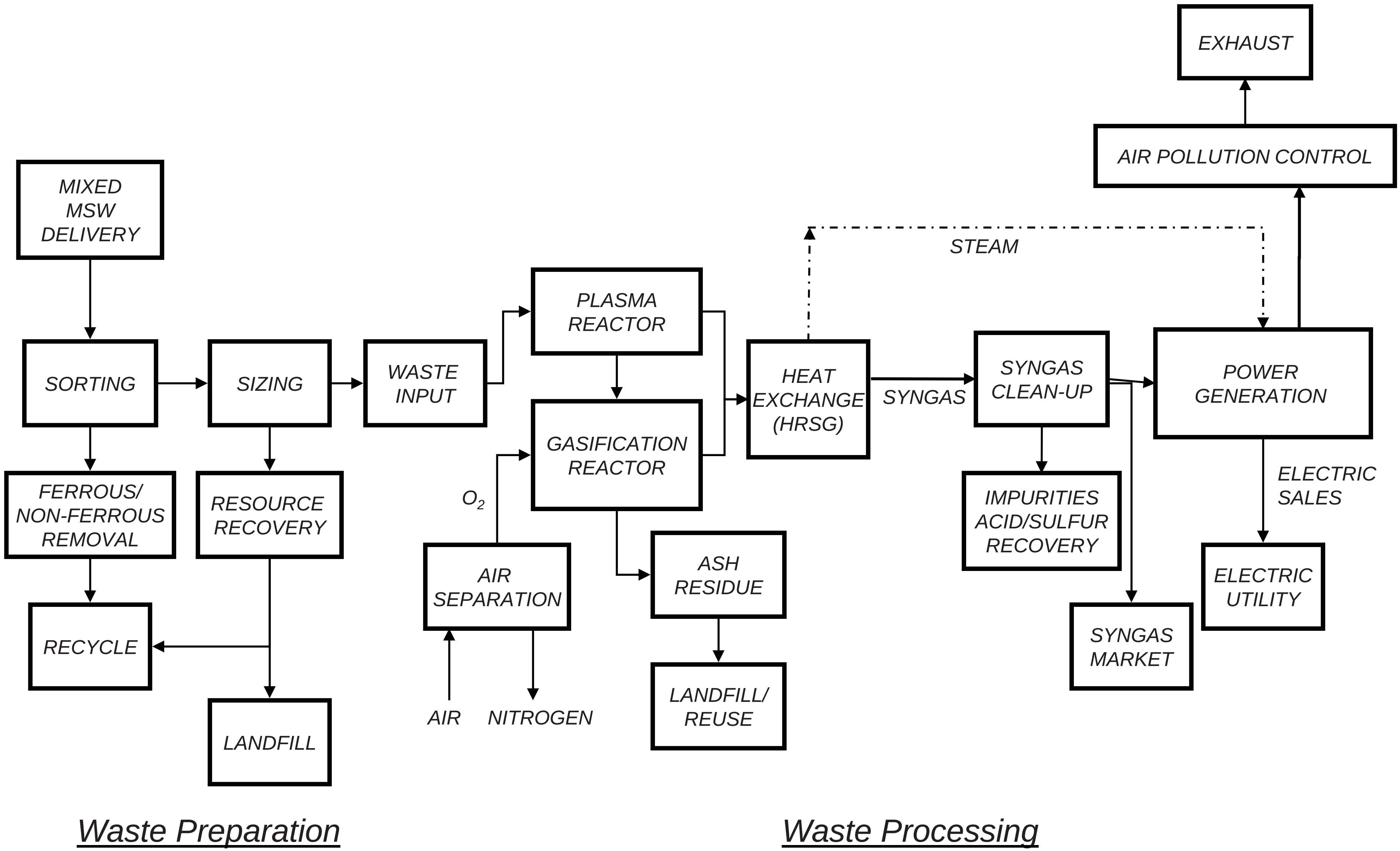
Combustion - Refuse-Derived Fuel (preparation process)



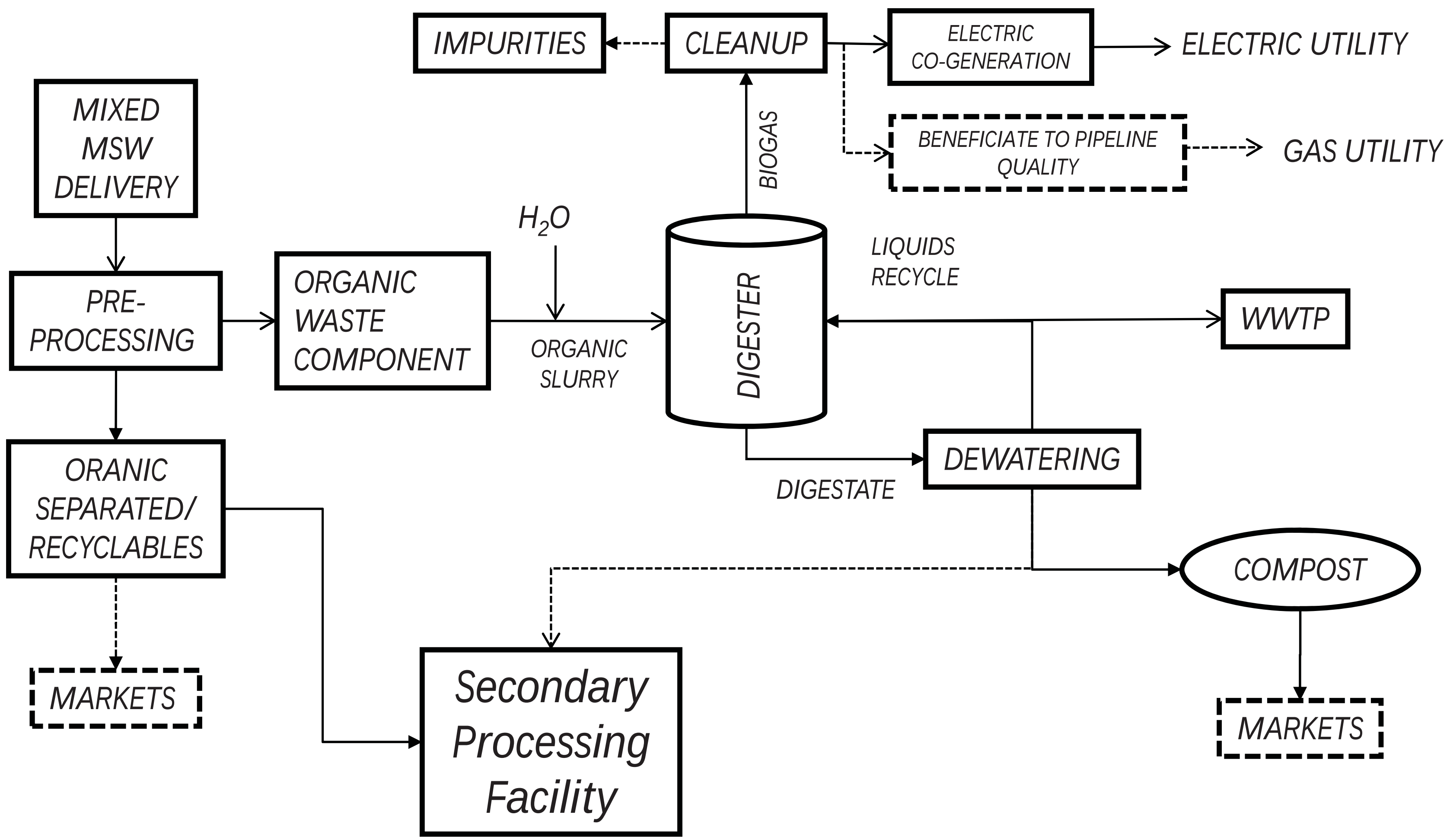
Thermal Conversion - Pyrolysis/Gasification



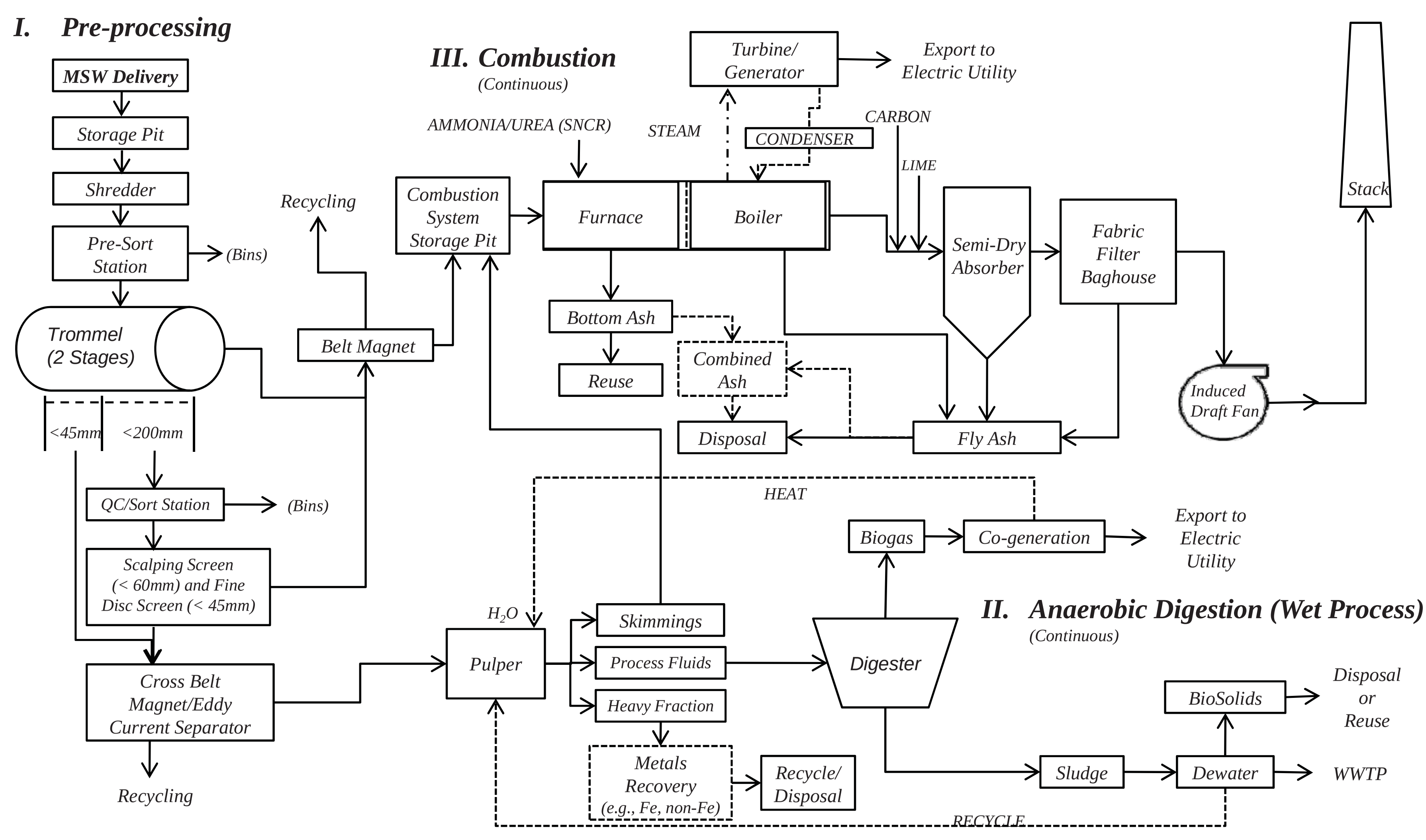
Thermal Conversion - Plasma Arc/ Gasification



Biological - Anaerobic Digestion



Combination AD + Mass Burn



Appendix 1-C
Conceptual Operation and Performance Comparison of Waste to Energy Technologies

MSW Processing Technology Matrix							
Technology	**Description**	**Performance Parameters**	**Energy Recovery**	**Residuals Reuse/Recycling**	**Environmental Impacts**	**Advantages/ Disadvantages**	**Preliminary Concept Level Cost (USD)**
Mass Burn/Advanced Thermal Recycling	Mass burn/advanced thermal recycling provides for residual minimization and generates useful byproducts that include (a) heat for steam generation, energy recovery and electric sales; (b) ash residue that is potentially reusable; and (c) recovered ferrous and non-ferrous metals (post-combustion). Minimal pre-processing necessary. Mass burn/advanced thermal recycling systems require sophisticated air pollution control (APC) equipment and to operate within regulatory compliance standards. **Processing Capacity** • Typically 200 tpd to 1,000 tpd units combined in anywhere from one to four units per facility for a range of facility throughput from 200 tpd to 3,000 tpd.	**Operating Experience** • Proven experience (>20 yrs) on a commercial operating basis in U.S. and internationally. • There are over 89 mass burn facilities in the U.S. and over 600 facilities worldwide. • More than 38 units (from mass burn plants) with rated capacities ≥ 1000 tpd currently operating in the US. • Technologies available from a number of commercially-viable vendors and operators. **Operational Requirements** • Processes mixed MSW. • Limited physical separation, including removal of metals, non-processibles and large objects may improve combustion efficiencies and energy recovery. • Materials recovered via physical separation may not meet market requirements, which may impact marketability and could result in additional costs for processing or disposal. **Pre-processing Requirements** • Physical separation of bulky items (large durables, stumps, construction debris, etc.) and hazardous waste. • Metals, plastics, and papers may be pre-processed at Materials Recycling Facility (MRF), but is not necessary. • Yard waste and organic wastes may be source separated for composting.	• Heat generated from the combustion process exhausted to a boiler to produce steam and electricity • Net electric generation for a US or European plant typically ranges from 500 to 600 kWh per tonne processed. •Energy recovery dependent on calorific value of waste.	• Residuals (byproducts) include ash residue (fly ash and bottom ash). • Combined ash residue may be reusable. **Residue Percent** • 25 to 30 % by weight	• Air emissions are controlled within regulated levels: these include carbon dioxide, nitrogen oxides, sulfur dioxide, hydrogen chloride, hydrogen fluoride, volatile organic compounds, volatilized metals (e.g., cadmium, nickel, arsenic and mercury) and dioxin/furan compounds. • Air emissions are addressed by the use of advanced combustion control and state of the art pollution control systems including catalytic or non catalytic reduction of NOx, lime injection/semi-dry absorbers and baghouse filters. • Air emissions Facility design minimizes the off-site release of dust and odors. In addition to air emissions, the production of ash and a moderate amount of wastewater account for the primary environmental impacts.	**Advantages** • Significant volume reduction (> 90 percent) • Net electric generation typically ranges from 500 to 600 kWh per ton processed (estimated 10 percent for in-house consumption) • Combined ash residue is reusable • Recoverable ferrous and non-ferrous metals • Pre-processing is not necessary **Disadvantages** • Physical separation (if used) increases operational requirements • Materials recovered via physical separation waste may not meet market requirements, which may impact marketability and could result in additional costs for processing or disposal	**Capital Investment** • $200,000-$250,000 per design tpd • Cost per design tpd has an inverse relationship to nominal capacity of unit **O&M** • $40 per ton - $80 per ton (not including pre-processing). • Economy of scale can benefit facilities with larger unit capacity.

MSW Processing Technology Matrix							
Technology	**Description**	**Performance Parameters**	**Energy Recovery**	**Residuals Reuse/Recycling**	**Environmental Impacts**	**Advantages/ Disadvantages**	**Preliminary Concept Level Cost (USD)**
Combustion of Refuse-Derived Fuel (RDF)	RDF technologies include mechanical steps to extensively separate, sort and/or size waste materials to produce the waste feedstock (e.g., homogenous, densified, etc.) required for the subsequent combustion processing system. RDF is fed directly to a combustion system. **Processing Capacity** • Typically 2 tpd to 1,000 tpd units combined in anywhere from one to four units per facility for a range of Facility throughput from 10 tpd to 3,000 tpd	**Operating Experience** • U.S. and international experience. • Commercially available. • There are 16 operating RDF facilities in the U.S. • Technologies available from a number of commercially-viable vendors and operators. **Operational Requirements** • Processes mixed MSW. • Physical separation, shredding (large objects), metals removal, etc. would likely improve operational efficiencies and quality of byproducts, as well as potentially lower air emissions. • Physical separation increases operational requirements. • Physical separation likely will not prevent contamination of recyclables, which may impact marketability and could result in additional costs for treatment or disposal. **Pre-processing Requirements** • Physical separation of bulky items (large durables, stumps, construction debris, etc.) and hazardous waste. • Metals, plastics, and papers may be pre-processed at Materials Recycling Facility (MRF), but is not necessary. • Yard waste and organic wastes may be source separated for composting.	• Physical processing systems are energy consumptive, reducing the net-electric produced and potential electric sales revenue • Energy recoverable through additional process such as combustion or conversion. •Energy recovery dependent on calorific value of waste.	• Residuals (byproducts) include non-processibles, and recyclables. Byproducts are process-dependent. • Marketability of separated materials uncertain. • Combustion of RDF may result in better quality of residuals (ash); thus increasing recyclables. **Residue Percent** • 10 to 30 % by weight	• Combustions of RDF may result in lower air emissions compared to mass burn process • Noise, dust, odor and litter at receiving end of plant can be controlled with proper process design	**Advantages** • Residuals (byproducts) include ash residue (fly ash and bottom ash) • Combustion of RDF may result in better quality of separated materials; thus increasing recyclables • Combustion system and boiler tend to be simpler than Mass/Burn • Environmental performance tends to be superior to Mass/Burn • Energy efficiency is higher than Mass/Burn **Disadvantages** • Physical separation (required) increases operational requirements and is labor intensive • Physical processing systems are energy consumptive, reducing the net-electric produced and potential electric sales revenue • Physical separation likely will not prevent contamination, which may impact marketability and could result in additional costs for treatment or disposal	**Capital Investment** • $200,000-$250,000 per design ton • Cost per design ton has an inverse relationship to nominal capacity of unit **O&M** • $40 per ton - $80 per ton (not including pre-processing). • Economy of scale can benefit facilities with larger unit capacity. • Additional $25 per ton - $40 per ton for pre-processing

MSW Processing Technology Matrix							
Technology	**Description**	**Performance Parameters**	**Energy Recovery**	**Residuals Reuse/Recycling**	**Environmental Impacts**	**Advantages/ Disadvantages**	**Preliminary Concept Level Cost (USD)**
Conversion (Pyrolysis/Plasma Arc)/Gasification	**Pyrolysis** -is an endothermic process that requires a source of heat to initiate the thermal reactions. Pyrolysis systems typically use drums, kiln structures, or tubes which are externally heated in a closed system (in the absence of oxygen). Pyrolysis systems operate at a range of temperatures (400°C to 800°C), depending on the feedstock and the desired byproducts. Pyrolysis can be supplemented by gasification to further process and recover energy from the pyrolysis residues. Pyrolysis/gasification includes pyrolysis as the initial step with the char or solid residue discharged to a gasification reactor. The liquid residue from the gasification process is typically discharged to a water bath and quenched to form a glassy, slag material. The off-gas (syngas) can be used as a heat source to be processed through a boiler for steam generation and electricity production and as a fuel or chemical feedstock. **Plasma Arc** - converts select waste streams to slag. The plasma arc system uses electrical current between two electrodes (the arc) to heat a gas (usually air, oxygen, nitrogen, argon, or a combination thereof) to temperatures of many thousands of degrees Celsius within the plasma arc reactor. The heated and ionized plasma gas is then used to treat the feedstock. Plasma arc/gasification includes plasma as the initial step with the char or solid residue discharged to a gasification reactor. The molten residue from the gasification process is typically discharged to a water bath and quenched to form a glassy, slag material. The syngas produced can be used as a heat source to be processed through a boiler for steam generation and electricity production and as a fuel or chemical feedstock. **Processing Capacity -** No available information to suggest ability to provide required processing capacity without employing numerous units. • Thermoselect reports ability to provide a 240 tpd unit. The largest Thermoselect facility processed 720 tpd with three units at 240 tpd per unit. Thermoselect reports that three facilities in Japan currently process MSW alone in 60 tpd to 140 tpd units combined in one to three lines per facility for a range of facility throughput from 120 tpd to 300 tpd. Largest reported plasma arc facility is under development in Rome, Italy (300 tpd).	**Operating Experience** • An emerging MSW treatment technology. • Attempted on a limited scale only, although numerous vendors are promoting systems globally. • Limited commercial operations with MSW alone. • Potentially lower emissions than combustion, primarily due to pre-processing. •Systems are modular **Operational Requirements** • Pre-processing required. • Gasification necessary to maximize energy recovery. • Pre-processing, shredding (large objects), metals removal, etc. would likely improve operational efficiencies and quality of byproducts, as well as potentially lower air emissions. • Pre-processing increases operational requirements. • Failure to produce materials that consistently meet market quality specifications may impact marketability and could result in additional costs for treatment and/or disposal. **Pre-processing Requirements** • Depending on the thermal conversion technology, one or more of the following pre-processing techniques of the mixed MSW feedstock may be required such as sorting, separation, shredding/size reduction, densification, and in some cases moisture reduction. • Facilities employing the Thermoselect process are reported to not require any pre-processing other than the removal of large objects, which is a similar processing step for thermal combustion facilities, and compressing the waste into waste slugs prior to feeding into the degassing channel. • Other thermal conversion technologies may require that grit, glass, metals, paper, and plastics removed using sorting, separation, size reduction, densification; possible to pre-process at MRF for pyrolysis technology • Depending on the technology, metals, glass, paper, plastics removed using shredding, screening, air classifier, drying, ferrous and non-ferrous metals removal; possible to pre-process at MRF for gasification processes.	• Produces syngas and/or steam that can be used for electricity production or other fuel uses. • Liquid byproducts are usable as light crude oil.	• Liquid byproducts may be marketable. • Solid byproducts generally inert and potentially reusable. • Market availability and stability unknown. **Residue Percent** • As little as 10% by volume (pyrolysis/gasification) • Up to 25% by weight (plasma arc/gasification)	• Air emissions are minimized due to absence of free air or oxygen to process MSW. • Contaminants are removed from flue gasses prior to being exhausted from stack. • Thermal conversion facilities comply with emissions regulations similar to combustion technology. A recent study of 16 thermal conversion plants around the world showed good compliance with relevant local emissions standards for hazardous air pollutants. • Based on USEPA standards some minor exceedances were reported. • In addition to ash and wastewater most thermal conversion processes generate a waste slag byproduct. • Noise, dust, odor and litter at receiving end of plant can be controlled with proper process design	**Advantages** • Produces syngas and/or steam that can be used for electricity production or other fuel uses. • Liquid byproducts are usable as light crude oil. • Solid byproducts generally inert and potentially reusable. • Separated materials from pre-processing are potentially reusable or recyclable. • Potentially lower emissions than combustion, primarily due to pre-processing **Disadvantages** • Requires one or more of the pre-processing techniques discussed above for the mixed MSW, which increases operational requirements. • Market availability and stability for residuals unknown. • No available information to suggest ability to provide required processing capacity without employing numerous units.	**Capital Investment** • $100,000/tpd - $500,000/tpd for gasification facilities (not including pre-processing or tipping fees) **O&M** • $50/ton - $150/ton for gasification process (not including pre-processing if required)

MSW Processing Technology Matrix							
Technology	**Description**	**Performance Parameters**	**Energy Recovery**	**Residuals Reuse/Recycling**	**Environmental Impacts**	**Advantages/ Disadvantages**	**Preliminary Concept Level Cost (USD)**
Anaerobic Digestion	For this process to be efficient with mixed MSW, pre-processing is required to remove non-biodegradable materials. The feedstock is often shredded and pulped to improve removal of inorganic materials and grit. The resulting organic feedstock (or slurry) is processed in one or more digestion units. **Processing Capacity** • Several companies offer commercial MSW anaerobic digestion plants with maximum feed rate capacity ranges from 50,000 – 245,000 Mg per year for installed systems. • Arrow Ecology & Engineering demonstrates a single 210 tpd module for a facility throughput of 77,000 tpy with no limit to the number of modules. • Canada Composting reports a minimum economic size is a single module of 110 tpd and a maximum "logical" size of 5 modules for a facility throughput of 40,000 to 200,000 tpy. •Compatability: AD plants successfully operate as a front-end (used in combination) to combustion plants.	**Operating Experience** • Experience limited to Canada and Europe. • Limited, if any, applications with mixed MSW. **Operational Requirements** • Mixed MSW pre-processing required. • Pre-processing, shredding (large objects), metals removal, etc. would likely improve operational efficiencies and quality of byproducts, as well as potentially lower air emissions. • Pre-processing increases operational requirements. • Pre-processing likely will not prevent contamination, which may impact marketability and could result in additional costs for treatment or disposal. **Pre-processing Requirements** • Metals, plastics, residue need to be removed; possible to pre-process at MRF	• Biogas (50-65% methane, 50-30% CO_2) can be used to generate electricity in gas engines. • An average biogas production rate of 112 Nm^3/Mg of digester feed has been reported •Net energy surplus range of 40 – 170 kWh per Mg of organic waste input	• Residuals (byproducts) include nonprocessibles and recyclables. Byproducts are process and waste stream dependent. • Marketability of separated materials uncertain. • Market availability and stability not known. • Filtrate liquid, solid filter cake, biogas. Filtrate liquid is recirculated; dewatered material may be used as compost (with aeration and/or curing) or landfill cover. **Residue Percent** • 10 to 30%	• Water emissions from digestion include nitrogen compounds, dissolved solids and moderate levels of BOD and COD. Dewatering effluent can be discharged to wastewater treatment plant. •There are some fugitive emissions of biogas from the digesters and storage tanks. •Internal combustion engines are fitted with pollution controls including catalytic reduction of nitrogen oxides to meet strict environmental compliance laws. •Residual solids from the digester may be disposed of separately or after suitable processing may be used for composting. • Noise, dust, odor and litter at receiving end of plant can be controlled with proper process design.	**Advantages** • Produces methane gas (50-70% concentration) and carbon dioxide. • Byproduct produced from solids (with aeration step included) can be used as compost or landfill cover. **Disadvantages** • Mixed MSW pre-processing required. • Marketability of separated materials uncertain. Market availability and stability not known. • Pre-processing likely will not prevent contamination, which may impact marketability and could result in additional const for treatment or disposal.	**Capital Investment** • $50,000-$100,000/tpd (not including pre-processing or tipping fees) **O&M** • $10-15/ton (excluding pre-processing) • Additional $25 per ton - $40 per ton for pre-processing

MSW Processing Technology Matrix							
Technology	**Description**	**Performance Parameters**	**Energy Recovery**	**Residuals Reuse/Recycling**	**Environmental Impacts**	**Advantages/ Disadvantages**	**Preliminary Concept Level Cost (USD)**
Combination Anaerobic Digestion + Combustion	• Refer to information above for Anaerobic Digestion and Combustion, respectively. o Combination AD + Combustion processes: o Can be developed as an integrated facility or at remote locations. o Pre-processing separates digestible organic fraction (sent to AD process). o Pre-processing can enhance the recovery of recyclable materials. o The balance fraction is processed at the combustion facility. The resulting waste (non-digestible or balance fraction) is generally of higher calorific value and lower moisture content, improving combustion process efficiencies.	**Operating Experience** • Numerous facilities in Europe (Netherlands, Belgium, Germany, Spain) where AD is integrated with a combustion facility or located separately, with transfer of the non-digestible fraction to a nearby combustion facility. **Operational Requirements** • Mixed MSW pre-processing required. • Pre-processing, shredding (large objects), metals removal, etc. would likely improve operational efficiencies and quality of byproducts, as well as potentially lower air emissions. • Pre-processing increases operational requirements. • Combustion by RDF will require additional pre-processing for feedstock preparation. • Pre-processing likely will not prevent contamination in separated waste streams, which may impact marketability and could result in additional costs for treatment or disposal. • Management of AD solid residuals (beneficial use, composting, or disposal) required. **Pre-processing Requirements** • Metals, plastics, residue need to be removed from digestible organic fraction (feedstock to AD process); possible to pre-process at MRF	See Combustion and Anaerobic Digestion, above. • Non-digestible fraction from AD pre-processing system processed at combustion plant.	See Combustion and Anaerobic Digestion above.	See Combustion and Anaerobic Digestion above.	**Advantages** Pre-processing can enhance the recovery of recyclable materials. The residual after pre-processing (non-digestible or balance fraction) is generally of higher calorific value and lower moisture content, improving combustion process efficiencies. **Disadvantages** Management of AD solid residuals (beneficial use, composting, or disposal)	Overall cost will be a combination of AD and Combustion plant costs given above. Will depend on the fraction of material diverted to AD and the residual available for combustion. Operating Costs affected by transport if located at independent sites

Appendix 2-A
Discussion on Alternative Combustion Technologies

APPENDIX 2A – DISCUSSION ON ALTERNATIVE COMBUSTION TECHNOLOGIES

The preliminary design for the combustion option is based on mass burn technology, the most commonly used WTE technology because of its simplicity, involving the combustion of minimally processed waste. While it is acknowledged that combustion of RDF is technically feasible, and the energy efficiency is typically higher than mass burn incineration, pre-processing energy use can erode this advantage on an overall basis. Note that the pre-processing required for an RDF system is complex compared to the pre-processing required for AD systems discussed in the memo.

In addition to RDF combustion, there are several enhancements that may be included when considering an MSW combustion facility. We describe several below and reasons why they have not been considered in this analysis.

- Cogeneration – beneficial use of waste heat from the steam cycle. Heat from the turbine exhaust or steam extraction may be captured in the form of steam or hot water for use in district heating or process heating application. This option is normally only considered in colder climates or where the waste to energy plant is located adjacent to an industrial facility with a demand for process steam.

- External Superheater – Incineration of the MSW is used to raise steam in a boiler which is then directed to a supplemental external superheater fired by an alternative means, such as directly from natural gas burners or waste heat from a gas turbine. This arrangement enables much higher steam temperatures, increasing the overall efficiency of the steam cycle. Another, related approach is to use waste heat from an external source for pre-heating combustion air and/or feedwater. The incremental benefit of adding an external superheater is subject to detailed cost-benefit analysis that goes beyond the scope of this memorandum. However, it may be appropriate to evaluate this approach during the tender phase of the project.

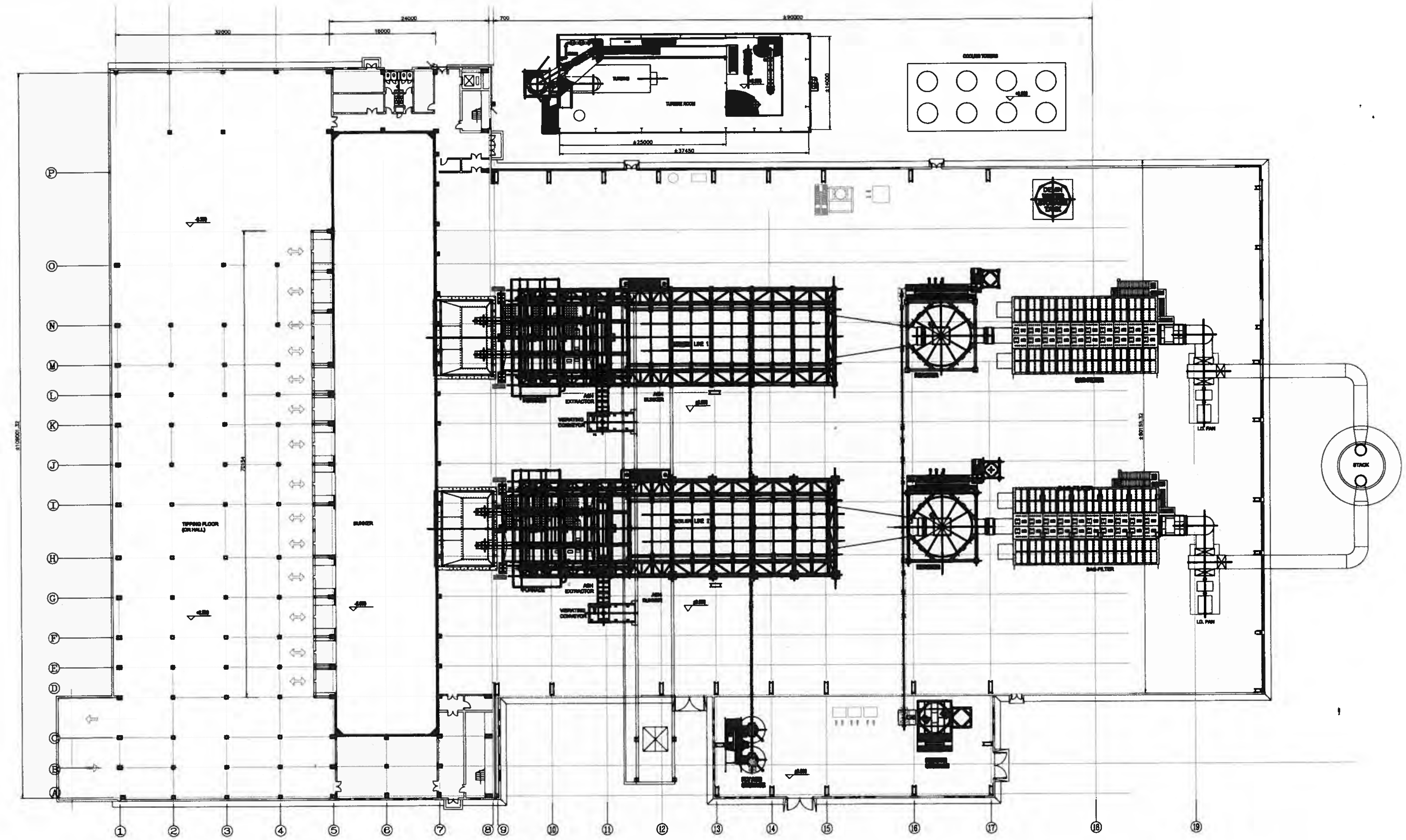
- Co-firing of MSW – when suitably processed, MSW may be co-fired in modified fossil fuel systems to maximize the use of existing infrastructure and reduce capital investment costs. However, there are no known fossil fuel power plants with this capability in the Rio de Janeiro area.

These enhanced design options may be suitable for this application; however, for the purpose of this least cost analysis and to preserve the generality of the assessment, a standard design mass burn facility is considered appropriate. Any enhanced combustion designs adopted for this project may ultimately be determined during the tender process and will depend on the vendor community active in Brazil and the particular technologies they may offer.

Appendix 2-B - Preliminary Layout Drawings

1. Option B Combustion Plant Layout

2. Option B Site Layout



MALCOLM PIRNIE

REVISIONS			
NO.	BY	DATE	REMARKS

DES TS/OM
DWN OM
CKD TS

RIO DE JANEIRO, BRASIL

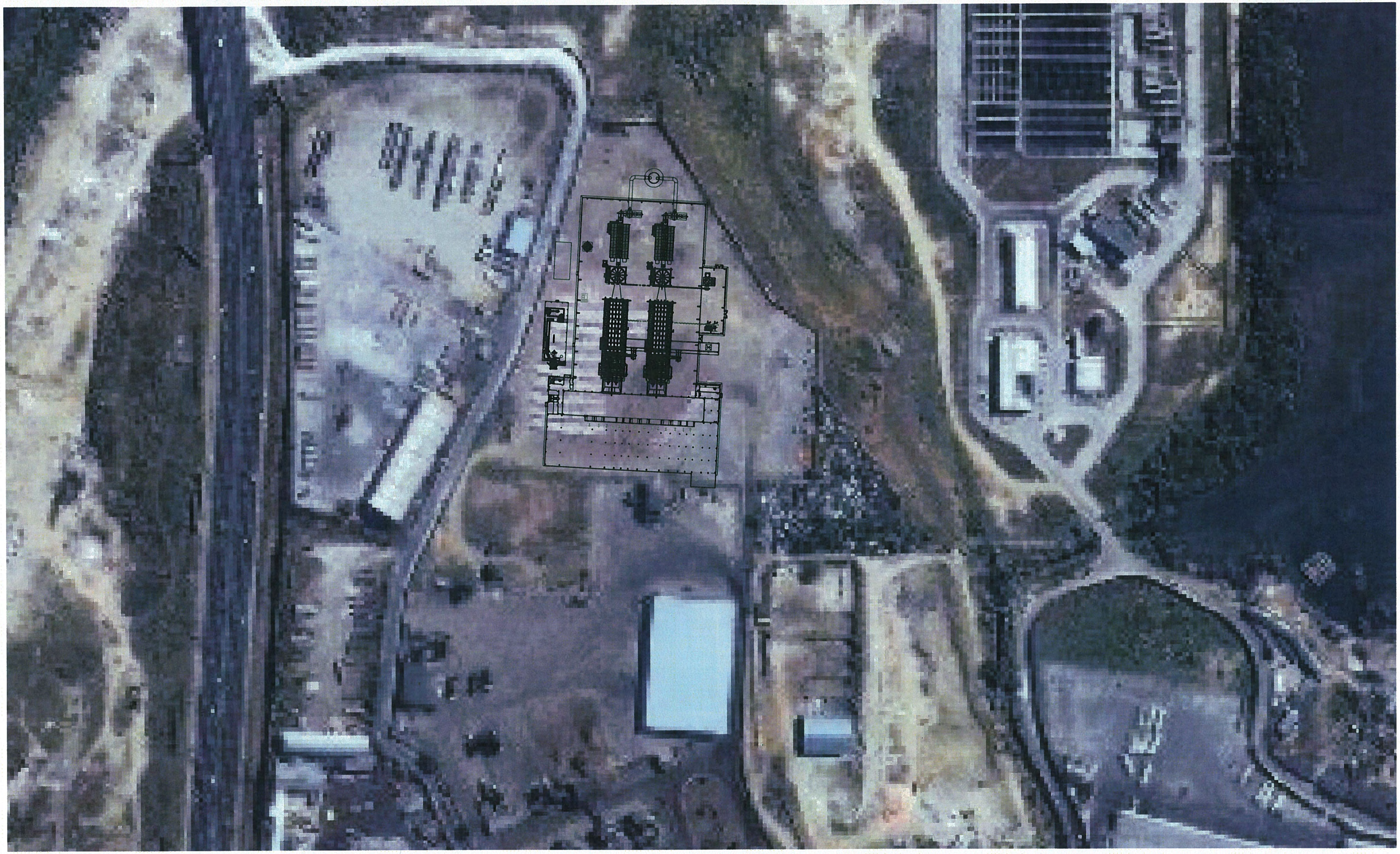
MPX ENERGIA S.A., RIO DE JANIERO, BRASIL

OPTION B – 1400 MTPD COMBUSTION WASTE -TO-ENERGY FACILITY PRELIMINARY PLANT LAYOUT

DATE

C SHEET 1 OF

CAD REF. NO. LAYOUT



MALCOLM PIRNIE

REVISIONS			
NO.	BY	DATE	REMARKS

DES TS/OM
DWN OM
CKD TS

RIO DE JANEIRO, BRASIL

MPX ENERGIA S.A., RIO DE JANIERO, BRASIL

OPTION B - 1400 MTPD COMBUSTION WASTE-TO-ENERGY FACILITY PRELIMINARY SITE LAYOUT

DATE

C SHEET 1 OF ____

CAD REF. NO. LAYOUT

Appendix 3-A - EPC Cost Estimate

1. **Summary Sheet**
2. **Component Cost Breakdown**

Inputs	
Import Duty [(1)]	14.00%
Port and Storage Costs	6.00%
Local Sales Tax [(2)]	0.00%
Construction Labor Cost Index	0.17
Construction Labor Efficiency Factor [(3)]	1.80
Brazil Materials Cost Index	1.00

Cost Category	Local Equipment	Imported Equipment [(1)]	Materials	Labor	Total
Refuse Charging					
	2,316,160	-	300,800	119,658	**$2,736,618**
<u>Chute to Stack Supply Contract</u>					
Combustion System					
	-	24,319,680	1,737,120	2,126,235	**$28,183,035**
Heat Recovery					
	-	66,879,120	4,777,080	5,847,146	**$77,503,346**
Ash Handling System					
	-	6,079,920	434,280	531,559	**$7,045,759**
Air Pollution Control System					
	-	24,319,680	1,737,120	2,126,235	**$28,183,035**
Distributed Control System (incl I&C)					
	2,556,800	-	4,060,800	2,577,254	**$9,194,854**
Turbine-Generator and Auxiliaries					
	7,098,880	-	1,323,520	1,104,538	**$9,526,938**
Power Cycle Equipment					
	3,553,200	-	733,200	414,202	**$4,700,602**
Cooling Tower					
	887,360	-	165,440	138,067	**$1,190,867**
Power System Piping					
	3,308,800	-	5,583,600	3,607,006	**$12,499,406**
Switchgear, transformers, MCCs, power panels, cables, conduits, lighting					
	5,264,000	-	7,896,000	4,026,960	**$17,186,960**
Balance of Plant Equipment					
	6,658,960	-	864,800	344,017	**$7,867,777**
Site Work and Buildings					
	-	-	27,072,000	8,974,368	**$36,046,368**
Start-up and Testing					
	-	-	-	2,416,176	**$2,416,176**
Contractor Engineering, Permitting, Home Office Management, Administration					
	-	-	-	5,407,632	**$5,407,632**
Contractor Profit, and contingency (4)					
	-	-	-	44,062,830	**$44,062,830**
Total					**$293,752,203**

1. Import duty provided by B&W and verified on *http://thebrazilbusiness.com/import-tax-guide*
2. Local Tax rates assumed to be exempt (ICMS = 0%, PIS = 0%, COFINS = 0%, IPI = 0%)
3. Construction labor Efficiency Factor from *www.icoste.org/intldata.htm*
4. Contractor Profit calculated as percentage of total poject value

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
1000 Tipping Hall and Refuse Pit	**$2,736,618**						
Subtotal		$ 2,316,160	$ -	$ 300,800	$ 119,658	**$ 2,736,618**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 2,316,160	$ -	$ 300,800	$ 119,658	**$ 2,736,618**	6,822

*Includes Grapple cranes and associated controls

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
2000 Combustion System *	**$28,183,035**						
Subtotal		$ -	$ 20,266,400	$ 1,737,120	$ 2,126,235	**$ 24,129,755**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ 4,053,280	$ -	$ -	**$ 4,053,280**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ 24,319,680	$ 1,737,120	$ 2,126,235	**$ 28,183,035**	121,222

*Includes charging hopper and feed chute, grate and hydraulic controls, ash discharger, forced draft and overfire air fans

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
3000 Heat Recovery *	**$77,503,346**						
Subtotal		$ -	$ 55,732,600	$ 4,777,080	$ 5,847,146	**$ 66,356,826**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ 11,146,520	$ -	$ -	**$ 11,146,520**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ 66,879,120	$ 4,777,080	$ 5,847,146	**$ 77,503,346**	333,361

* Includes waterwall furnace, superheater, boiler, economiser, superheater and boiler rapping systems, startup burners with PLC based BMS

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
4000 Ash Handling System *	**$7,045,759**						
Subtotal		$ -	$ 5,066,600	$ 434,280	$ 531,559	**$ 6,032,439**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ 1,013,320	$ -	$ -	**$ 1,013,320**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ 6,079,920	$ 434,280	$ 531,559	**$ 7,045,759**	30,306

*Includes bottom ash handling, metals recovery and fly ash handling

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
5000 Distributed Control System	**$9,194,854**						
Subtotal		$ 2,556,800	$ -	$ 4,060,800	$ 2,577,254	**$ 9,194,854**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 2,556,800	$ -	$ 4,060,800	$ 2,577,254	**$ 9,194,854**	146,936

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
6000 Air Pollution Control *	**$28,183,035**						
Subtotal		$ -	$ 20,266,400	$ 1,737,120	$ 2,126,235	**$ 24,129,755**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ 4,053,280	$ -	$ -	**$ 4,053,280**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ 24,319,680	$ 1,737,120	$ 2,126,235	**$ 28,183,035**	121,222

* Includes Stack with flue liners, scrubbers-baghouse and breeching, SNCR de-NOx, Carbon Injection, ID Fan, electrical equipment and foundation, CEMS

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
7100 Steam Turbine Generator *	**$9,526,938**						
Subtotal		$ 7,098,880	$ -	$ 1,323,520	$ 1,104,538	**$ 9,526,938**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 7,098,880	$ -	$ 1,323,520	$ 1,104,538	**$ 9,526,938**	62,972

* Includes turbine, generator and auxiliary equipmnent

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
7200 Boiler Feedwater System *	**$4,700,602**						
Subtotal		$ 3,553,200	$ -	$ 733,200	$ 414,202	**$ 4,700,602**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 3,553,200	$ -	$ 733,200	$ 414,202	**$ 4,700,602**	23,615

* Includes feedwater pumps, feedwater heaters, deaerator, condenser, condensate treatment

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
7300 Cooling Tower	**$1,190,867**						
Subtotal		$ 887,360	$ -	$ 165,440	$ 138,067	**$ 1,190,867**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 887,360	$ -	$ 165,440	$ 138,067	**$ 1,190,867**	7,872

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
7400 Power System Piping *	**$12,499,406**						
Subtotal		$ 3,308,800	$ -	$ 5,583,600	$ 3,607,006	**$ 12,499,406**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 3,308,800	$ -	$ 5,583,600	$ 3,607,006	**$ 12,499,406**	205,645

* Includes HP, LP and MP steam and cooling water pipework

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
7140 Electrical *	**$17,186,960**						
Subtotal		$ 5,264,000	$ -	$ 7,896,000	$ 4,026,960	**$ 17,186,960**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 5,264,000	$ -	$ 7,896,000	$ 4,026,960	**$ 17,186,960**	229,587

*Includes HV (4160) and LV (480) switchgear, MCCs, power panels, cables, conduit, and lighting

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
8000 Balance of Plant *	**$7,867,777**						
Subtotal		$ 6,658,960	$ -	$ 864,800	$ 344,017	**$ 7,867,777**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 6,658,960	$ -	$ 864,800	$ 344,017	**$ 7,867,777**	19,613

* Includes auxiliary fuel supply, water treatment, compressed air, chemical feed, fire protection, HVAC, shop tools, rolling stock and initial spare parts

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
9100 Building Refuse Hall	**$7,209,274**						
Subtotal		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	102,330

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
9200 Ash Building	**$2,415,107**						
Subtotal		$ -	$ -	$ 1,813,824	$ 601,283	**$ 2,415,107**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ -	$ 1,813,824	$ 601,283	**$ 2,415,107**	34,281

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
9300 Foundations and Structures*	**$7,209,274**						
Subtotal		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	102,330

*Includes turbine/generator foundation, other foundations, concrete and steel structures

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
9400 Miscellaneous Buildings *	**$7,209,274**						
Subtotal		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ -	$ 5,414,400	$ 1,794,874	**$ 7,209,274**	102,330

*Includes control room, adminiatration and maintenance buildings, parking lots and site roads.

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
9500 Site Preparation and Demo	**$12,003,441**						
Subtotal		$ -	$ -	$ 9,014,976	$ 2,988,465	**$ 12,003,441**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ -	$ -	$ 9,014,976	$ 2,988,465	**$ 12,003,441**	170,380

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Port and Storage Costs	6.00%	COFINS	0.00%
Brazil Materials Cost Index	1.00	ICMS	0.00%
Brazil Labor Index	0.17	IPI	0.00%
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
10100 Startup and Testing	**$2,416,176**				$2,416,176		
Total		$ -	$ -	$ -	$ 2,416,176	**$ 2,416,176**	
10200 Other Costs	**$5,407,632**						
1. Contractor Engineering					$ 3,785,342		
2. Permitting					$ 540,763		
3. Project Management and Admin					$ 1,081,526		
Total		$ -	$ -	$ -	$ 5,407,632	**$ 5,407,632**	
10300 Contractor Profit and Continge	**$44,062,830**						
1. Profit						$ 14,540,734	
2. Contingency						$ 29,522,096	
Total		$ -	$ -	$ -	$ -	**$ 44,062,830**	

Cost Category	Cost for this Component	Local Equipment	Imported Equipment	Materials	Labor	Total	Man Hours
Anaerobic Digester *	**5,350,000 €**						
1. AD	4,250,000 €	$ 5,652,500					
2. Dewatering	1,100,000 €	$ 1,463,000					
Subtotal		$ 7,115,500	$ -	$ -	$ -	**$ 7,115,500**	
Freight		$ -	$ -	$ -	$ -	**$ -**	
Import Duty and Port Costs		$ -	$ -	$ -	$ -	**$ -**	
Sales Tax		$ -	$ -	$ -	$ -	**$ -**	
Total		$ 7,115,500	$ -	$ -	$ -	**$ 7,115,500**	

* Budget Proposal from OWS includes freight and installation parts and labor

Inputs		Sales Tax	
Import Duty	14.00%	PIS	0.00%
Exchange Rate (USD per Euro)	1.33	COFINS	0.00%
Port and Storage Costs	6.00%	ICMS	0.00%
Brazil Materials Cost Index	1.00	IPI	0.00%
Brazil Labor Index	0.17		
Brazil Construction Labor Rate (USD)	$17.54		
Brazil Labor Efficiency factor	1.80		

Appendix 3-B - Budget Proposals

1. Babcock and Wilcox – 2 x 750 mtpd MSW Boiler Train

2. Enfil S/A Controle Ambiental – Energy From Waste FGD System

To: Amit Chattopadhyay
Chief Consultant – Malcolm Pirnie

Re: Rio de Janeiro EfW Facility – Budgetary Price 2 x 750 mTPD Mass-Fired Boiler Trains

Dear Mr. Chattopadhyay

In response to your email dated June 22, 2011, the Babcock & Wilcox Power Generation Group, Inc. (B&W) has prepared the following budgetary pricing for the chute-to-stack boiler train that will be part of the 1500 mTPD Energy-from-Waste Facility feasibility study your firm is preparing for the city of Rio de Janeiro, Brazil. The boiler technology offered in this budgetary price is B&W's mass-fired municipal solid waste boiler technology that utilizes the B&W Volund "WaVe Grate" grate technology. The equipment design is intended to be similar to the equipment offered by B&W for the West Palm Beach project with the exception that an SNCR system is provided in place of the SCR system included with the West Palm Beach offer. Please note that due to the low calorific value of the MSW I have based the budgetary price on superheater outlet steam conditions of 750psig / 750F rather than the initial conditions of 900psig/830F.

I am attaching copies of preliminary layout drawings that should be representative of the equipment arrangement envisioned for this project.

Budgetary Price

The budgetary price for a total of two (2) mass-fired WTE boiler/AQCS equipment trains each capable of burning 750 mTPD of municipal solid waste to generate steam with superheater outlet conditions of 750 psig / 750F, including the scope of supply described below is US$99,700,000 on a material delivered basis.

Scope of Supply

The following scope of supply is included with each boiler

- MSW feed hopper with hydraulic ram feeder
- Combustion grate
- Bottom ash chute
- Ram de-asher bottom ash quencher
- Furnace
- Superheater
- Generating modules
- Economizer
- SH and Gen Module Rapping system
- Sootblower system
- Flues and ducts
- Undergrate and over-fire air systems
- Start-up burners with PLC-base burner management system
- PA, SA, and ID fans and drives
- Activated carbon injection system
- SDA system including lime prep and structural steel.
- Baghouse, including structural steel
- SNCR NOx reduction system including ammonia system
- Bottom ash handling system including metals recovery system
- Flyash handling system
- Engineering and Project Management Services
- Freight to port of Rio de Janeiro

Conditions of the Budgetary Price

- This budgetary pricing is current day and does not include any escalation to time of performance, taxes and duties, currency fluctuation or security costs.·

- This budgetary price is based on in-house data, recent trends for raw material and equipment costs, parametric size factors from past projects, and global sourcing. We will commence project specific design, sizing, equipment performance and arrangement activity during the proposal phase to obtain actual quotes and pricing from our vendors and fabricators.

- Please note that this budgetary pricing is provided for preliminary project planning purposes only and should not be considered an offer to sell.

Please feel free to contact me if you have any questions or comments.

Best regards,

Jim Gittinger
Babcock & Wilcox Power Generation Group, Inc.
Office: (330) 860-6056
Fax: (330) 860-9211
E-mail: jsgittinger@babcock.com

PR- 11.135-13-G – CT- 001/11

July 22th, 2011

To:

Amit Chattopadhyay, PE, BCEE | Principal Consultant II | amit.chattopadhyay@arcadis-us.com

Malcolm Pirnie - a Division of ARCADIS U.S., Inc. | 17-17 Route 208 North, 2nd Floor | Fair Lawn, NJ 07410
T. 201.398.4311 | M. 914.473.5046 | F. 201.797.4558
www.arcadis-us.com

Ref.: SEMI-DRY FLUE GAS DESULFURIZATION SYSTEMS FOR ARCADIS
Our Proposal PR-11.135-13-G

Dear Mr. AMIT

We are pleased to submit our Technical Proposal to supply Semi-Dry Flue Gas Desulfurization Systems for Energy from Waste (2 x 750 tpd) based on the Rotary Atomizer Technology.

Should you require further information please, do not hesitate to contact us.

Warm Regards,

Franco Castellani Tarabini Junior
Director

Marcelo Ozawa
Technology Manager

FCT/MO

ENERGY FROM WASTE

FGD System – SDA

COMMERCIAL PROPOSAL

Proposal nº: PR-11.135-13-G
Issue Date : July, 15th 2011.

ENFIL S/A CONTROLE AMBIENTAL
Av. das Nações Unidas, 12.995, 25º andar -Brooklin Novo
04578-911 - São Paulo – SP, Brazil
Tel.: (55-11) 3076-2700
Fax: (55-11) 3093-2728
e-mail: rafy@enfil.com.br
http://www.enfil.com.br

INDEX

1 OBJECTIVE

This COMMERCIAL PROPOSAL establishes the basic requirements for the supply FGD system, SDA with rotary atomizer from Komline Sanderson – USA and Bag FIlter to be installed in RIO DE JANEIRO CITY for waste incineration plant.

The customer is Arcadis U.S.

2 DEFINITION

For the purpose of this COMMERCIAL PROPOSAL (as hereinafter defined), the following terms with capitalized initials shall have the meanings respectively assigned to them below:

“CLIENT” means

“VENDOR” shall be Enfil and/or its nominee designated by Enfil and/or our subsidiaries.

“CONTRACT” shall mean an indivisible contract to be entered between CLIENT and VENDOR in relation to the supply of for the.

“COMMERCIAL PROPOSAL” shall mean this proposal for commercial conditions submitted to CLIENT by VENDOR.

“EQUIPMENT” shall mean all or any part of equipment and materials which shall be supplied by VENDOR to CLIENT under the CONTRACT as per the TECHNICAL PROPOSAL.

“ENGINEERING” shall mean all or any of engineering in relation to the EQUIPMENT and PLANT which shall be supplied by VENDOR to CLIENT under the CONTRACT as per the TECHNICAL PROPOSAL.

“SUPERVISORY SERVICE” shall mean all or any part of supervisory work for site management, installation and commissioning in relation to the EQUIPMENT and PLANT which shall be supplied by VENDOR to CLIENT under the CONTRACT as per the TECHNICAL PROPOSAL

“WORKS” shall mean the WORKS in relation to supply of the EQUIPMENT and SERVICES to be executed by VENDOR in accordance with the CONTRACT.

3 VENDORS PRICES

The prices indicated below :

PER UNIT 750 ton per day EACH

US$ 13,120,000.00 (Thirteen million, one hundred-twenty thousand U.S. dollars).

ENFIL

Supervision and training

1	Supervisors (*1) diary rate for erection works, commissioning and start up.	1,100.00 / working day (all inclusive)
2	Supervisors (*2) for training and performance testing.	1,500.00 / working day (all inclusive)

All inclusive means costs as Air ticket, hotels, meals. Working day means 1(one) Enginner grade per 1 day, 8 hours working, 1 hour for lunch. Not Saturdays or Sundays.

4 DELIVERY CONDITIONS and DELIVERY TIME

The prices are for delivery condition according to FOB (INCOTERMS 2000) and consider:

FOB- International port: China (Shanghai Port), Turkey, USA (Newark Port) and Brazil (Santos Port).

The materials and equipments will be ready for shipment (after contract signature) after 18 months for first Plant and 22 months for second Plant.

5 PAYMENT CONDITIONS

Item	Percentage	Cumulative Percentage	Description
1	10%	10 %	Of the amount of the Contract Value shall be paid within the purchase order or letter of award to Enfil, against an Advanced Payment Bond (Bank Guarantee) submitted by Enfil of the same amount. The customer should present a letter of credit of 90% (ninety percent) of the total amount of the contract.
2	15%	25 %	Of the amount of the Contract Value shall be paid at the submittal of the basic engineering
3	35%	60 %	Of the amount of the Contract Value shall be paid at the submittal of the purchase order and/or during the equipment manufacturing.
4	37%	97 %	Of the amount of the Contract Value shall be

Item	Percentage	Cumulative Percentage	Description
			paid within the delivery “pro-rata”
5	3%	100%	Of the amount of the Contract Value shall be paid within the PAC – Provisional Acceptance Certificate, but not later than **2 (two) months after the last delivery,** against a “Refundment Bond” (Bank Guarantee) submitted by Enfil of the same amount.

Note 1 – Payment terms are fixed for all invoices 30 days from the receipt date of the invoice and all the requested documentation.

6 TAXES AND DUTIES

All taxes, duties, levies & customs charges in connection with the scope of supplies and services as well as all others costs liable to be raised on import into the country or in the country itself are **not included in the price.**

7 BOND

10% (ten percent) Advanced payment Bond

VENDOR will provide an insurance bond to cover the amount equal of 10% (ten percent) of the Contract Value. Such advanced payment bond shall be valid until 10 days after the last shipment.

8 WARRANTIES

ENFIL warranties the equipment of its manufacture or from his sub-suppliers to be free from defects in material and workmanship for a period of 12 (twelve) months from start up or 18 (eighteen) months after last shipment, prevailing which occurs first.

Our guarantee is valid if equipment is properly installed, maintained, and operated under normal conditions with competent personnel and supervision, and does not cover damages or defects resulting from ordinary wear, excessive heat, improper lubricating oil, improper extended storage prior to start up, or application outside the design limitations of said equipment.

CLIENT should notify ENFIL about any claimed defect equipment and/or materials, as well as to allow ENFIL to inspect it. ENFIL will make no allowance or reimbursement for repairs, alterations, replacements or work of any kind done or ordered by others without ENFIL´s prior written authorization.

In case of defective parts, VENDOR must be notified in due time and should present to CLIENT up to 10 working days a solution plan for correction or substitution of the defective parts. In case of any defective parts that not be VENDOR responsibility, all the costs for achieving the repair will be at CLIENTs responsibility.

In case of the defective parts that be the VENDOR responsibility, the costs of repairs will be paid by the VENDOR.

The costs of dismounting, assembling and transportation will be CLIENT's responsibility.

ENFIL expressly disclaims ability for incidental and consequential damages.

General

The items 10.1 and 10.2 are applicable for all the clause 13 of your purchase conditions.

The maximum overall liquidated damages is 10%. In this case any other cost, penalties or backcharge will not be accepted.

Any indemnity and compensation fees will not be accepted.

9 EFFECTIVE DATE OF CONTRACT

The CONTRACT shall be effective and the contractual delivery period shall start when the following conditions are all fulfilled.

A Letter of Award by and between CLIENT and VENDOR.

10 PERMITS AND LICENSES

CLIENT shall be responsible for obtaining all necessary approvals, permits and licenses from all government and/or municipal agencies having jurisdiction over the facility. The obligation of CLIENT to pay for the WORKS shall not in any manner be waived by the delay or failure to secure or renew, or by the cancellation of, any required licenses, permits or authorizations.

11 PROPRIETARY INFORMATION

CLIENT shall keep confidential and shall not, without the prior written consent of VENDOR, divulge to any third party not involved in the Power Plant construction any documents, data or other information furnished directly or indirectly by VENDOR in connection with the TECHNICAL PROPOSAL and this COMMERCIAL PROPOSAL. The Purchaser is responsible to ensure that the third party will not use these information.

12 ASSIGNMENT

There shall be no assignment by either party without prior written approval of the other party.

13 VALIDITY OF THE PROPOSAL

We consider this proposal to be valid until August 22 th, 2011.

14 PENALITIES AND LIQUIDATED DAMAGES

The aggregated maximum liquidated damage overall accepted by the VENDOR is 10% (ten percent) of the Contract Value.

14.1 Liquidated damages for Documentation Delivery and Supply Delays:
The Maximum liquidated damages for Documentation Delivery Delay is 0,1% per day limitated to 2,0% (two percent).of the amount the Contract Value.

The Maximum liquidated damages for Supply Delays is is 0,1% per day limitated to 3,0% (three percent).of the amount the Contract Value.

14.2 Liquidated damages for Performance
The Maximum liquidated damages for Performance is 5,0% (five percent).of the amount the Contract Value.

15 CANCELLATIONS

Cancellation for VENDOR's defaut by CLIENT:

15.1 If VENDOR is not executing the supply in accordance with or as specified in the CONTRACT.

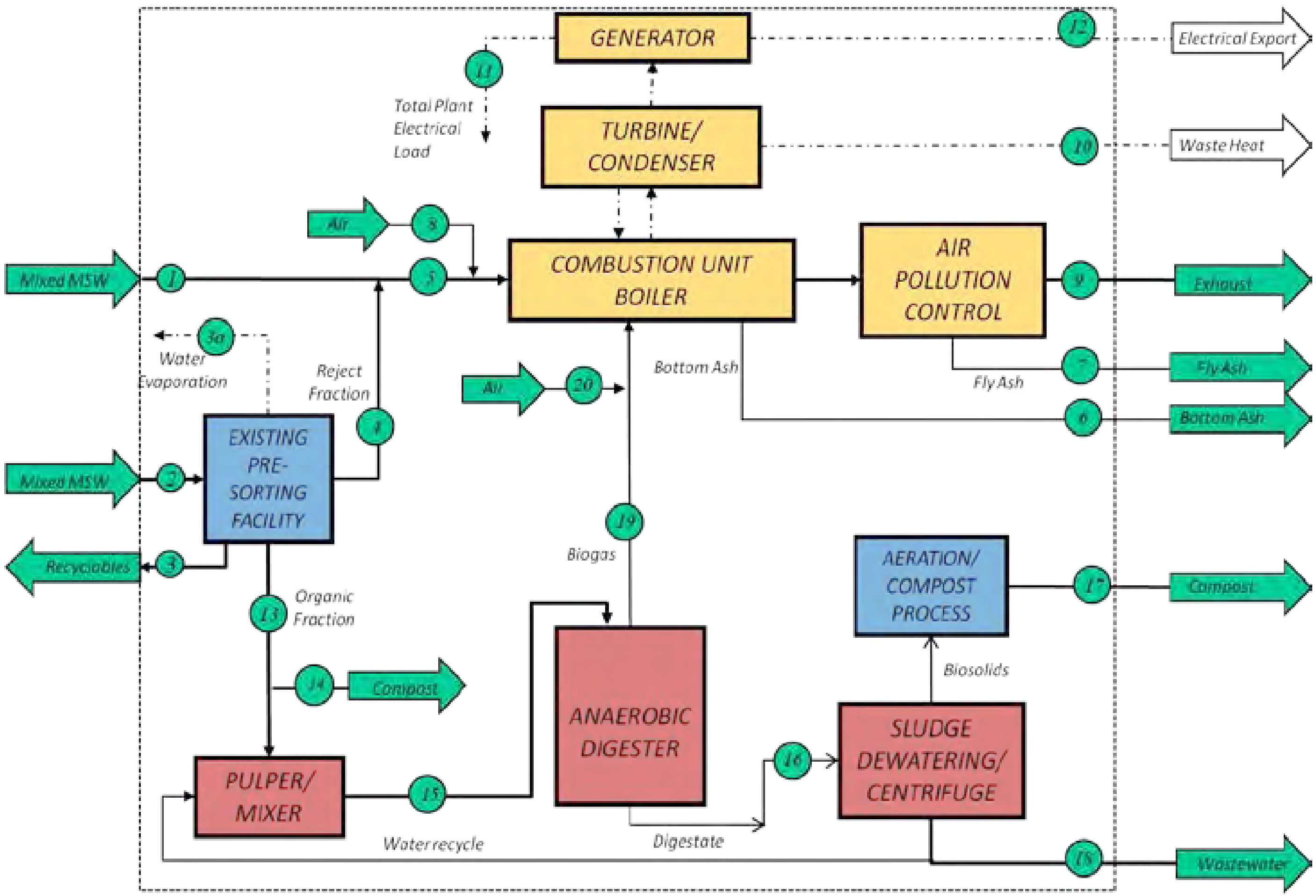
Cancellation for CLIENT's defaut by VENDOR:

15.2 If the payment not be released up to 30 days of the scheduled payment date of each event of the contract gives the rights to the VENDOR to cancel the Contract.

The CONTRACT can be cancelled through a notification to both parties in case of:

- Insolvency or bankruptcy
- Interruption of the Company activities by Authorities.

Appendix 4-A - Mass and Energy Balance



Stream	1	2	3	3a	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
	MSW direct to Combustion	MSW to Sorting	Recyclables from Sorting	Water loss	Rejects from Sorting	Total Feed to Furnace	Bottom Ash	Fly Ash	Furnace Combustion Air	Furnace Exhaust	Waste Heat	Plant Electrical Load	Electrical Export	Organic Fraction from Sorting	Organic Fraction to Compost	Feed to Digestor	Digestate	AD Residual Solids	Waste water	Biogas	Biogas Combustion Air
Mass Flow (tpd)	900	800	46	38	502	1,402	161	5	235,400	284,900	-	-	-	214	165	49	43	18	24	230	1,400
Energy (2) (MW)	83	74.1	7.1	-	56.1	139.39	1.83	0.06	-	24.97	78.39	5.31	30.07	10.8	8.3	2.5	1.3	1.3	-	1.2	-

Appendix 4-B - Financial Model Base Case

Inputs 2011 US Dollars

Waste Escalation	0%
Borrowing Cost	9.5%
Interest Rate/Reinvestment	1.0%
Electric Sales Rate ($/kWh)	$ 115.00
Compost Sales Rate	$ 9.00
Tipping Fee Escalation	0.0%
Inflation Rate (O&M)	5.0%
Electric Sales Escalation Rate	1.0%
Compost Sales Escalation Rate	0.0%

Ferrous Metals ($/ton)	$ 40.00
Non-Ferrous Metals ($/ton)	$ 400.00
Tipping Fee ($/ton)	$ 25.00
Bottom Ash Disp Fee ($/ton)	$ 25.00
Fly Ash Disp Fee ($/ton)	$ 400.00
Combust O&M ($/ton)	$ 29.00
CDM CER Rate	$ 8.00
CDM CER Escalation Rate	0.0%

Tax Rates	
COFINS	7.60%
PIS	1.65%
IRPJ *	25%
CSLL	9%

* 15% rate applies up to 134,000 USD

Construction Cost ($1000)	
Land Acquisition Costs	$ -
Site and Civil	$ 2,000
Pre-processing	$ -
AD plant	$ 7,115
Mass burn Combustion	$ 293,752
Total Construction Cost	$ 302,900
Indirect Cost (permit, legal, procure, etc)	$ 10,700
Total Project Cost	$ 314,000

Preliminary Economic Analysis of Rio WTE Facility Operations

Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Waste Data (metric tons)																				
Waste Delivered	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000	558,000
Ferrous Metals Recovered	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
Non-Ferrous Metals Recovered	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Non-Processibles Disposal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Waste to Combustion System	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000	459,000
AD System Dewatered Solids (to compost)	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Bottom Ash Generation (to disposal)	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000	81,000
Fly Ash Generation (to disposal)	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Net Compost Produced	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100	33,100
Net Electrical Generation - Combustion System (MWh)	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000	238,000
Emissions Reduction (0.06 mt CO_2e/mt MSW)	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540	27,540
Revenue ($1000)																				
Tipping Fee ($/ton)	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00	$ 25.00
Tipping Fees Revenue	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950	$ 13,950
Ferrous Metals	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120	$ 120
Non-Ferrous Metals	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400	$ 400
Compost	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298	$ 298
Net Electric Sales - Combustion System	$ 27,370	$ 27,644	$ 27,920	$ 28,199	$ 28,481	$ 28,766	$ 29,054	$ 29,344	$ 29,638	$ 29,934	$ 30,234	$ 30,536	$ 30,841	$ 31,150	$ 31,461	$ 31,776	$ 32,093	$ 32,414	$ 32,739	$ 33,066
Sale of Clean Development CER's	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220	$ 220
Additional Revenue	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Total Revenues	**$ 42,358**	**$ 42,632**	**$ 42,908**	**$ 43,188**	**$ 43,470**	**$ 43,754**	**$ 44,042**	**$ 44,333**	**$ 44,626**	**$ 44,922**	**$ 45,222**	**$ 45,524**	**$ 45,829**	**$ 46,138**	**$ 46,449**	**$ 46,764**	**$ 47,082**	**$ 47,403**	**$ 47,727**	**$ 48,054**
Expenses ($1000)																				
Principal & Interest	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632	$ 35,632
Capital Replacement Reserve (10 yr)	$ 500	$ 525	$ 551	$ 579	$ 608	$ 638	$ 670	$ 704	$ 739	$ 776	$ 814	$ 855	$ 898	$ 943	$ 990	$ 1,039	$ 1,091	$ 1,146	$ 1,203	$ 1,263
Operations & Maintenance																				
Pre-Processing - Maintenance Labor & Supplies	$ 144	$ 151	$ 159	$ 167	$ 175	$ 184	$ 193	$ 203	$ 213	$ 223	$ 235	$ 246	$ 259	$ 272	$ 285	$ 299	$ 314	$ 330	$ 347	$ 364
AD - Maintenance Labor & Supplies	$ 120	$ 126	$ 132	$ 139	$ 146	$ 153	$ 161	$ 169	$ 177	$ 186	$ 195	$ 205	$ 216	$ 226	$ 238	$ 249	$ 262	$ 275	$ 289	$ 303
AD System - Operations Labor	$ 110	$ 116	$ 121	$ 127	$ 134	$ 140	$ 147	$ 155	$ 163	$ 171	$ 179	$ 188	$ 198	$ 207	$ 218	$ 229	$ 240	$ 252	$ 265	$ 278
O&M Combustion	$ 13,311	$ 13,977	$ 14,675	$ 15,409	$ 16,180	$ 16,989	$ 17,838	$ 18,730	$ 19,666	$ 20,650	$ 21,682	$ 22,766	$ 23,905	$ 25,100	$ 26,355	$ 27,673	$ 29,056	$ 30,509	$ 32,035	$ 33,636
Miscellaneous Expense (Allowance)	$ 250	$ 263	$ 276	$ 289	$ 304	$ 319	$ 335	$ 352	$ 369	$ 388	$ 407	$ 428	$ 449	$ 471	$ 495	$ 520	$ 546	$ 573	$ 602	$ 632
Disposal - Non-processibles	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Disposal - AD Dewatered Solids	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Disposal - Combustion Bottom Ash Residue	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025	$ 2,025
Disposal - Combustion Fly Ash	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914	$ 914
Total Expenses	**$ 53,006**	**$ 53,728**	**$ 54,486**	**$ 55,281**	**$ 56,117**	**$ 56,994**	**$ 57,915**	**$ 58,882**	**$ 59,898**	**$ 60,964**	**$ 62,084**	**$ 63,260**	**$ 64,494**	**$ 65,790**	**$ 67,151**	**$ 68,580**	**$ 70,081**	**$ 71,656**	**$ 73,311**	**$ 75,047**
Project Analysis																				
Excess Revenue (shortfall) [$1000s]	**$ (10,648)**	**$ (11,096)**	**$ (11,577)**	**$ (12,094)**	**$ (12,647)**	**$ (13,240)**	**$ (13,873)**	**$ (14,550)**	**$ (15,272)**	**$ (16,042)**	**$ (16,862)**	**$ (17,736)**	**$ (18,665)**	**$ (19,652)**	**$ (20,702)**	**$ (21,816)**	**$ (22,999)**	**$ (24,254)**	**$ (25,584)**	**$ (26,993)**
TAX - PIS	$ 699	$ 703	$ 708	$ 713	$ 717	$ 722	$ 727	$ 731	$ 736	$ 741	$ 746	$ 751	$ 756	$ 761	$ 766	$ 772	$ 777	$ 782	$ 787	$ 793
TAX - COFINS	$ 3,219	$ 3,240	$ 3,261	$ 3,282	$ 3,304	$ 3,325	$ 3,347	$ 3,369	$ 3,392	$ 3,414	$ 3,437	$ 3,460	$ 3,483	$ 3,506	$ 3,530	$ 3,554	$ 3,578	$ 3,603	$ 3,627	$ 3,652
Operating Profit	$ (14,566)	$ (15,039)	$ (15,546)	$ (16,089)	$ (16,668)	$ (17,287)	$ (17,947)	$ (18,651)	$ (19,400)	$ (20,197)	$ (21,045)	$ (21,947)	$ (22,904)	$ (23,920)	$ (24,999)	$ (26,142)	$ (27,354)	$ (28,638)	$ (29,998)	$ (31,438)
TAX - IRPJ	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
TAX - CSLL	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Profit After Tax (PIS, COFINS, IRPJ, CSLL)	**$ (14,566)**	**$ (15,039)**	**$ (15,546)**	**$ (16,089)**	**$ (16,668)**	**$ (17,287)**	**$ (17,947)**	**$ (18,651)**	**$ (19,400)**	**$ (20,197)**	**$ (21,045)**	**$ (21,947)**	**$ (22,904)**	**$ (23,920)**	**$ (24,999)**	**$ (26,142)**	**$ (27,354)**	**$ (28,638)**	**$ (29,998)**	**$ (31,438)**

Net Present Value (2011 $US) [$1000s]	($250,700)
Internal Rate of Return	-100.0%

MALCOLM PIRNIE

MPX Uma empresa do Grupo EEX

Appendix 4-C - Preliminary Operating Cost

Mass Burn WTE - Operating and Maintenance Cost Data

Item	Category	1400 mtpd (2 * 700)			
		Unit	Consumption per tonne processed	unit price USD	Price per metric tonne processed
1.0	O&M Labor [(2)]	annual		$1,766,400	$3.84
2.0	Major Maintenace [(3)]	annual		$5,000,000	$10.87
3.0	Repair and Maint Parts	annual		$2,000,000	$4.35
4.0	Reagents [(4)]				
4.11	Lime	kg	8.6	$0.08	$0.69
4.12	Carbon	kg	0.2	$1.00	$0.19
4.13	Ammonia [(5)]	kg	2.4	$0.55	$1.32
4.14	Other Chemicals[(6)]	-			$0.06
4.2	Supplementary Fuel	MMBtu	0.2	$7.00	$1.43
4.3	Water	klitres	2.0	$0.95	$1.90
4.4	Purchased electricity	kWh	1.1	$0.05	$0.06
5.0	Regulatory				$0.20
6.0	Insurance				$0.50
7.0	Taxes				$0.50
8.0	Other conumables				$0.05
	Total of above				$26.15
	Profit, 10%				$2.62
	Grand Total				$28.77
				Rounded	**$29.00**
	Total				

Notes:

1 Design throughput 459,900 mt annual
Cost of Equipment 100 MM USD
2 Operating Labor for two lines, FTE = 46 $ 38,400 = Burdened Salary (Brazil)
3 Labour = 5% of original equipment cost annually
Major Parts = 2% of original equipment cost annually
4 Price Data based on US sourded materials
Consumable rates adjusted for lower HHV = 4000
5 Emission factor = 2 kg NOx/ tonne MSW
6 Includes water treatment, boiler water and cooling tower chemicals
7 Purchased elecrtricity includes for occasional plant stops and a 3-weekly turbine maintenance outage every 6 years

Appendix 5-A - Description of Air Pollution Control System

Appendix 5-A: Description of Air Pollution Control System for a Mass Burn WTE Plant

The following pages summarise the air pollution control equipment for the proposed enterprise. These control technologies have proven successful in achieving permit emission limits for waste to energy plants in the USA and Europe. Depending on the actual permit conditions applied to the Caju site, additional NOx control and continuous emissions monitoring system (CEMS) may also be required.

The combustion train is furnished with a semi-dry scrubber; reagent injection systems (lime and powdered activated carbon); baghouse; induced draft fan, SNCR NO_x control system, flued stack; and all necessary ductwork, ancillary and accessory equipment for removal of HCl, SO_2, Hg, dioxin, NO_x and particulates from flue gas. The air pollution control system will beinstalled outdoors, and designed to meet emission limits for various regulated pollutants.

Acid Gas Control System

Control of HCl, HF and SO2 in the flue gas is achieved by bringing it into contact with a lime slurry. The semi-dry scrubber is designed to treat the flue gas as it leaves the economizer section of the boiler. The design temperature of the flue gases exiting the reaction chamber should be approximately 140 – 150 ^{o}C. Atomization and spraying of water should result in complete evaporation of the water without wetting of walls and causing deposit formations. Flue gas residence time should be sufficient to provide for the efficient removal of acid gas emissions. The semi-dry scrubber system should include: spray dryer/absorbers, pebble lime storage silos, lime feeders, lime slakers, slurry storage tanks, slurry pumps, complete piping, nozzles for slurry spray, reaction chambers, heat insulation, and process controls. In lieu of a spray dryer/absorber and baghouse system a lime-based semi-dry system (or a variation thereof) with ash recirculation and associated baghouse may be provided.

Semi-dry Spray Dryer/Absorber Vessel (or Semi-dry Scrubber) – The scrubber vessel consists of an inlet flue gas distribution head, reaction area and a conical product collection hopper, and side flue gas exit or approved equal. The vessel design includes provisions for cleaning solids buildup within the vessel, especially at the collection hopper.

The spray dryer/absorber (SDA) should be designed with a separate flue gas discharge and a separate discharge for solid materials that may fall out in the scrubber.

Atomizers – Either of the two lime slurry atomization methods (rotary atomizer or dual fluid nozzles) is provided.

Reagent Storage/Feed Equipment – Carbon steel reagent storage silo(s) sized for minimum seven (7) days operation at nominal waste throughput is provided. A lime slaking and lime slurry system is provided for the SDA system.

Semi-dry Scrubber Control - The system is designed to operate continuously and automatically over a range of 75% of design MCR to the peak design requirements necessary to cover all conditions. The overall air pollution control system is through the distributed control system (DCS) utilizing the control room interface. Total slurry/hydrated lime feed to the air pollution control system is controlled based on the spray dryer/absorber outlet temperature and SO_2 emission levels.

The SDA outlet temperature should be controlled by varying the amount of dilution water added to the slurry/reactor chamber being pumped to the atomizers.

Carbon Injection System

Activated carbon adsorbs volatile mercury in the flue gas as well as volatile organic carbon, including dioxins and furans. The carbon injection system is designed to inject activated carbon into the flue gas ductwork entering the scrubber or into the recirculation-type semi-dry reactor chamber. The system is designed to receive activated carbon delivered either by bulk bag or pneumatically from bulk tank trucks. The silo is sized to receive one truckload of activated carbon.

The system is designed to feed carbon product in a controlled manner from the storage silo(s) into the injection system.

The carbon injection system is installed fully enclosed. All piping joints and connections, including any flexible hose type connection should provide leak-free operation.

Baghouse

The air pollution control system is equipped with a multi-module fabric filter baghouse, including a cleaning system with controls, compartment isolation system and ash collecting hoppers with heaters installed at the lower third of each hopper. The baghouse is designed to achieve the specified outlet particulate concentration requirements.

The baghouse unit contains a minimum of six (6) compartments. Baghouse compartments should be completely independent from the gas flow to permit maintenance on any isolated compartment during full load operation of the Facility. Maximum design air-to-cloth ratio, with one compartment offline for cleaning under the maximum flue gas flow conditions should be 3.2 cfm/sf.

The baghouses are designed for continuous operation at the specified conditions and for a long bag life. This design temperature should protect the bags in the event of a scrubber lime slurry atomization system failure. The baghouse casing is of welded steel construction. Each compartment is furnished with one pyramidal shaped hopper to collect ash. The maximum bag length should not exceed eight (8) m, subject to supplier's proven experience in waste-to-energy facilities. Fabric material should be minimum 22 ounces/square yard woven fiberglass acid resistant finish, and PTFE membrane or similar material. Bags are to be cleaned by pulse jets. Off-line cleaning should occur by automatically closing the module outlet isolation damper.

Selective Non-Catalytic Reduction System

The design performance of the SNCR system is coordinated with the furnace NOx control performance. The system is designed to inject aqueous ammonia or urea into the furnace. Additional NOx control enhancements, such as flue gas recirculation may also be included. Required tanks, pumps, injection nodes, distribution systems, metering, circulation systems, heaters, compressed air, piping, instrumentation and controls, and auxiliary equipment necessary for a complete SNCR system are provided.

The maximum concentration of aqueous ammonia stored on site should be 19% by weight unless the local authority permits a higher concentration. Storage capacity of aqueous ammonia is for a minimum of seven (7) days. Locations, quantity, and orientation of injection ports are properly coordinated with the furnace/boiler design. The ammonia storage tank is constructed of carbon steel.

The design for urea (if urea is used as an alternative to ammonia) includes a minimum storage capacity of seven days of 50% concentrate urea solution. Piping and tubing are stainless steel.

Induced Draft Fans

The boiler is equipped with an electrically driven induced draft fan installed at the discharge of the baghouse and is designed to handle the flue gas quantity leaving the air pollution control system. The test block capacity provides needed margin for all operating conditions. The induced draft fan is designed for continuous operation at the maximum temperature of the economizer outlet. The induced draft fan is coupled to an electric motor drive with boiler draft control from the fan inlet dampers, or as an alternative, provided with variable frequency drive.

Stack

The stack is free standing on its own foundation. The stack cross-section is round in shape. The stack height is such that the top of the flue is based on air emissions modeling. The stack design requirements are as follows:

- § The stack is designed and erected in accordance with “Minimum Design Loads for Buildings and Other Structures” (ASCE) and in accordance with all other applicable codes and regulations. The stack is designed for all conditions, loads and effects to which it may be subjected, including wind loading, thermal load, earthquake loading, dead loading, reaction forces, and vibration effects from vortices produced. Measures to reduce or eliminate nuisance noise propagation to nearby residences need to be considered in the design of the stack.

- Height of the stack has been established based on considerations of residual pollutant dispersion analysis. The flue liner has a circular cross-section.

- Stack silencers can be used, if necessary to reduce noise.

- The insulation for the stack liner is designed to maintain gas exit temperature at not more than 12^{o}C loss in temperature exiting the scrubber. The top 3-4 m of flue liner should be of 316 L stainless steel. The liner is self-venting (i.e., no positive pressures at the stack base) at all loads. A strobe light is provided at the top of the stack at the highest point.

- Consideration should be given to sizing the stack diameter to accommodate a second flue in anticipation of expansion to the facility combustion system.

Appendix 6-A-1 - ANEEL – Normative Resolution #271, of July 3, 2007

Appendix 6-A-2- ANEEL – Normative Resolution #304, of March 4, 2008

Appendix 6-A-3 - ANEEL – Order #4080, of December 27, 2010

Appendix 6-A-4 - Ordinance #319, of September 26, 2008

APPENDIX 6-A

LAWS AND REGULATIONS

A-1: ANEEL – NORMATIVE RESOLUTION #271, OF JULY 3, 2007

A-2: ANEEL – NORMATIVE RESOLUTION #304, OF MARCH 4, 2008

A-3: ANEEL – ORDER #4080, OF DECEMBER 27, 2010

A-4: ORDINANCE #319, OF SEPTEMBER 26, 2008

FRAMEWORK ON THE SPECIAL INCENTIVE SCHEME FOR THE DEVELOPMENT OF INFRASTRUCTURE – REIDI

These laws and regulations have been translated to English from the original Portuguese text, using an automated translation tool. Their inclusion here is intended to convey general concepts covered in the law, rather than precise legal or technical meanings.

Appendix A-1: ANEEL – NORMATIVE RESOLUTION #271, OF JULY 3, 2007

AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA (National Agency of Electrical Energy) – ANEEL
NORMATIVE RESOLUTION #271, OF JULY 3rd, 2007
Changes the wording of the articles 1 and 3 of the Normative Resolution #77, of August 18th 2004
(*) See changes and additions in the end of the text
Report
Vote

The CEO of the AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA - ANEEL, in the use of his regimental assignments, according to resolution of the Board, taking into consideration the provision in article 26, §§ 1, 5 and 8, of Law #9427, of December 26th, 1996, with wording given by article 17 of Law #10438, April 26th, 2002, and by article 21 of Law #11488, of June 15th, 2007, in article 7 of Decree #2655, of July 2nd, 1998, based on article 4, item III, Attachment I, of Decree #2335, of October 6th, 1997, in Normative Resolution #77, of August 18th, 2004, which appears in Process # 48500.004606/03-53, whereas:

The contributions received between February 5th, 2007 and March 5th, 2007, period of the performance of the Public Hearing (*Audiência Pública*) #002/2007, by documental exchange, were object of analysis of ANEEL and allowed the improving of this regulating act, resolves:

Article 1 Change articles 1 and 3 of the Normative Resolution #77, of August 18th, 2004, that become effective with the following wording:

"Art. 1 Establish, in the form of this Resolution, the procedures related to the reduction of the use fees of the electrical systems of transmission and distribution, applicable to the hydroelectric enterprises with power equal to or less than 1000 (one thousand) kW, for those characterized as a small hydroelectric system and those based on solar, wind, biomass or qualified co-generation resources, according to the regulation of ANEEL, the power of which injected in the systems of transmission or distribution is less than or equal to 30,000 (thirty thousand) kW, focusing on the production and consumption of the energy marketed by the use".

....

"Art. 3 It is assured the right to 100% of reduction, to be applied to the usage fees of the electrical systems of transmission and distribution, focusing on the production and on the consumption of the energy marketed by the enterprises to which the article 1 of this Resolution is referred, as long as it meets one of the following conditions:

....

IV – those who use as energy input, at least, 50% (fifty percent) of **biomass** composed of urban solid wastes and/or sanitary landfill biogas or biodigestors of vegetal or animal waste, as well as sludge sewage treatment plants.

....

(Sheet. 2 of the Normative Resolution #271 of July 3rd, 2007)

§ 3 Those responsible for the enterprises mentioned in item IV, in possession of the Environment Installation License, must ask ANEEL for the emission of the referred authorized act."

Art. 2 The menu of Normative Resolution #077, 2004, goes into effect with the following wording:

"Establishes the procedures related to the reduction of the use fees of the electrical systems of transmission and distribution, applicable to the hydroelectric enterprises and those based on solar, wind, **biomass** or qualified co-generation resources the power of which injected in the systems of transmission or distribution is less than or equal to 30,000 kW".

Art. 3 This Resolution goes into effect on its date of publication.

JERSON KELMAN

This text does not substitute the one published on the Official Gazette (D.O.) of 07.18.2007, section 1, p. 94, v. 144, n. 137.

(*) Text in bold with altered wording according to adjustment published on the D.O. of 07.25.2007, section 1, p. 60, v. 144, n. 142.

Appendix A-2: ANEEL – NORMATIVE RESOLUTION #304, OF MARCH 4, 2008.

AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA (National Agency of Electrical Energy) – ANEEL
NORMATIVE RESOLUTION #304, OF MARCH 4th, 2008.

Changes provisions of the Resolution #371, of December 29th, 1999, that regulates the contracting and marketing of the capacity reservation by self producer or independent producer to meet the consumer unit directly connected to its installations of generation, and provide other procedures.

Report
Vote

The CEO of the AGÊNCIA NACIONAL DE ENERGIA ELÉTRICA - ANEEL, in the use of his regimental assignments, according to resolution of the Board, taking into consideration the provision in article 9 of Law #9648, of May 27th, 1998, in Resolution #281, of October 1st, 1999, based on article 1 of Decree #4932, of December 23rd, 2003, with wording given by Decree #4970, of January 30th, 2004, which appears in Process #48500.005357/2006-39, whereas:

The need to promote the energy rationalizing, where the implantation of distributed generation, in industrial, commercial and service facilities, contributes to the improvement of the reliability of the electrical systems, reducing investments and costs; and

The Public Hearing #001/2007, by documental exchange, performed in the period between January 26th to March 2nd, 2007, that allowed the collection of subsidies to improve this regulating act, resolves:

Art. 1 Change articles 1, 2, 3, 4 and 5 of Resolution #371, of December 29th, 1999, that goes into effect with the following wording:

"Art. 1 Establish, in the form of this Resolution, the general conditions for the contracting of capacity reservation for self producer or independent power producer, the producing unit of which meets, totally or partly, consumer directly connected to its installations of generation.

§ 1º The Capacity reservation is the sum of usage, in MW, required of the electrical systems of transmission or of distribution for supplying one or more consumer units directly connected to the self producing plant or the independent energy producer plant, when there are interruptions or temporary reductions in the generation of electrical energy of the mentioned plant, additionally to the sum of usage already hired permanently to attend the mentioned consumer units

§ 2 the contracting of capacity reservation is optional and it's urgent, it may be performed for planned maintenance that require interruption or reduction in the generation of electrical energy, being prohibited its hiring for any other purpose.

§ 3 The execution of the request of capacity reservation must be done based on the usage of the remaining capacity of the electrical system of transmission or distribution, the existence of this capacity must be evaluated at the beginning of every contractual cycle in a feedback issued by ONS or by the concessionaire or distribution permittee, depending on the installations accessed by the self producer or independent power producer.

§ 4 It is allowed the performance of services on the electrical system of distribution, according to the procedures established in article 5-A of this Resolution, when its electrical system of distribution accessed by the self producer or independent producer does not have the remaining capacity enough to meet the request of capacity reservation."

"Art. 2 The self producer or independent power producer is responsible for the installation of the measurement system needed for accounting and billing of the usage of the capacity reservation."

"Art. 3 The electrical energy destined to the usage of the capacity reservation, in MWh, except the cases in which the self producer or independent power producer is a participant of the Power Relocation Facility (*Mecanismo de Realocação de Energia – MRE*), must be acquired by the referred agent by one of the following:

I – in the Unregulated Contracting Environment – ACL – through bilateral contracting freely negotiated;

II – in the short term market to the Differences in Liquidated Prices – PLD –, when the agent the treats the caput has defined physical guarantee; or

III – with the concessionaire or permittee of accessed distribution, to its discretion, the regulated conditions must be applied.

Sole paragraph. In cases of acquisition of electrical energy regarding items I and II, the self producer or independent power producer must adhere to the Chamber for Electricity Trading (*Câmara de Comercialização de Energia Elétrica – CCEE*) or be represented by an agent who is member of this Chamber."

"Art. 4 The self producer or independent power producer that meets the conditions established in article 1 of this Resolution must perform the hiring of capacity reservation through the celebration of the specific Contract of Usage of the Transmission System (*Contrato de Uso do Sistema de Transmissão – CUST*) or of Contract of Usage of the Distribution System (*Contrato de Uso do Sistema de Distribuição – CUSD*), depending on the installations accessed by the contractor, in compliance with the Net Procedures or the Distribution Procedures, depending on the case.

§ 1 The contracting regarding the caput must be annual, and the contract should concern, amongst other aspects, the period in which it will be possible to use the capacity reservation, which must coincide with the period of generation of electrical energy of the plant of the contracting agent, whether full or seasonal.

§ 2 The contract of capacity reservation must be the only point of connection to the accessed electrical system and the value of the sum of usage of the systems of transmission or of distribution to be contracted must be limited to the value, in MW, of the installed rated power of generation of the contractor plant.

§ 3 In contracting the capacity reservation the following deadlines must be noted:
I – the execution of the request to the capacity reservation must be done at least 60 (sixty) days before and must not exceed 180 (a hundred and eighty) days;
II – the answer to the request, through the feedback regarding § 3 of article 1 of this Resolution, must be issued up to:
a) 30 (thirty) days, from the date the request was received; or
b) 120 (a hundred and twenty) days, counted from the date the request was received, when there is the necessity of works to be done in order to satisfy the request, as mentioned in § 4 of article 1 of this Resolution.
III – the contracting, by the celebration of specific CUST or CUSD, must be done up to 90 (ninety) days after the emission of the feedback mentioned on the previous item, without loss of priority service."
"Art. 5 The amount to be charged in the contract of capacity reservation by the use of electrical systems of transmission or distribution will be calculated by the following equation:

$$E_{RC} = (M_p \times T_p + M_{fp} \times T_{fp}) \times \frac{n_u}{n_m},$$

Where:

ERC: monthly charge by the use of the capacity reservation, in R$;
n_u: number of days in which the capacity reservation was used in the given month;
n_m: number of days in the given month;
T_p: usage fee of the system of transmission or distribution in the peak time for consumer units, in R$/kW;
T_{fp}: usage fee for the system of transmission or distribution in off-peak time for consumer units, in R$/kW;
M_p: sum of the usage of capacity reservation for the peak time, in kW, determined by the biggest value between that contracted and the verified by measurement in the given month, the referred amount must be one for the whole contractual cycle;

M_{fp}: sum of the usage of capacity reservation for the off-peak time, in kW, determined by the biggest value between that contracted and the verified by measurement in the given month, the referred amount must be one for the whole contractual cycle;

§ 1 In case, in a determined contractual cycle, the accumulated number of days in which the capacity reservation was used exceeds 60 (sixty) days, the rates applicable to the monthly charge calculation by the usage of the capacity reservation related to the exceeding days will be a value of four times the usage fees for the system of transmission or of distribution established for the peak and off-peak times.
§ 2 To the parcel of the sum of usage of capacity reservation verified by measurement superior to the contracted value it will be applied an exceeding fee three times the

applicable amount of the usage fee of the system of transmission or distribution established in each period, when the exceeding is verified to be more than 5% (five per cent) of the contracted amount, considering that nu = nm in the equation referred in the caput.

Article 2 article 5 was included in Resolution #371, of 1999, with the following wording:

"Article 5-A The works in the electrical system of distribution needed to the contracting of capacity reservation are the responsibility of the interested self producer or independent power producer, the beginning of its implementation must be preceded from the celebration of the CUSD to which article 4 in this Resolution refers to.

§ 1 The works to which the caput refers must be specified and its necessity justified through the feedback mentioned in § 3 of article 1 of this Resolution, which must have the history of calculation of the budgeted costs and physical and financial schedule for the performance of the works.

§ 2 After the emission of the feedback mentioned in § 1, the self producer or independent power producer have up to 90 (ninety) days to officially communicate to the concessionaire or permittee of accessed distribution their choice of performing the work by a third party legally licensed or by the accessed, according to budget and schedule presented in the feedback.

§ 3 In case of direct execution of the work, the accessee is responsible for elaborating the basic and executive projects, besides specifying the equipment that will be integrated to the electrical system of the concessionaire or permittee of accessed distribution, in compliance with the rules and technical standards and the Distribution Procedures.

§ 4 The implemented installations must be transferred to the concessionaire or permittee of accessed distribution and registered in its fixed asset, in compensation for Obligations Linked to the Concession of the Public Service of Electricity (Special Obligations), the referred transfers must occur by the building cost effectively performed informed by the transferor, not generating the right of repair to the self producer or independent power producer.

§ 5 The concessionaire or permittee of accessed distribution is responsible for the verification of the accordance of the specifications and the projects referred in § 3 in this article, as well as by the commissioning of the installations to be transferred, being the costs of reference for operation and maintenance of these installations considered in the calculation of its Usage Fee of the Distribution System (*Tarifa de Uso do Sistema de Distribuição – TUSD*).

§ 6 When the works referred to in the caput are executed for the execution of the request of capacity reservation in a determined contractual cycle, the self producer or independent power producer will have assured the value of the sum of the contracted usage in the referred cycle, in MW, in the later hiring of capacity reservation for a minimum period of 10 (ten) years.

Article 3 Change item II of article 4 of Resolution #715, of December 28th, 2001, that goes into effect with the following wording:

"Article 4 ....

II – for the accessees mentioned in item III of article 2, the charges will be due merely by the utilized period and proportionally calculated to the number of days;

....".

Art. 4 The current contracts related to capacity reservation should be adequate to the dispositions established in up to one year, from the publication date of this Resolution.

Art. 5 Article 23 of Resolution #281, of October 1st, 1999, and item V of article 2 of Resolution #715, 2001, are revoked.

Art. 6 This Resolution goes into effect on its date of publication.

JERSON KELMAN

This text does not substitute the one published in the D.O. of 03.13.2008, section 1, p. 56, v. 145, n.50.

Appendix A-3: ANEEL - ORDER #4080, OF DECEMBER 27, 2010

Selected example of Independent Power Producers from sanitary landfill gas and TFSEE requirements:

Auto Produtores e Produtores Independentes	Tipo	Empreendi-mento	UF	Potência (kW)	Ajuste 2009	Ajuste 2010	TFSEE 2011	TOTAL 2011	TOTAL 2011 MENSAL	Observações
São João Energia Ambiental S/A	UTE	São João Biogás	SP	21.560,00			41.581,69	41.581,69	3.465,14	
São Joaquim Energia S/A	PCH	São Joaquim	ES	21.000,00			40.501,65	40.501,65	3.375,14	
São Martinho S. A.	UTE	Iracema	SP	14.000,00			27.001,10	27.001,10	2.250,09	
São Miguel - Central Geradora de Energia Ltda	UTE	São Miguel	AL	13.200,00	-	8.415,60	25.458,18	33.873,78	2.822,81	Despacho nº 2.488/2010
São Pedro Energia S.A.	PCH	São Pedro	ES	30.000,00			57.859,50	57.859,50	4.821,63	
São Simão Energia S.A.	PCH	São Simão	ES	27.000,00			52.073,55	52.073,55	4.339,46	
Sengés Papel e Celulose Ltda	PCH	Jaguaricatu I	PR	2.200,00			4.243,03	4.243,03	353,59	
Sengés Papel e Celulose Ltda	PCH	Jaguaricatu II	PR	2.400,00			4.628,76	4.628,76	385,73	
Serra Negra Energética S/A	PCH	Piranhas	GO	18.000,00			34.715,70	34.715,70	2.892,98	
Siderúrgica Alterosa S.A.,	UTE	Alterosa	MG	6.000,00			11.571,90	11.571,90	964,33	
SIIF cinco Geração e comercialização de energia S.A.	EOL	Foz do Rio Choró	CE	25.200,00			48.601,98	48.601,98	4.050,17	
SPE Cocais Grande Energia S.A.	PCH	Cocais Grande	MG	10.000,00			19.286,50	19.286,50	1.607,21	
SPE Alto Irani Energia S/A	PCH	Alto Irani	SC	21.000,00			40.501,65	40.501,65	3.375,14	
SPE Millennium Central Geradora Eólica S.A.	EOL	Millennium	PB	10.200,00			19.672,23	19.672,23	1.639,35	
SPE Plano Alto Energia S/A (Centrais Elétricas da Mantiqueira)	PCH	Plano Alto	SC	16.000,00			30.858,40	30.858,40	2.571,53	
Suzano Papel e Celulose S/A	UTE	Suzano	SP	39.900,00			76.953,14	76.953,14	6.412,76	

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Proprietário	Empreendimento	UF	%Potência (kW)	Ajuste 2009	Ajuste 2010	TFSEE 2011	TOTAL 2011	TOTAL 2011 MENSAL	Observações
VALESUL Valesul Alumínio S/A	UHE Machadinho	RS/SC	94.537			182.328,36	182.328,36	15.194,03	
FURNAS Furnas Centrais Elétricas S/A	UHE Manso	MT	147.000			283.511,55	283.511,55	23.625,96	
PROMAN Produtores Energéticos de Manso S/A	UHE Manso	MT	63.000			121.504,95	121.504,95	10.125,41	
Coteminas S.A.	UHE Porto Estrela	MG	37.341			72.017,33	72.017,33	6.001,44	
CEMIG GT CEMIG Geração e Transmissão S/A	UHE Porto Estrela	MG	37.341			72.017,33	72.017,33	6.001,44	
CVRD Companhia Vale do Rio Doce	UHE Porto Estrela	MG	37.341			72.017,33	72.017,33	6.001,44	
CEBPAR CEB Participações S/A	UHE Queimado	GO/MG	18.375			35.438,94	35.438,94	2.953,25	
CEMIG GT CEMIG Geração e Transmissão S/A	UHE Queimado	GO/MG	86.625			167.069,31	167.069,31	13.922,44	
CVRD Companhia Vale do Rio Doce	UHE Risoleta Neves (ExCandonga)	MG	70.000			135.005,50	135.005,50	11.250,46	
NOVELIS Novelis do Brasil Ltda	UHE Risoleta Neves (ExCandonga)	MG	70.000			135.005,50	135.005,50	11.250,46	
Biogeração Energia S/A	UTE Bandeirante	SP	14.000			27.001,10	27.001,10	2.250,09	
UNIBANCO União de Bancos Brasileiros S.A.	UTE Bandeirante	SP	6.000			11.571,90	11.571,90	964,33	
Companhia Siderúrgica Vale do Pindaré	UTE Simasa	MA	4.000			7.714,60	7.714,60	642,88	
SIMASA Siderúrgica do Maranhão S/A	UTE Simasa	MA	4.000			7.714,60	7.714,60	642,88	
Andrade Açucar e Álcool S/A	UTE Ibitiúva Bioenergética (Ex.Destilaria Andrade)	SP	8.943		20.609,66	17.247,92	37.857,58	3.154,80	Despacho 1.490/2010
Ibitiúva Bioenergética S/A	UTE Ibitiúva Bioenergética (Ex.Destilaria Andrade)	SP	24.057		7.661,48	46.397,53	54.059,01	4.504,92	Despacho 1.490/2010

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Appendix A-4: Framework for the Special Incentive Scheme for the Development of Infrastructure – REIDI – ORDINANCE #319, OF SEPTEMBER 26

OFFICE OF THE MINISTER DECREE in 319, SEPTEMBER 26, 2008.

Establishes the procedure for the approval of projects for the generation, transmission and distribution of electric power to the Special System of Incentives for the Development of Infrastructure - REIDI, established by Law no. 11,488 , June 15, 2007, and regulated by the Decree no. 6,144 , July 3, 2007, and the other measures.

Original Text: http://www.aneel.gov.br/cedoc/prt2008319mme.pdf

English Translation:

THE MINISTER OF STATE FOR MINES AND ENERGY, in the use of the powers conferred on it by Article 8, single paragraph sections II and IV of the Constitution, with a view to the provisions in Art. 6 of Decree no. 6,144, July 3, 2007, with the text given by Decree no. 6,167, July 24, 2007, and no. 6,416 , March 28, 2008, addresses:

CHAPTER I REQUEST AND THE FRAMEWORK OF PROJECTS IN THE REIDI

Article 1

The legal person of private law, proprietor of granting permission, authorization or registration of generation, transmission or distribution of electricity, interested in enabling the Special Regime of incentives for the development of infrastructure - REIDI, should ask the National Electric Energy Agency - ANEEL on the framework of the respective project Infrastructure to the said scheme." (NR)

(wording given by MME Ordinance no. 86 of 03.20.2010)

§ 1° - Owner of the project:

I - the legal person that executes the project, incorporating the work of infrastructure to the fixed assets; or

II - in cases of projects executed in consortium:

a) the legal persons participating in the consortium, in which case all the legal persons must submit the required documentation; or

(b) the legal person leader of the consortium, in which case is only should submit the required documentation.

§ 2° - The request should include:

I - the business name and the number of the entry in the National Registry of Legal Person - CNPJ from the legal person owner of the project to be approved, which may require empowerment to the REIDI;

II - a description of the infrastructure project in the electrical energy sector, covering:

a) the name of the enterprise;

(b) the number of the process of the act of concession;

(c) the number of act of authorization, permission or grant;

(d) location: municipality and Unity of the Federation;

e) for generation projects: installed power in kW, number of machines, type of source and, in case of heat source, type of fuel;

(f) for transmission projects: voltage, power and Extension;

(g) for projects of distribution: materials and equipment for improving the infrastructure of the electric energy distribution;

III - the documentation required in arts. 4 °, 5° and 7° of this Ordinance, as the case; and

IV - in cases of projects executed in a consortium, the indication of option to which paragraph II of § 1 of art. 1 °.

§ 3° (repealed by Concierge MME no 127 of 02.23.2011).

Article 1-A

The legal person may request the approval of your project to the REIDI, prior to obtaining the respective grants, observed the following requirements:

I - must be winning bids of which they treat the sections II and III of art. 3, provided that approved and awarded the object of the event auction;

II - owner of the order of receipt of application for grant, issued by ANEEL, laid down in the Resolutions Normative ANEEL no. 390 and no. 391, both of 15 December 2009;

III - have the order of final approval of the basic project, issued by ANEEL, as has the Regulatory Resolutions ANEEL no. 343, December 9, 2008, and no. 412 of 5 October 2010;

§ 1) The legal person is exempted to inform the number of act of authorization, permission or grant;

§ 2 of the request for approval must be done by legal person for which will be granted the award;

§ 3 The approval of the project the REIDI, in the form of this article, it does not generate right to grant permission, this being requested approval for the account and risk of the applicant; and

§ 4 of the Decree of approval of the project to the REIDI, in accordance with this article, shall be canceled in case of non-issuance of grants, for any reason, the legal person whose project has been approved the REIDI." (NR)

(wording given by MME Decree No 127 of 02.23.2011)

(wording given previously By Decree MME no. 86 of 03.20.2010)

Article 2

ANEEL will examine the appropriateness of the request to the terms of the law and regulation of REIDI and conformity of the documents submitted.

§ 1° in the hypothesis to be failure observed in the instruction of the request, the applicant shall be summoned to settle the pending issues, within twenty days, counted as of subpoenas.

§ 2) Closed the analysis referred to in the caput, ANEEL shall deliver Letter to the Ministry of Mines and Energy - MME, listing the documents submitted, informing the data indicated in art. 1, § 2, of this ordinance, and attesting the conformity of the project.

§ 3 of the project will be considered approved the REIDI through the publication in the Official Gazette of the Administrative Rule specifies the MME." (NR)

(wording given by MME Ordinance no. 127 of 02.23.2011)

Article 3

For approval to the REIDI, the projects should be framed in one of the following categories:

I - projects of generation or transmission of electrical energy without a contract governed by the public power; (NR)

(wording given by MME Ordinance no. 403 of 10.20.2009)

II - projects of electric power generation with contract of energy marketing governed by the public power, due to participation of bidding, in the modality auction or in the modality called Public, held after January 22, 2007;

III - projects for the transmission of energy With electrical contract governed by the public power, due to participation of bidding, in the modality auction, held after January 22, 2007;

IV - projects of strengthening, improving and expanding facilities for the distribution of electrical energy;

V - projects for generation or transmission of electrical energy with contracts regulated by the public power traded before 22 January 2007;

VI - projects for strengthening and improving on the premises of electric energy transmission with Authorizing Resolution with date prior to 18 September 2007; and

VII - projects for strengthening and improving on the premises of electric energy transmission with Authorizing Resolution with date equal to or later September 18, 2007.

§ 1) For the purposes of this Ordinance, shall be considered as regulated by public power:

a) the contracts for the sale of electric energy in the environment governed - CCEAR;

(b) contracts of Distributed Generation, as art. 14 of the Decree no. 5,163 , July 30, 2004;

(c) the contracts resulting from the sale of electric energy framed in Incentive Program for Alternative Sources of Electrical Energy - PROINFA program, established by Law no. 10,438 , 26 April 2002;

(d) the contracts to supply energy to care the Public Service for the distribution of energy within the framework of isolated systems;

e) the Concession Contracts of Public Service for the transmission of electrical energy;

(f) the Concession Contracts of Public Service Distribution of electrical energy. "

(g) the contracts for the sale of Reserve Energy - CER." (NR)

(wording given by MME Ordinance no. 86 of 03.20.2010)

§ 2) For purposes of determining the date of the contract negotiations that this is the section V of the caput, the date of the respective Auction or Call public.

§ 3° The approval of the projects referred to in sections I, II and III of the caput of this article depends on, only, to request of the interested party in the form of this Decree, in which case there is a presumption that the impacts of REIDI have already been considered by the holder of the project.

§ 4° for the projects of which deals with section IV, ANEEL should consider the positive impact of the implementation of the REIDI in acquisitions and imports of goods and services by concessionaires and permit holders of public service for the distribution of electric energy, when determining the fixed assets in service that includes the Basis of remuneration for purposes of tariff review, according to methodology and criteria established by it.

§ 5) The approval of projects framed in sections V to VII of the caput of this article will depend on meeting the provisions of articles 4 °, 5 °, 6° and 7° of this Ordinance, as appropriate.

CHAPTER II OF THE PROJECTS OF GENERATION AND TRANSMISSION WITH CONTRACT GOVERNED BY PUBLIC AUTHORITIES PRIOR TO JANUARY 22, 2007

Article 4

For the compliance with the provisions of the § 1 art. 6 of the Decree no. 6,144, 2007, the legal person holder of generation project with CCEARs, with contracts for Distributed Generation, with contracts in the context of PROINFA, or with contracts of supply of energy in the context of isolated systems, with date of trading before the January 22, 2007, must submit, together the documentation required in art. 1 °, Additive contract providing for the incorporation of the positive impact of the implementation of the REIDI in the price of the contract, pursuant to Annex I of this Ordinance.

§ 1° - Within sixty days after the date of entry into commercial operation of the last generation Unit, the legal person empowered the REIDI should investigate the positive impact of the REIDI in accordance with the provisions of Annex II of this Ordinance and divert to ANEEL:

I - signing of the Declaration in Annex III of this ordinance;

II - opinion of independent audit firm, duly registered with the Securities and Exchange Commission - CVM, attesting to the accuracy of the value of the benefit calculated, based on the Formulas prepared in Annex II of this ordinance, and that has audited all of the goods and services tied to the project;

III - certified copy of the memory of calculation, signed by the Counter responsible, the total impact of discharged as the Provisions of this ordinance; and

IV - certified copy of the Tables Monthly dealt with in Annex IV of this Ordinance.

§ 2° - Showing co-enabling, for the purposes of the application of the Formulas listed in Annex II of this Ordinance, the owner of the project must:

I - send to ANEEL copy of the contract exclusively for the implementation of works on the project approved by Administrative Rule mentioned in § 3 of art. 2 °;

II - get close to the co-enabled report outlining the value total discharged tax suspended by REIDI, for each month, as posted in Fiscal Notes and calculated based on the tables Monthly dealt with in Annex V of this ordinance; and

III - get close to the co-authorized opinion of independent audit firm duly registered at the Securities and Exchange Commission - CVM, attesting to the accuracy of the value assessed on the basis of the Tables treated in Annex V of this Ordinance and the veracity of the information provided in the report provided for in paragraph II.

§ 3° - The legal person empowered or co-empowered the REIDI should keep under his care, for the possible supervision of ANEEL and other competent bodies, all of the fiscal notes arising from transactions to which they relate the sections I and II of article 2 of the Decree no. 6,144 , 2007, relating to purchases on REIDI, sorted monthly and accompanied by the tables drawn up in the mold of Annexs IV and V of this Ordinance and their memories of calculation.

Article 5

For the compliance with the provisions of the § 1 art. 6 of Decree no. 6,144 , 2007, the legal person holder project of Transmission Line with Concession Contract, with date of trading before the January 22, 2007, must submit, together the documentation required in art. 1 °, Additive contract providing for the incorporation of the positive impact of the implementation of the REIDI in the Concession Contract in accordance with Annex I of this Ordinance.

§ 1° in until sixty days after the date of entry into commercial operation of transmission facilities, the legal person empowered the REIDI should investigate the positive impact the REIDI in accordance with the annex VI of this Ordinance and divert to ANEEL:

I - the signing of the Declaration in Annex III of this ordinance;

II - opinion of independent audit firm duly registered at the Securities and Exchange Commission - CVM, attesting to the accuracy of the value of the benefit calculated on the basis of the formulae arranged in Annex VI of this ordinance, and that has audited all of the goods and services tied to the project;

III - certified copy of the memory of calculation, signed by the Counter responsible, the total impact of discharged as the Provisions of this ordinance; and

IV - certified copy of the Tables Monthly dealt with in Annex IV of this Ordinance.

§ 2° showing co-enabling, for the purposes of the application of the Formulas listed in Annex VI of this Ordinance, the owner of the project must:

I - send to ANEEL copy of the contract exclusively for the implementation of works on the project approved by Administrative Rule mentioned in § 3 of art. 2 of this Ordinance.

II - get close to the co-enabled report outlining the value total discharged of tax suspended by REIDI, for each month, as posted in the Notes tax is calculated on the basis of monthly tables treated in Annex V of this ordinance; and

III - get close to the co-authorized opinion of independent audit firm duly registered at the Securities and Exchange Commission - CVM, attesting to the accuracy of the value assessed on the basis of Tables dealt with in Annex V of this Ordinance and the veracity of the information provided in the report provided for in section II, this paragraph.

§ 3° the legal person empowered or co-empowered the REIDI should keep under his custody, for possible supervision of ANEEL and other competent bodies, all the Notes Tax arising from the transactions referred to in the sections I and II of article 2 of the Decree no. 6,144, 2007, relating to purchases on REIDI, sorted monthly and accompanied by the tables drawn up in the mold of Annexs IV and V of this Ordinance and the respective Memories of calculation.

CHAPTER III OF AUTHORIZATION OF PROJECT OF REINFORCEMENT AND IMPROVEMENT IN FACILITIES OF TRANSMISSION

Article 6

The Resolutions .projects for strengthening and improving the transmission facilities of electric energy published by ANEEL as from the date of publication of this ordinance will consider the impact of the benefit of the REIDI in establishment of Annual Revenue allowed.

Article 7

For compliance with the provisions of the § 1 art. 6 of Decree no. 6,144 , 2007, the legal person holder of project for strengthening and improvement in facilities of electric energy transmission with Authorizing Resolution published prior to the date September 18, 2007 must submit, together the documentation required in Article 1 of this Ordinance, declaration of incorporation of the positive impact of the application of REIDI in accordance with Annex VII of this Ordinance.

§ 1° for analysis of determination of the positive impact of reidi and approval of the reduction of the value of Annual Revenue allowed the legal person empowered the REIDI should, in up to sixty days from the date of entry into commercial operation, divert to ANEEL the documentation referred to in the § 2° and 3 °, art. 5) of this Ordinance.

§ 2 THE legal person empowered or co-empowered the REIDI should remain under his care, for the possible supervision of ANEEL and other competent bodies, all the Notes Tax arising from the transactions referred to in the sections I and II of article 2 of the Decree no. 6,144 , 2007, relating to purchases on REIDI, sorted monthly and accompanied by the tables drawn up in the mold of Annexs IV and V of this Ordinance and their memories of calculation.

§ 3° The Annual Revenue Allowed approved in accordance with § 1 of this article will assert from the date of entry into commercial operation of the enterprise, being that the amount received the greatest by the licensee, including the one resulting from the rate previously practiced, will be discounted of the plots of subsequent revenue, at a time to be determined by ANEEL.

CHAPTER IV FINAL PROVISIONS

Article 8

The acts of the review process of the project will be archived and available in ANEEL for consultation and supervision of the MME and of the organs of control.

Article 8-A

ANEEL, interpreting the standards applicable to the REIDI, according to the purposes for which it was intended, indicate solutions for cases not provided for in existing legislation." (NR)

(wording given by MME Ordinance no. 127 of 02.23.2011)

Article 9

This Ordinance shall enter into force on the date of its publication.

Article 10

MME no. 263, of September 17, 2007 is revoked, keeping you the purposes for energy projects approved on REIDI during their lifetime.

Also included in the legislation:

ANNEX I

MODEL CLAUSE TO BE INSERTED IN ADDITIVE CONTRACTUAL - CONTRACTS FOR THE SALE OF ENERGY IN THE MODALITY BY QUANTITY

ANNEX II

FORMULAS OF LEAD AFTER THE IMPACT OF THE REIDI

ANNEX III

DECLARATION OF THE VALUE OF THE POSITIVE IMPACT THAT CAN BE DEDUCTED FROM THE SALE PRICE OF THE CONTRACT FOR THE SALE OF ENERGY PER QUANTITY

ANNEX IV

TABLE OF FISCAL NOTES OF THE MONTH – HOLDER

ANNEX V

TABLE OF FISCAL NOTES OF THE MONTH - CO-ENABLED

ANNEX VI

FORMULA TO LEAD AFTER THE IMPACT OF THE REIDI - PROJECTS FOR AUTHORIZATION OR CONCESSION OF TRANSMISSION

ANNEX VII

STATEMENT OF CONSIDERATION OF IMPACTS THE REIDI

MALCOLM PIRNIE | ARCADIS

Appendix 7
Request for
Expression of
Interest

Appendix 7: Request for Expression of Interest

The Feasibility Study:

Malcolm Pirnie, a division of ARCADIS US (www.arcadis-us.com) is undertaking a feasibility study for a proposed WTE facility in the city of Rio de Janeiro. The client is MPX Energia SA, a private Brazilian energy developer and part of the EBX group (www.ebx.com.br). The feasibility study is sponsored by the US Trade and Development Agency (USTDA).

Although the results of the feasibility study are intended to be applicable for any potential site in Brazil, MPX have entered into an agreement with the waste management authority for the City of Rio (COMLURB) to use Caju transfer station as the site for this feasibility study.

The feasibility study is broken into nine tasks, as follows:

Task 1 - Assessment of Municipal Solid Waste (MSW) Supply and WTE Options

Task 2 - Evaluation of Proposed Options via Least Cost Analysis

Task 3 – Detailed Cost and Implementation Schedule Estimates

Task 4 – Economic Evaluation of the Selected Alternative

Task 5 – Environmental and Social/Economic Impact Assessment

Task 6 – Legal, Regulatory, and Institutional Review

Task 7 – Financing Options Review

Task 8 – Tender Document Preparation (Optional)

Task 9 – Final Report

As part of Task 7 **please advise your level of interest** in financing the project and the terms and conditions of your involvement. We hope to compile letters of intent on behalf of MPX, including terms and conditions where appropriate. I am the principle contact in the US, based in the Washington DC area and available for face to face meetings if preferred. We can also arrange meetings in Brazil.

US contact:

Tim Shelton – Timothy.Shelton@arcadis-us.com
+1 703. 389. 6624

Brazil Contact:

Vanessa Reich de Oliveira - vanessa.oliveira@mpx.com.br
+55 21 2555-4288

The Proposed Enterprise

The proposed facility will integrate COMLURB's existing MSW sorting facility and composting operation with a new combustion WTE facility. The financial model would include an agreement between MPX and COMLURB to jointly own and operate the facility. For the purpose of this study the integrated facility is treated as a single entity and the revenue and cost data are generated on this basis.

The facility is effectively four plants operating together as an integrated waste management system. The overall mass flow in metric tonnes per day (tpd) is as follows:

- Mechanical and manual sorting/recycling (800 tpd, existing)
- Organic fraction to aerobic digestion (composting) (165 tpd, existing)
- Organic fraction to anaerobic digestion (50 tpd, new plant)
- Recyclable, and moisture loss (85 tpd)
- Rejects to mass WTE plant (500 tpd)
- MSW direct to WTE plant (900 tpd)
- Mass burn combustion WTE plant (1400 tpd, new plant)

The largest part of the proposed facility is the mass burn waste to energy plant, preliminary design as follows:

- Average Throughput: 460,000 tons per annum (90% availability)
- Design Capacity: 1402 tpd
- MSW Lower Heating Value: 8.6 MJ/kg (average)
- Steam Generation (MCR): 140,000 kg/h
- Steam Condition at Turbine Inlet: 42 bar/400°C
- T-G Capacity: 44.1 MVA (Power Factor of 0.8)
- T-G Output (MCR): 35.3 MW
- Net Average Export: 30 MW

Plenty of detailed information is available - just let me know what you'd like to see. A preliminary cost estimate for the plant has been prepared, as follows:

Preliminary Capital Budget (2011 $US)	
Cost Component	Value
Land Acquisition Costs	$ -
Site and Civil for the AD plant	$2,000,000
AD plant	$7,150,000
Mass burn Combustion	$293,000,000
Total Construction Cost	$302,900,000
Additional (Permitting, Legal, Procurement, Due	$10,700,000
Total Project Cost	$314,000,000