

# Clean Development Mechanism and Development of a Methodology for the Recycling of Municipal Solid Waste

Charles Peterson, World Bank  
Julie Godin, World Bank

## CONTACT

Contact name:	Charles Peterson	Julie Godin
Organization:	World Bank	World Bank
Postal address:	1818 H Street, NW (MC 3-309) Washington, DC 20433 USA	1818 H Street, NW (MC 3-309) Washington, DC 20433 USA
Telephone:	(202) 458-0168	(202) 456-1359
Email:	<a href="mailto:cpeterson@worldbank.org">cpeterson@worldbank.org</a>	<a href="mailto:jgodin@worldbank.org">jgodin@worldbank.org</a>

## EXECUTIVE SUMMARY

The World Bank (Bank, [www.worldbank.org](http://www.worldbank.org)) is involved with more than 100 projects (active or under development) with municipal solid waste<sup>1</sup> management components in developing countries. Loan and grant commitments have been made for capital investments in a broad scope of waste management functions including recycling, collection, transfer stations, and landfill design/construction. Loans and grants are an important, traditional, Bank activity.

A more recent Bank program is carbon finance, which is the purchase of greenhouse gas (GHG) emission reductions from developing countries under the Clean Development Mechanism (CDM), a sustainable financing instrument created by in the Kyoto Protocol. The Bank purchases CDM emission reductions for a group of 11 carbon funds or facilities for various European countries and Japan, utilities, and manufacturing companies to assist in offsetting their emission reduction targets under the Kyoto Protocol.

Emission reductions are determined under methodologies approved by the CDM Executive Board of the United Nations Framework Convention on Climate Change (UNFCCC). These methodologies establish eligibility criteria for projects

- Baseline scenario and emissions. Existing, or business as usual, level of emissions.
- Additionality scenario and emissions. The proposed CDM project activity that needs to be additional (beyond the baseline scenario).
- Monitoring procedures to allow project performance to be tracked during the crediting period.

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<sup>1</sup> Municipal solid waste is composed of discards primarily from residences and commercial operations, such as retail stores and office as well as institutions and non-hazardous industrial wastes.

CDM approved municipal solid waste methodologies include the capture of landfill gas (ACM0001) and methane avoidance projects such as aerobic composting and incineration (AM0025).

Recycling is one important waste management area for which a CDM methodology has yet to be approved. The Bank is seeking to remedy this through the development of a methodology for recycling. In conjunction with a draft CDM methodology, an assessment (project design document, or PDD) was prepared on a pilot project that will involve installation of eight sorting plants in the area of Buenos Aires, Argentina.

The draft CDM methodology focuses on recycling of plastics - high density polyethylene (HDPE) and low density polyethylene (LDPE). When the methodology is approved by the CDM Executive Board and made available to any project developers, additional methodologies will be submitted for other recyclables including metals, paper, and glass. It is anticipated by the World Bank that a methodology for HDPE and LDPE may be approved by mid-2010.

Development of a recycling methodology is a complex process. The methodology follows the principles of life-cycle assessment and compares the greenhouse gas emissions from all steps involved under the project activity.

The methodology will promote higher recovery rates for recyclables and higher market for recyclables through upgrading of the materials offered for sale. In addition, it will improve the working conditions for those that recover materials from the waste stream.

The informal recycling sector is a global phenomenon that involves 1 to 2% of the urban population in developing countries. The people in this sector often are at the very low incomes and living standards in urban areas.

The expected emission reductions from the methodology under development are expected to be relatively small because of the small quantity of plastics (HDPE and LDPE) forecast to be recycled and the focus on only one recyclable category. The rate will increase as additional methodologies for recyclable materials are developed and approved. The Bank also is working towards an urban methodology that will enable smaller individual activities to gain the financial benefits of incremental reductions in GHG emissions. This new program is targeting three sectors – environmental management, (primarily solid waste), energy efficiency (areas such as building efficiency and street lighting), and transit.

## **INTRODUCTION**

Municipal solid waste is a significant contributor to GHG emissions. One effort to date to remedy the effect of municipal waste on climate change has been the capture and destruction of the methane generated in landfills from the decomposition of the organic biomass fraction of solid waste such as food, paper, and wood. Another effort is the avoidance of methane generation by the treatment of municipal waste through various non-landfill processes including aerobic composting and incineration.

Even though recycling of the materials in municipal solid waste has been shown to reduce the level of GHG emissions relative to the use of virgin feedstock, a methodology that will measure and monitor the emission reductions from a recycling program has yet to be

approved by the CDM Executive Board. The Bank is working to remedy this situation with the development of a methodology for the recycling of materials from municipal waste.

Except for paper, recyclables, such as plastics, aluminum, ferrous metal, and glass, do not degrade in a landfill to form methane. The greenhouse gas benefit of recycling is a reduction in emissions from the use of fossil-fuel energy in the extraction and manufacture of products from virgin materials versus secondary materials.

The Bank's methodology initiative to measure and monitor GHG emissions is focused on the recycling of products manufactured from high density polyethylene (HDPE), such as plastic bottles, and low density polyethylene (LDPE), such as plastic bags. Methodologies will be developed for other materials after the methodology for HDPE and LDPE is approved.

The process for development of a methodology requires a specific project to demonstrate the application. A recycling project in the area of Buenos Aires, Argentina is the sample project being used for this purpose.

## **BACKGROUND**

### **World Bank**

The World Bank's role is to reduce poverty in developing countries through loans, grants, and technical assistance in a range of areas including infrastructure such as waste management. Currently, the Bank has more than 100 projects (active or under development) with waste management components with total investment commitments of US\$2.3 billion. The waste management projects cover the spectrum of the solid waste field – recycling, collection equipment, transfer stations, and landfill design/construction.

Carbon finance or the purchase of GHG emission reductions from projects is a service the Bank (<http://carbonfinance.org>) has offered to developing countries since the year 2000. Carbon finance was developed to meet the opportunities provided by the Clean Development Mechanism (CDM, <http://cdm.unfccc.int/index.html>), a provision in the Kyoto Protocol ([http://unfccc.int/kyoto\\_protocol/items/2830.php](http://unfccc.int/kyoto_protocol/items/2830.php)), which enables buyers from developed countries to purchase GHG emission reductions from projects in developing countries. Such emission reductions are credited towards the emission reduction targets for developed countries under the Kyoto Protocol. The Bank is as a trustee for a group of 11 funds and facilities.

In the waste management area, existing CDM methodologies in which the Bank is involved include landfill gas collection with energy recovery / flaring and composting projects. The Bank is developing a methodology for methane avoidance through recycling. In the carbon finance area, the Bank has 32 municipal waste management projects, including 25 in landfill gas capture and 7 in composting; plus additional projects for agricultural wastes.

### **Solid Waste and Greenhouse Gas Emissions**

Methane, a by-product of the decomposition of the organic biomass portion of solid waste disposed of in a landfill, is a greenhouse gas, which has 21 times the global warming potential of carbon dioxide (CO<sub>2</sub>).<sup>2</sup>

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<sup>2</sup> Methane has an atmospheric life in the range of 9 to 15 years with a GWP over 20 years of 56, declining to 21 over 100 years, including indirect effects of tropospheric ozone production and stratospheric water vapor production. (Source: [http://unfccc.int/ghg\\_data/items/3825.php](http://unfccc.int/ghg_data/items/3825.php)). Values of the Revised 1996 IPCC Guidelines

Total anthropogenic (human induced) methane emissions represent about 15% of greenhouse gases (EPA, June 2006. p. I-2). Worldwide, waste disposal accounts more than 20% of anthropogenic methane (EPA. June 2006. P. III-1), which makes waste disposal the fourth largest source of non-carbon dioxide greenhouse gas.

Carbon dioxide from biomass organics in municipal waste are considered climate neutral. This includes CO<sub>2</sub> from composting (aerobic) as well as burning of methane in a flare or a generator to produce electricity.

### **Clean Development Mechanism**

Projects in developing countries that have ratified the Kyoto Protocol must comply with the conditions of an approved methodology to develop an eligible project and sell their emission reduction credits. These methodologies are overseen by the CDM Executive Board under the UNFCCC (<http://unfccc.int>).

A common element of all methodologies is the need to set a baseline scenario, which is the level of greenhouse gas that would be emitted in the absence of the CDM project activity (also known as the business as usual or base case scenario). For recycling projects, the baseline is rate of recovery for the targeted material under existing conditions. Additionality, or the additional level of GHG emission reductions that would be achieved beyond the baseline because of CDM incentives, is a second basic element.

Additionality can be demonstrated using the barrier approach, the obstacles that prevent a project from happening in the absence of CDM incentives. Examples of barriers that prevent a CDM project include access to financing sources, significant technological risks, barriers due to prevailing practice in the host country where the project is taking place. In addition, on current practices barrier, the first-of-its-kind barrier could be used to demonstrate the additionality of the CDM project using documented evidences on the sector and common practices in the host country.

Additionality can also be demonstrated using an investment analysis such as a simple cost analysis, internal rate of return (IRR) or net present value (NPV) of the project. The project must show that it is not the most financially attractive investment scenario. Alternatively benchmark approach could also be used to demonstrate the additionality if a project using investment analysis. In this case, it is necessary to demonstrated that the CDM project activity has a less favorable indicator (e.g. lower IRR) than the benchmark.

### **Approved CDM Methodologies**

Since a CDM approved methodology for recycling does not exist, the Bank is pursuing development of such methodology. The methodology is being developed under the CDM small-scale modalities and rules that will yield a maximum 60,000 tons<sup>3</sup> of carbon dioxide equivalent (tCO<sub>2</sub>e) per year per project.

An advantage with small-scale projects is that they can be developed using simplified rules, including simplified monitoring once operations begin. Offsetting these advantages is the relatively high development cost for the emission reductions that can be earned with small-scale projects.

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for National Greenhouse Gas Inventories (1996) are to be used for the first crediting period of CDM project (i.e, 21 for methane).

<sup>3</sup> Ton = metric ton.

## **Methodology Applications**

Preparation of a Project Design Document (PDD), a formal requirement of the CDM Procedures and Modalities to register a CDM project and start generating credits, defines the nature of a proposed project, the expected emission reductions, the factors used to estimate expected reductions, and describes a monitoring plan to track future performance, is a critical step in the development of a project. The completion of a PDD is also required to demonstrate a typical application when developing a new CDM methodology.

A PDD has been prepared as part of the development initiative for a recycling methodology. A project in the metropolitan area of Buenos Aires, Argentina is the sample project addressed in the PDD.

## **PROJECT DESCRIPTION**

The CEAMSE Plastic Recycling Project will be developed by CEAMSE<sup>4</sup>, the entity in charge of the collection and final disposal of municipal solid waste in Buenos Aires city and its surroundings.

The project consists of the installation of eight recycling plants where HDPE and LDPE discards will be recovered from post-consumer waste, classified, packaged and sold as raw materials for the production of HDPE and LDPE products such as bottles and bags. These recycling plants, also called social plants, will be operated by civil associations. CEAMSE will collect the waste and provide the land, the infrastructure and some of the equipment needed for operation of the recycling facilities. The workers will keep the net revenue from the sale of recovered HDPE and LDPE.

The project is forecast to reduce GHG emissions by 914 tCO<sub>2</sub>e per year with the use of recycled HDPE and LDPE rather than the manufacture of products from virgin raw materials. The amount of emission reductions and credits will increase significantly once the methodology will cover other recyclables such metals and paper.

About 500 tons of HDPE and LDPE will be recovered annually because of this project activity. In absence of the project, the HDPE and LDPE residues would have been disposed in CEAMSE's landfill. This project only takes into account the emission reductions associated with the energy saved during the production of plastic products because of the complexity of tracking overall material life-cycle emissions.

The project in Buenos Aires will contribute to sustainable development in the following manner:

- Decrease in overall energy use, greenhouse gas emissions, and the environmental effect from raw material extraction through manufacture with secondary material instead of using virgin material.

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<sup>4</sup> *Coordinación Ecológica Área Metropolitana Sociedad del Estado* (CEAMSE) is a governmental organization in charge of the collection, treatment and final disposal of solid waste generated in Buenos Aires and its surroundings. CEAMSE collects more than 435,000 tons of residues per month, which is the equivalent of the residues generated by 13.0 million habitants. CEAMSE has inter-jurisdictional character, since its capital stock is shared in equal parts by the Government of the Province of Buenos Aires and the Government of the Independent City of Buenos Aires.

- Reduced demand for capacity at CEAMSE’s landfill.
- Provide employment in the recycling plants that will be operated by local people living in the extremely poor neighborhoods. Currently these people are earning income as waste pickers, an unsanitary working environment. The eight social plants will hire about 40 people per plant. The revenue generated from the sale of recyclables will be paid to the employees.
- Promotion of organized recycling activity in Argentina and technology transfer for the production of plastic using recycled material.

The following activities will be undertaken at the recycling facilities:

- At the eight recycling plants, the discards collected by CEAMSE will be delivered to a recycling plant, placed on a conveyor that will move the waste to be sorted through a facility. Workers will manually separate recyclables and place them in baskets according to their types: cardboard, plastics, paper, and aluminum. The residues that are not recyclable will fall into another container at the end of the line and will be disposed at the CEAMSE’s landfill.
- Separated plastics in the initial step will be manually sorted further according to different plastic types including HDPE, LDPE, PET, PC, PP, PVC or PS and colors.
- The classified material, including LDPE and HDPE, will then be packaged to be sold.

The total *ex-ante* emission reductions for the 10-year crediting period of the project are estimated to be 9,140 tCO<sub>2e</sub>. The actual amount of emission reductions will be based on the quantity of waste recycled and, therefore, will be evaluated *ex-post*.

### Estimating Emission Reductions

The emission reductions achieved by the project activity will be the difference between baseline emissions and project emissions as well as leakage<sup>5</sup>, see equation 1.

$$ER_y = BE_y - PE_y - LE_y \quad (1)$$

Where:

- $ER_y$  = Emission reductions in year  $y$  (tCO<sub>2e</sub>).
- $BE_y$  = Baseline emissions in year  $y$  (tCO<sub>2e</sub>).
- $PE_y$  = Project emissions in year  $y$  (tCO<sub>2e</sub>).
- $LE_y$  = Leakage emissions in year  $y$  (tCO<sub>2e</sub>).

Baseline emissions are calculated using equation 2.

$$BE_y = \sum_i L_{B,i,y} * BE_{PM,i} * r_i \quad (2)$$

Where:

- $BE_y$  = Baseline emissions in year  $y$  (tCO<sub>2e</sub>/y).
- $I$  = Material  $i$  (HDPE and LDPE)

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<sup>5</sup> Leakage is emissions associated with a project activity that occur outside the project boundary.

- $L_{B,i,y}$  = Quantity of material  $i$  recycled in year  $y$  (ton of material  $i/y$ ) – this parameter will be measured ex-post. For ex-antes estimation,  $L_{B,HDPE,y} = 116$  tons,  $L_{B,LDPE,y} = 388$  tons.
- $BE_{PM,I}$  = Emissions generated during the processing/manufacturing of material  $i$  produced from virgin inputs per ton of material  $i$  (tCO<sub>2</sub>e/ton of material  $i$ ).
- $ri$  = Ratio to account for material loss (%), specific to material  $i$  (0.77).

Equation 3 provides the calculation for emissions during processing / manufacturing.

$$BE_{PM,i} = EG_{PM,i} * EF_{grid} \quad (3)$$

Where:

- $EG_{PM,I}$  = Electricity consumed at the processing/manufacturing level per ton of material  $i$  made of virgin input, using data from published references (MWh/ton of material  $i$ ). As no country specific values are available, values for HDPE and LDPE are from the literature (McDougall, 2007),  $EG_{PM,HDPE} = 9.31$  MWh/ton HDPE,  $EG_{PM,LDPE} = 11.43$  MWh/ton LDPE.
- $EF_{grid}$  = Emission factor for the electrical grid system (tCO<sub>2</sub>e/MWh). Emission factor, made available by the Designated National Authority (DNA), the CDM representative in Argentina<sup>6</sup>.  $EF_{grid} = 0.425$  tCO<sub>2</sub>e/ MWh.

Project emissions are calculated using the formula provided in equation 4.

$$PE_y = \sum_i L_{B,i,y} * (PE_{R,i,y} + PE_{PM,i,y}) \quad (4)$$

Where:

- $PE_y$  = Project emissions in year  $y$  (tCO<sub>2</sub>e/y).
- $i$  = Recycled material  $i$  in year  $y$  (*HDPE, LDPE*).
- $L_{B,i,y}$  = Quantity of material  $i$  recycled in year  $y$  (tons of material  $i/y$ ). This parameter will be measured ex-post. For ex-antes estimation,  $L_{B,HDPE,y} = 116$  tons,  $L_{B,LDPE,y} = 388$  tons.
- $PE_{R,I,y}$  = Emissions generated at recycling facility for the recycled material  $i$  in year  $y$  (tCO<sub>2</sub>e/y).
- $PE_{PM,I,y}$  = Emissions generated during the processing/manufacturing of the recycled material  $i$  in year  $y$  (tCO<sub>2</sub>e/y ton of material  $i$ ).

Emissions associated with transportation of recyclables under the project activity are negligible when compared with baseline and consequently are neglected under this methodology (EPA, September 2006).

Emissions at a recycling facility will be calculated using equation 5.

$$PE_{R,i,y} = \frac{(EG_{R,i} * EF_{grid}) + \sum_j FC_{SP,j} * NCV_j * EF_{CO2,j} * 44/12}{M_{SP,y}} \quad (5)$$

<sup>6</sup> Link URL, access November 2008:

[http://www.ambiente.gov.ar/archivos/web/UCC/File/220807\\_calculo\\_factor\\_emision.pdf](http://www.ambiente.gov.ar/archivos/web/UCC/File/220807_calculo_factor_emision.pdf)

Where:

- $EG_{R,i}$  = Electricity consumed at recycling facility at year  $y$  (MWh) - this will be measured ex-post separately for HDPE and LDPE. For ex-ante estimation, an estimate of 350 MWh is used (total for the eight plants).
- $EF_{grid}$  = Emission factor for the electrical grid system (tCO<sub>2</sub>e/MWh). Emission factor for the electrical grid system (tCO<sub>2</sub>e/MWh). Emission factor, made available by national DNA<sup>7</sup>.  $EF_{grid} = 0.425$  tCO<sub>2</sub>e/MWh.
- $FC_{SP,i}$  = Quantity of fossil fuel type  $j$  combusted at the recycling facility at year  $y$  (ton). This will be measured ex-post, for ex-antes estimation, this is estimated at 20,000 tons for the eight plants per year for gasoil.
- $J$  = All fuel type combusted at manufacturing level – only gasoil.
- $NCV_j$  = Net calorific value of fuel  $j$  (GJ/ton). NCV of gasoil = 0.0427 TJ/ton. (IPCC, 2006)
- $EF_{CO_2,j}$  = Weighted average CO<sub>2</sub> emission factor of fuel type  $j = 20.2$  tCO<sub>2</sub>e/TJ.
- 44/12 = Mass conversion factor.
- $M_{SPT,y}$  = Quantity of solid waste entering the recycling facility at year  $y$  (ton/y) – This parameter will be measured ex-post, 60,000 tons/y is used for ex-ante estimation (based on capacity of the eight plants).

Emissions at recycled facility are allocated to material  $i$  using mass fraction of material  $i$  on total mass entering the recycling facility at year  $y$ .

Processing/manufacturing emissions are expressed by equation 6.

$$PE_{PM,i} = EG_{PMR,i} * EF_{pm} \quad (6)$$

Where:

- $EG_{PMR,i}$  = Electricity consumed at the processing/manufacturing stage per ton of material  $i$  made of recycled inputs, using data from published references (MWh/ton of material  $i$ ). As no country specific values is available, values for HDPE and LDPE are from the literature, (McDougall, 2007)  $EG_{PMR,HDPE} = 2.13$  MWh/ton HDPE,  $EG_{PMR,LDPE} = 7.11$  MWh/ton LDPE.
- $EF_{grid}$  = Emission factor for the electrical grid ( $EF_{pm} = EF_{grid}$ ) or emission factor corresponding to the highest fossil fuel used for generation of heat or electricity fuel. Value used for Argentina is 1.3 tCO<sub>2</sub>e/MWh. Derived from, fuel oil; 41,816 Kg/KJ (low calorific value; emission factor tCO<sub>2</sub>e/TJ; oxidation 100%. (IPCC, 2006. P 1.24).

## Monitoring

The monitoring protocol is important to tracking the performance of a CDM project. Payment for emission reduction is based on the verified results of the monitoring data, so projects must be judicious in the collection and storage of monitoring data.

A monitoring plan will be implemented by CEAMSE in collaboration with the associations in charge of the each recycling plant. The plan is made to verify that the

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<sup>7</sup> Link URL, access November 2008:

[http://www.ambiente.gov.ar/archivos/web/UCC/File/220807\\_calculo\\_factor\\_emision.pdf](http://www.ambiente.gov.ar/archivos/web/UCC/File/220807_calculo_factor_emision.pdf)

emission reductions are real and measurable. The monitoring protocol will involve the collection of the following:

- Mass of each recycled material entering the recycling facility ( $L_{B,i,y}$ ), measured by direct weighing.
- Total mass of solid waste entering the recycling facility ( $M_{SPT,y}$ ) measured by direct weighing.
- Amount of electricity consumed at the recycling facility for power equipment ( $EG_{R,i}$ ).
- Emission factor for the electrical grid system ( $EF_{grid}$ ).
- Amount of fossil fuel type  $j$  combusted at the recycling facility ( $FC_{SP,i}$ ).
- Net calorific value of each fuel used at recycling facility ( $NCV_j$ ).
- The weighted average  $CO_2$  emission factor of fuel type  $j$  ( $EF_{CO_2,j}$ ).
- Sale price of recycled material  $i$  is monitored and reported annually, sale receipts are collected for annual verification.
- At processing/manufacturing facility, production factors that comprise  $PE_{PM,j}$

### **Methodology Development - Timeline**

The proposed methodology and associated PDD were originally submitted to the Small-Scale Working Group (SSC WG) in December of 2008. As of early July 2009, the Bank has responded to two rounds of questions, and at this time the methodology is still under review.

Two topics still pending with the SSC WG are:

- Material loss. The SSC WG has commented that there should be a discount on the quantity of material recovered to account for material losses during the recycling process as well as the loss in product quality that requires a higher level of material use in production of a manufactured item. As an example, the Working Group has stated that plastic bags made from secondary LDPE use 50% more material than such bags manufactured with virgin stock.
- Primary energy and electricity use. The Bank suggested the use of a universal default value, which the SSC WG determined to not be applicable in all locations. As an alternative, emissions data for a range of developing countries is being reviewed to formulate default values on a regional basis.

Final responses on these topics are to be submitted to the Working Group for their next formal meeting, which is scheduled for late September 2009. It is anticipated that if this effort is successful that a methodology on the recycling of HDPE and LDPE will be approved by mid-2010. With approval the Bank will pursue similar methodologies for other recoverable materials including ferrous metal, paper, and glass.

Additionally, the Bank is separately working on the development of a new urban-wide approach to carbon finance (Ranade). The approach will combine emission reduction activities from several urban areas, including waste management, transport, and energy efficiency, to increase the scope of carbon finance programs to include smaller activities that might not justify a separate CDM project.

### **CONCLUSION**

As a stand-alone project, the proposed project for the recycling of HDPE and LDPE is very small as a CDM activity. Even with the anticipated, eventual of other recyclable material the project will generate only small level of greenhouse gas emissions. Nonetheless, the development of the proposed methodology for the recovery of secondary material from post-consumer discards is deemed a worthwhile undertaking as registered projects will generate additional revenue for waste pickers who as a group survive on very low incomes.

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Sandra Cointreau. Solid Waste Advisor, World Bank.

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