Clean Development Mechanism (CDM) and Municipal Solid Waste Management

Global Waste Management Symposium
Copper Mountain, Colorado
September 9, 2008

Presentation Topics

• Solid waste and greenhouse gas emissions
• CDM and the Kyoto Protocol
• CDM methodologies
• Application of CDM to landfill gas and composting
• Conclusions

Tianjin, China – LFG
Tonnage: 1,000 tpd
ERs: 913,000 tCO2e
Solid Waste and Greenhouse Gas (GHG) Emissions

- **Methane**
  - Generated in anaerobic conditions in landfills
  - 21x global warming potential (GWP) of CO₂
- **Landfills**
  - 12%+ global anthropogenic methane emissions
  - 4ᵗʰ largest source of non-CO₂ GHG emissions
- **Compost**
  - CO₂ from decay of organic material consider neutral to atmosphere

CDM and the Kyoto Protocol

- **Intergovernmental Panel on Climate Change (IPCC), 1988**
- **UN Framework Convention on Climate Change (UNFCCC)**
  - Voluntary program (1994), after Rio Earth Summit, to stabilize greenhouse gas (GHG) emissions
- **Kyoto Protocol**
  - Legally binding program to reduce GHG emissions
  - Ratified 2005; effective period through end of 2012
  - CDM: Provision for sale of emission reductions by developing countries to developed countries
CDM Process

- Carbon finance, payment for performance
- Methodologies to measure reduction in GHG must be approved by UNFCCC
- Conditions include
  - **Baseline**: GHG emissions in the absence of action (landfill). For compost projects waste would go to a landfill and generate landfill gas (50% methane)
  - **Additionality**: GHG emission reduction that would be achieved with project
    - Barriers – Investment, technical, common practice

Amman, Jordan – LFG
Tonnage: 3,000 tpd
ERs (7 yrs): 1,520 tCO2e

Approved CDM Methodologies: LFG

- **Large-scale**
  - ACM001. Landfill gas projects
  - Related tools
    1. Demonstration and assessment of additionality
    2. Determination of methane emissions avoided from dumping waste at a disposal site
    3. Determine project emissions from flaring gases containing methane
    4. Identify the baseline scenario and demonstrate additionality
    5. Calculate project or leakage CO2 emissions from fossil fuel combustion
    6. Calculate project emissions from electricity consumption

- **Small-scale**
  - AMS-IILG. Landfill methane recovery

- **Power generation**
  - AMS-ID. Grid connected renewable electricity generation (<15 MW)
Approved CDM Methodologies: MSW Compost

- Large-scale
  - AM0025. Avoided landfill emissions (methane) from anaerobic decomposition of organic waste through alternatives, incl composting
  - Related Tools
    1. Tool for the demonstration and assessment of additionality
    2. Tool to determine methane emissions avoided from dumping waste at a solid waste disposal site

- Small-scale
  - AMS-III.F. Avoidance of methane production from decay of biomass through composting (< 60,000 tCO₂e/yr)

CDM Methodology: LFG and Compost

- Both LFG and composting approaches rely on First Order Decay (FOD) model to assess potential gas collection rates or avoided methane

- FOD model factors
  - Project emissions
    - Waste composition
    - Ambient temp. / precipitation
    - Methane correction factor

Cairo, Egypt – Composting
Tonnage: 1,200 tpd
ERs (7 yrs): 536,500 tCO₂e
### FOD Model Factor: Waste Composition

<table>
<thead>
<tr>
<th>Material</th>
<th>Low</th>
<th>Middle</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td>40-85%</td>
<td>20-65%</td>
<td>20-50%</td>
</tr>
<tr>
<td>Paper</td>
<td>1-10%</td>
<td>15-40%</td>
<td>15-40%</td>
</tr>
<tr>
<td>Recyclables</td>
<td>4-25%</td>
<td>5-26%</td>
<td>11-43%</td>
</tr>
<tr>
<td>Fines</td>
<td>15-50%</td>
<td>15-50%</td>
<td>5-20%</td>
</tr>
<tr>
<td>Moisture</td>
<td>40-80%</td>
<td>40-60%</td>
<td>20-30%</td>
</tr>
</tbody>
</table>

### FOD Model Factor: Ambient Temp. / Precipitation: k Value (Decay Constant)

<table>
<thead>
<tr>
<th>Type of Waste</th>
<th>Boreal and Temperate (MAT ≤ 20°C)</th>
<th>Tropical (MAT &gt; 20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dry (MAP/PET &lt; 1)</td>
<td>Wet (MAP/PET &gt; 1)</td>
</tr>
<tr>
<td></td>
<td>Default</td>
<td>Range</td>
</tr>
</tbody>
</table>

- Slowly degrading waste
  - Paper/textile waste: 0.04, 0.05<sup>2</sup> – 0.07<sup>4</sup>, 0.06 – 0.08<sup>5</sup>
  - Wood/staw waste: 0.02, 0.02<sup>2</sup> – 0.03<sup>4</sup>, 0.03 – 0.06<sup>5</sup>

- Moderately degrading waste
  - Other (non-food) organic/potentially/ Garden and park waste: 0.05, 0.04 – 0.06, 0.1, 0.06 – 0.1<sup>6</sup>, 0.065, 0.05 – 0.08, 0.17, 0.15 – 0.2

- Rapidly degrading waste
  - Food waste/Sewage sludge: 0.06, 0.04 – 0.06, 0.189<sup>7</sup> – 0.2<sup>10</sup>, 0.085, 0.07 – 0.1, 0.4, 0.17 – 0.7<sup>10</sup>

- Bulk Waste: 0.05, 0.04 – 0.06, 0.09, 0.03<sup>8</sup> – 0.1, 0.065, 0.05 – 0.08, 0.17, 0.13<sup>11</sup> – 0.2
FOD Model Factor: Methane Correction Factor

<table>
<thead>
<tr>
<th>Landfill Type</th>
<th>Correction Factor (MCF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Managed – Anaerobic</td>
<td>1.0</td>
</tr>
<tr>
<td>Managed – Semi-aerobic</td>
<td>0.5</td>
</tr>
<tr>
<td>Unmanaged – Deep &gt; 5m</td>
<td>0.8</td>
</tr>
<tr>
<td>Unmanaged – Shallow &lt; 5 m</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Sample ER Calculations: AM0025
Effect of Ambient Temp. / Precipitation

- **Scenario, Base Conditions**
  - Waste quantity: 750 tons per day
  - Organic fraction: 64%
    - Food (55%) & Paper, Wood, Garden (3% each)
  - Degradable Organic Carbon, Fraction: 0.50
  - Methane Correction Factor: 1.0
  - Compost Efficiency: 95%
  - Crediting period: 7 yrs

Durbin, South Africa – LFG
Tonnage: 1,000 tpd (2 sites)
ERs (7 yrs): 480,000 tCO2e
Sample ER Calculations: AM0025
Effect of Ambient Temp. / Precipitation
(Total ERs: 7-yr Crediting Period)

<table>
<thead>
<tr>
<th>Temperature / Precipitation</th>
<th>Temperate (MAT&lt; 20°C)</th>
<th>Tropical (MAT&gt;20°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet (MAP&gt;1,000 mm)</td>
<td>476,500 tCO₂e</td>
<td>695,000 tCO₂e</td>
</tr>
<tr>
<td>Dry (MAP&lt;1,000 mm)</td>
<td>214,350 tCO₂e</td>
<td>281,150 tCO₂e</td>
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</tbody>
</table>

CDM and Municipal Waste Management

- **LFG**
  - % of registered CDM projects: 7.7%
  - % of WB Carbon Finance projects: 15.5%
  - WB LFG projects:
    ERPA – 15
    Total – 34

- **Composting (municipal waste)**
  - % of WB carbon finance projects: 4.0%
  - WB composting projects:
    ERPA – 4
    Total – 9
Carbon Finance Project Cycle: World Bank

- Project Idea Note (PIN)
- Letter of Intent (LOI)
- Project Design Document (PDD)
- Validation
- Emission Reduction Purchase Agreement (ERPA)
- Registration / Verification / Certification

CDM and Waste Management

<table>
<thead>
<tr>
<th>Status</th>
<th>No. of LFG Projects</th>
<th>No. of MSW Composting Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Register Projects</td>
<td>75</td>
<td>3</td>
</tr>
<tr>
<td>Registration Pending</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Validation Pending</td>
<td>85</td>
<td>11</td>
</tr>
<tr>
<td>TOTAL</td>
<td>167</td>
<td>14</td>
</tr>
</tbody>
</table>
World Bank

- Founded 1944 for post-war reconstruction
- Role to alleviate poverty in developing countries
- Organization
  - Int’l Bank for Reconstruction and Development (IBRD)
  - International Development Association (IDA)
  - International Finance Group (IFC)
  - Multilateral Investment Guarantee Agency (MIGA)
  - Int’l Centre for Settlement of Investment Disputes (ICSID)

World Bank, Carbon Finance

- Initiated carbon finance program 1999 to stimulate market
- Trustee of 11 Funds / Facilities for governments and firms
- Carbon Finance Unit contracts to purchase emission reductions for Fund / Facility members
- Carbon financee contributes to sustainable development and reduction in climate change

Kota Kinabalu, Malaysia – Composting
Tonnage: 500 tpd
ERs (7 yrs): 566,300
Conclusions

- Waste management of municipal discards is an important part of the CDM program to reduce greenhouse gas emissions
- Number of both LFG and composting projects are expected to grow
- For municipal solid waste, CDM focus has been on landfill gas recovery (existing disposal sites)
- Growing interest in compost to avoid methane generation
- Recent decisions of CDM EB has made composting less financial rewarding, especially in areas with dry climates

Thank You

Charles Peterson: cpeterson@worldbank.org
Zarina Azizova: zazizova@worldbank.org
Additional Information

- World Bank’s Carbon Finance Unit website: www.carbonfinance.org
- UNFCCC's CDM website: http://cdm.unfccc.int/index.html

Selected Large-Scale Methodologies

- LFG - ACM0001, Consolidated baseline and monitoring methodology for landfill gas project activities
  http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_BTH14FSTZKN0WN9
  PBDLG9D2183HXBQ
- Composting - AM0025, Avoided emissions from organic waste through alternative waste treatment processes
  http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_SN0FN11ZSNL3UX7I
  KRZFTRZ92XUYKK

Additional Information (Continued)

Selected Small-Scale Methodologies

- LFG - AMS-III.G, Landfill methane recovery
  http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_341FT628YO0PX
  9D2BW9IDMHTPY139
- LFG to Power - AMS-III.D, Grid connected renewable electricity generation
  http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_PHPY5WESAC
  MBTJ2YY54GAJYSEIE13HD
- Composting - AMS-III.F, Avoidance of methane production from decay of biomass through composting
  http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_6NOS8D6BN7GD
  231AN3DVLG1EPPYXUK
LFG, Over-Estimation Concerns

- Reports of ER shortfalls raised concerns
- Bank Actions
  - Review of PDDs and monitoring reports
  - SCS study (2007)
  - LFG workshop, LCR and CFU (2007)

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<table>
<thead>
<tr>
<th>Project (Crediting Period)</th>
<th>Lo / k</th>
<th>Recovery Rate</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil, NovaGerar (7/04)</td>
<td>163 / 0.10</td>
<td>85%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>29%</td>
<td>-</td>
</tr>
<tr>
<td>Brazil, Salvador Bahia (1/04)</td>
<td>180 / 0.12</td>
<td>80%</td>
<td>8%</td>
<td>44%</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Argentina, Villa Dominica (8/04)</td>
<td>NA / NA</td>
<td>70%</td>
<td>0%</td>
<td>28%</td>
<td>12%</td>
<td>12%</td>
<td>-</td>
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<tr>
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<td>NA / NA</td>
<td>50%</td>
<td>39%</td>
<td>39%</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Brazil, Tremembe (1/06)</td>
<td>NA / NA</td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Chile, Copiulemu (1/06)</td>
<td>163 / 0.10</td>
<td>85%</td>
<td>NA</td>
<td>NA</td>
<td>15%</td>
<td>27%</td>
<td>-</td>
</tr>
<tr>
<td>Chile, Cosmito (1/06)</td>
<td>163 / 0.10</td>
<td>60%</td>
<td>NA</td>
<td>NA</td>
<td>19%</td>
<td>32%</td>
<td>-</td>
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<tr>
<td>China, Nanjing (5/05)</td>
<td>159 / 0.10</td>
<td>58%</td>
<td>NA</td>
<td>22%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Chile, EL Mole (12/06)</td>
<td>100 / 0.07</td>
<td>75%</td>
<td>NA</td>
<td>NA</td>
<td>28%</td>
<td>37%</td>
<td>-</td>
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<tr>
<td>Brazil, Bandeirantes (12/03)</td>
<td>81 / 0.11</td>
<td>NA</td>
<td>58%</td>
<td>58%</td>
<td>46%</td>
<td>59%</td>
<td>-</td>
</tr>
<tr>
<td>Brazil, Paulina (9/06)</td>
<td>83 / 0.12</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>89%</td>
<td>90%</td>
<td>90%</td>
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## % Actual vs. Predicted ERs,
### CDM Projects with Monitoring Reports (March 2008)

<table>
<thead>
<tr>
<th>Project (Crediting Period)</th>
<th>Lo / k</th>
<th>Recovery Rate</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>China, Meizhou (9/05)</td>
<td>NA/NA</td>
<td>85%</td>
<td>NA</td>
<td>32%</td>
<td>16%</td>
<td>20%</td>
<td>-</td>
</tr>
<tr>
<td>Brazil, Caieiras (3/06)</td>
<td>116/0.08</td>
<td>60-80%</td>
<td>NA</td>
<td>NA</td>
<td>0%</td>
<td>71%</td>
<td>-</td>
</tr>
<tr>
<td>El Salvador, Nejapa (6/06)</td>
<td>116/0.07</td>
<td>70%</td>
<td>NA</td>
<td>NA</td>
<td>91%</td>
<td>106%</td>
<td>88%</td>
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<tr>
<td>Chile, Lepanto (3/06)</td>
<td>160/0.36</td>
<td>85%</td>
<td>NA</td>
<td>NA</td>
<td>8%</td>
<td>9%</td>
<td>-</td>
</tr>
<tr>
<td>Brazil, Maua (9/06)</td>
<td>160/0.10</td>
<td>75%</td>
<td>NA</td>
<td>NA</td>
<td>35%</td>
<td>29%</td>
<td>28%</td>
</tr>
<tr>
<td>China, Anding (1/05)</td>
<td>47/0.08</td>
<td>68%</td>
<td>NA</td>
<td>66%</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Argentina, Buenos Aires (8/06)</td>
<td>160/0.03</td>
<td>65%</td>
<td>NA</td>
<td>NA</td>
<td>33%</td>
<td>27%</td>
<td>-</td>
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<tr>
<td>Brazil, Sao Joao (5/07)</td>
<td>96/0.11</td>
<td>80%</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>60%</td>
<td>-</td>
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<tr>
<td>Mexico, Aquacalientes (7/06)</td>
<td>160/0.12</td>
<td>50-70%</td>
<td>NA</td>
<td>NA</td>
<td>72%</td>
<td>65%</td>
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<td>170/0.05</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>6%</td>
<td>-</td>
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<td>Argentina, Puente Gallego (9/06)</td>
<td>160/0.03</td>
<td>65%</td>
<td>NA</td>
<td>NA</td>
<td>13%</td>
<td>46%</td>
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</tr>
</tbody>
</table>

## % Actual vs. Predicted ERs,
### CDM Projects with Monitoring Reports (March 2008)

<table>
<thead>
<tr>
<th>Project (Crediting Period)</th>
<th>Lo / k</th>
<th>Recovery Rate</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico, Ecatepec (10/06)</td>
<td>160/0.12</td>
<td>60%</td>
<td>NA</td>
<td>NA</td>
<td>8%</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>South Africa, Durbin (12/06)</td>
<td>NA/NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>40%</td>
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<tr>
<td>Egypt, Alexandria (12/06)</td>
<td>136/0.05</td>
<td>70%</td>
<td>NA</td>
<td>NA</td>
<td>11%</td>
<td>11%</td>
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<td>Ecuador, Zambiza (3/07)</td>
<td>126/0.05</td>
<td>NA</td>
<td>NA</td>
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<td>NA</td>
<td>30%</td>
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<tr>
<td>Chile, Santa Maria (3/07)</td>
<td>100/0.07</td>
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<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>54%</td>
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<td>Israel, Taila (3/07)</td>
<td>NA/0.03</td>
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<td>NA</td>
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<td>NA</td>
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<td>-</td>
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<td>189/0.06</td>
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<td>NA</td>
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<td>60%</td>
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<td>NA</td>
<td>NA</td>
<td>31%</td>
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<td>Brazil, Itapevi (8/07)</td>
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<td>NA</td>
<td>NA</td>
<td>119%</td>
<td>75%</td>
</tr>
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</table>