THE WASTE CRISIS IN BRAZIL:
opportunity for waste-to-energy in Rio de Janeiro

### Waste Generation in Rio de Janeiro

<table>
<thead>
<tr>
<th>Category</th>
<th>2001 Population</th>
<th>2002 Population</th>
<th>Characteristics</th>
<th>Daily Mean</th>
<th>Annual Mean</th>
<th>% of Total</th>
<th>% of Previous Year</th>
<th>Per Capita</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic (DOM)</td>
<td>5,825,827</td>
<td>6,033,752</td>
<td>Daily Mean</td>
<td>3,095</td>
<td>1,425,175</td>
<td>47.8</td>
<td>-1.0</td>
<td>658.8</td>
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<tr>
<td>Public (PUB)</td>
<td></td>
<td></td>
<td>Annual Mean</td>
<td>2,849</td>
<td>1,039,636</td>
<td>34.9</td>
<td>7.5</td>
<td>480.7</td>
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<tr>
<td>Hospital (HOS)</td>
<td></td>
<td></td>
<td>% of Total</td>
<td>44</td>
<td>15,984</td>
<td>0.5</td>
<td>1.7</td>
<td>7.4</td>
</tr>
<tr>
<td>Generators (G)</td>
<td></td>
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<td>% of Annual</td>
<td>975</td>
<td>355,890</td>
<td>11.9</td>
<td>7.4</td>
<td>164.5</td>
</tr>
<tr>
<td>Others (OUT)</td>
<td></td>
<td></td>
<td>Per Capita</td>
<td>388</td>
<td>141,750</td>
<td>4.8</td>
<td>-36.0</td>
<td>65.5</td>
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<tr>
<td>Municipal (LI)</td>
<td>8,160</td>
<td>2,978,474</td>
<td>0.2</td>
<td>1,377,1</td>
<td>3,238,376</td>
<td>100.0</td>
<td>8.7</td>
<td>1,477.8</td>
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<tr>
<td>Prefeituras (P)</td>
<td>1,161</td>
<td>423,593</td>
<td>-6.5</td>
<td>1,066</td>
<td>388,235</td>
<td>-6.5</td>
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<tr>
<td>Total Received</td>
<td>9,321</td>
<td>3,402,067</td>
<td>0.5</td>
<td>9,958</td>
<td>3,634,511</td>
<td>6.8</td>
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</tbody>
</table>

WASTE GENERATION IN RIO DE JANEIRO
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Materia Orgânica</td>
<td>55.7</td>
<td>49.5</td>
<td>48.2</td>
<td>57.5</td>
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<tr>
<td>Papel, Papelão e Jomal</td>
<td>16.6</td>
<td>18.8</td>
<td>16.4</td>
<td>11.1</td>
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<tr>
<td>Embalagem Longa Vida</td>
<td>-</td>
<td>-</td>
<td>0.9</td>
<td>1.3</td>
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<tr>
<td>Plásticos (Mole e Duro), PET e Isopor</td>
<td>14.3</td>
<td>22.9</td>
<td>16.8</td>
<td>16.8</td>
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<tr>
<td>Metais Ferrosos</td>
<td>2.1</td>
<td>2.0</td>
<td>2.6</td>
<td>1.5</td>
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<tr>
<td>Metais Não Ferrosos (Alumínio)</td>
<td>0.7</td>
<td>0.9</td>
<td>0.7</td>
<td>0.7</td>
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<tr>
<td>Trapos, Panos, Couro e Borracha</td>
<td>5.7</td>
<td>3.0</td>
<td>*</td>
<td>4.1</td>
</tr>
<tr>
<td>Pilhas e Baterias</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Vidro</td>
<td>2.3</td>
<td>1.5</td>
<td>1.3</td>
<td>1.8</td>
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<tr>
<td>Terra e Pedra</td>
<td>-</td>
<td>0.2</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Madeira</td>
<td>-</td>
<td>1.3</td>
<td>2.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Diversos</td>
<td>2.6</td>
<td>-</td>
<td>9.3</td>
<td>1.0</td>
</tr>
</tbody>
</table>

* Trapos, Couros e Borracha foram incluídos nos diversos

**FABRICS, LEATHER & RUBBER INCLUDED IN OTHERS**

### Average Composition of Domestic Waste in City of São Paulo

### FINAL DESTINATION OF WASTE IN RIO DE JANEIRO

**GRAMACHO LANDFILL → 8,000 TON/D**

Was open dump – since 1996 has been recovered - will close 2005

**BANGU LANDFILL → 2,000 TON/D**

**PROBLEM → NEW PACIENCIA LANDFILL FACING DIFFICULTIES TO OBTAIN ENVIRONMENTAL LICENSE**
JULIO & SIMÕES BOUGHT A LARGE AREA (1.4 SQ. MILES) IN PACIENCIA (40 MILES AWAY FROM DOWNTOWN) WITH CAPACITY FOR 9,000 TON/DAY

AREA IS RESIDENTIAL AND THEY ARE FACING GREAT DIFFICULTY IN OBTAINNING ENVIRONMENTAL LICENSE
paciencia landfill aerial view

final paciencia landfill configuration
GRAMACHO LANDFILL-General view before recovery

Dumping area before landfill recovery
Open dump and fire before landfill recovery

Scavengers at the dumping site
Beginning of cover of the waste with clay 1996

Covered waste and internal roads
Biogas compressor house and flare

Biogas well and network connections
IN SUMMARY → SINCE THERE IS NO PLAN B, GRAMACHO LANDFILL WILL HAVE TO OPERATE AT GREAT RISK FOR THE ENVIRONMENT, INCLUDING SLIDING OF THE WASTE AND CONTAMINATION OF THE NEARBY GUANABARA BAY WITH LEACHATE.
CAJU TRANSFER STATION – 3,200 TON/DAY
10% RECYCLED (HIGH INCOME HOUSES)
90% TO GRAMACHO LANDFILL
PREPARE WASTE TO FEED “USINA VERDE”

BURN 30 TON/DAY OF MSW WITHOUT ENERGY RECOVERY → TESTING NEW GAS CLEANING SYSTEM
PLAN TO RECOVER 1 MW\text{e} INTRODUCING BOILER
ENERGY SITUATION IN BRAZIL

• HYDROPOWER $\rightarrow$ 90% (RAINS $\rightarrow$ CHEAP)

• THERMOELECTRIC $\rightarrow$ 6% (FUEL EXPENSIVE)

• NUCLEAR $\rightarrow$ 4% (STRATEGIC)
MAIN HYDROPOWER PLANTS IN BRAZIL

ENERGY BALANCE BETWEEN REGIONS
(TOTAL SEPTEMBER VALUES TILL 09/02/2004)
IN 2001 → DRAUGHT → POWER SHORTAGE → ENERGY RATIONING

ENERGY PRICES UP → US$ 250/MWh

GOVERNMENT (THROUGH PPA´s SIGNED BY PETROBRÁS) ENCOURAGED NEW THERMOELECTRIC PLANTS BURNING NATURAL GAS → US$ 50/MWh

IN 2002  HEAVY RAINS → RESERVOIRS FULL

PEOPLE SAVED ENERGY → POWER CONSUMPTION DROP → CHEAP HYDRO ENERGY AGAIN  @ US$ 10/MWh

THERMOELECTRIC POWER PLANTS CANNOT COMPETE AND ARE NOT OPERATING - PETROBRÁS IS LOSING MONEY PAYING THE CAPITAL PART OF PPA´s
TO FIX THIS SITUATION A NEW ENERGY MODEL IS BEING PROPOSED BY THE GOVERNMENT

NEW MODEL ENCOURAGES DISTRIBUTED POWER → COGENERATION (HEAT, COLD, WASTE?) → utilities must estimate market 5 years ahead and buy in energy auctions.

NEW POWER PLANTS SITUATION

HYDRO → PROBLEMS TO OBTAIN ENVIRONMENTAL LICENSE

THERMAL → NATURAL GAS FROM BOLIVIA THROUGH BOLIVIAN GAS PIPELINE BUT DISTRIBUTION BRANCHES NOT BUILT – WAITING FOR MARKET

WTE → CONVENTIONAL WTE PLANTS @ CURRENT TIPPING FEES NOT FEASIBLE (7 US$/TON)
POSSIBLE NEW MARKET NICHE

SMALL TO MEDIUM SIZE COMBINED CYCLE PLANTS BURNING NATURAL GAS AND WASTE CLOSE TO CONSUMER (DP) – ENHANCES NG MARKET - ALSO BETTER FOR THE ENVIRONMENT

TARGET → CONDOMINUMS (0.5 MW 1 TON/DAY)
SHOPPING CENTERS (5 MW 40 TON/DAY)
MID-SIZE TOWNS (25 MW 200 TON/DAY)
SIMPLE MATHEMATICAL MODEL

NATURAL GAS $\rightarrow$ US$ 3 / MMBTU

TIPPING FEE $\rightarrow$ US$ 7 / TON

GIVEN A GAS TURBINE WE CAN DETERMINE THE OPTIMUM WASTE AMOUNT TO BE INCINERATED

RESULTS

VALIDATION OF MODEL $\rightarrow$ ZABALGARBI IN SPAIN
GT GE LM6000 (46 Mwe) AND 792 TON/DAY (1850 Kcal/Kg)

MODEL YIELDS $\rightarrow$ STEAM TURBINE POWER = 54 Mwe
EFFECTIVE NG COST = US$ 11/ MWh
(TIPPING FEE = 7 US$/TON)
OTHER RESULTS

CASE 1 → GT GE10 + 220 TON/DAY (1722 Kcal/Kg)
TOTAL POWER = 23 MWe
EFFECTIVE NG COST = US$ 13/ MWh

CASE 2 → GT GE2 + 40 TON/DAY (1722 Kcal/Kg)
TOTAL POWER = 4.5 MWe
EFFECTIVE NG COST = US$ 14/ MWh
(for tipping fee of US$ 25/TON the effective NG cost will be = US$ 7/MWh)

ELECTRICITY PRICES IN BRAZIL

DOMESTIC TARIF → US$ 150/MWh
TAXES → 40% SALES TAX
THEN UTILITY GETS US$ 90/MWh

IN DP → NO SALE (SELF GENERATOR)
CONCLUSION → IF TOTAL GENERATING COST LESS THAN US$ 150/MWh (very high) → GOOD DEAL
OTHER POSSIBILITY

BUILD LARGE WTE PLANT IN GRAMACHO TO BURN LANDFILL GAS (FREE) IN GT AND FAIR PART OF THE WASTE THAT WOULD BE LANDFILLED ➞ 100 OR 200 MWe

IF LANDFILL GAS NOT ENOUGH PETROBRAS OIL REFINARY NEXT DOOR ➞ IDEAL AREA

THIS PLANT WOULD BURN ALMOST 100% OF BIOMASS

HUGE CARBON CREDITS FROM KYOTO´S CDM

MEGA PROJECT PROPOSAL

PETROBRAS BUILT 1 GW THERMOELECTRIC PLANT NEXT DOOR TO GRAMACHO LANDFILL ➞ NATURAL GAS, OPEN CYCLE

CAN INTRODUCE COMBINED CYCLE WITH WASTE

WILL TAKE CARE OF ALL DOMESTIC WASTE CURRENTLY DISPOSED IN GRAMACHO LANDFILL
CONCLUSIONS

1. BEFORE GOING TO LARGE WTE PLANTS BETTER TO BUILD SMALL ONES TO DEVELOP EXPERIENCE AND EASE ACCEPTANCE

2. SMALL DP WTE PLANTS ARE ECONOMICALLY FEASIBLE WITH COMBINED CYCLE NG/WASTE WITH COGENERATION → CHP + WTE (no collection and disposal fees also no energy sales tax 40%)

3. LARGE COMBINED CYCLE WTE PLANTS BUILT AT END OF LIFE LANDFILL WILL PRODUCE A LOT OF ENERGY AT VERY LOW COST (NEGATIVE COST FUEL)

4. IN RIO, 5 WTE PLANTS SIMILAR TO SPANISH ZABALGARBI (100 MWe AND 792TON/D) WOULD TAKE CARE OF ALL CITY ILLUMINATION AND 100% OF DOMESTIC MSW