

Evaluating the Greenhouse Gas Impacts of National Waste Prevention Activities: The U.S. Experience

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Abstract

The U.S. Environmental Protection Agency (EPA) has initiated a Climate and Waste Program aimed at reducing greenhouse gas (GHG) emissions from waste management. The Climate and Waste Program utilizes a three pronged approach: (1) research and technical assistance, (2) program implementation, and (3) outreach and education.

Research and technical assistance provide the scientific underpinning for the Climate and Waste Program. Waste management affects most of the major categories of GHG emissions and sinks, including energy, forestry, industrial processes, and landfill methane, with many important effects occurring upstream of the point of disposal. EPA combined a life cycle analysis framework with the emission accounting guidelines established by the Intergovernmental Panel on Climate Change (IPCC) to estimate GHG emissions from materials in waste management practices.

EPA's program implementation efforts have included three programs: WasteWise, Pay-As-You-Throw (PAYT), and Waste Reduction Demonstration Projects. The WasteWise program encourages organizations to take cost-effective actions to reduce solid waste, and to quantify progress toward goals. EPA's PAYT team distributes information, provides training, and offers technical assistance to waste managers and to local planners across the US. EPA also supports over 30 state and local demonstration projects that emphasize innovative approaches to waste reduction and climate protection.

EPA conducts an outreach and education program to communicate the link between climate change and waste management. This program produces educational materials, maintains a website, prepares papers, and makes presentations to stakeholders.

The Climate and Waste Program is on track to meet its emission reduction goal of 5 million metric tons of carbon equivalent (MMTCE) by 2000, which puts the program on par with several other major U.S. initiatives to reduce GHGs. Much of the experience gained in the US is transferable to other nations interested in broadening their climate mitigation portfolios to include waste management.

Program Overview

As one of the elements of the U.S. Climate Change Action Plan,¹ the US Environmental Protection Agency (EPA) is implementing an innovative, three-pronged approach to address the link between waste prevention and climate protection:

1. EPA conducts research and provides technical assistance on waste management options and their impact on greenhouse gas (GHG) emissions. The research efforts have been the first to combine a life cycle analysis framework with the emission inventory guidance of the Intergovernmental Panel on Climate Change (IPCC). The principal products of this research are a set of emission factors which enable someone to measure the GHG impacts of choosing a particular waste management option for a particular material.

¹The Climate and Waste Program comprises Initiative 16 (Accelerate Source Reduction, Pollution Prevention, and Recycling) of the U.S. Climate Change Action Plan.

2. EPA operates national program efforts, such as WasteWise and Pay-As-You-Throw, that link waste reduction to climate change mitigation. These programs are designed to produce environmental benefits, with emphasis on waste and GHG emission reductions.
3. EPA conducts an outreach and education program on the linkage between climate change and waste management. This program produces educational materials, maintains a website,² prepares papers, and makes presentations to state, local, international, and industry stakeholders.

This program has proven to be effective in broadening the U.S. GHG mitigation portfolio. The remainder of this paper addresses the first two elements of the program, and in particular, how the research results can be used to measure progress of national waste prevention programs. We offer these findings in hopes that other countries attempting to establish similar programs may take advantage of our experience.

Research and Technical Assistance

Measurement and evaluation are important components of EPA's Climate and Waste Program. Like all other climate change actions in the US, this program is frequently evaluated to assure that it is effective at reducing emissions. EPA initiated a research program in 1994 to quantify the impacts of waste management practices on GHG emissions. These measurement methods help the program target the materials and management methods with large emission reduction potential. They also help to fulfill the requirements of the Government Performance and Results Act (GPRA), which requires all U.S. government departments and agencies to specify measurable program goals and to track their performance in meeting these goals.³ The results of this research have been made available to state, local, international, and industry stakeholders.

The primary objective of the research effort is to provide the scientific basis for estimating GHG emission reduction benefits of various waste management actions. Climate change analysts have long recognized that landfills can be a significant source of methane emissions. Less widely recognized, but equally important, are other links between GHGs and waste management. For example, source reduction and recycling can indirectly reduce GHG emissions by reducing fossil fuel-related emissions in the raw materials extraction and manufacturing process, or by reducing the rate of timber harvest for paper and wood products, thereby resulting in enhanced forest carbon storage. Our research indicates that in some cases the upstream materials management decisions (e.g., material use) can have a greater effect on GHG emissions than decisions at the downstream (waste disposal) end. Thus, to incorporate the full range of effects through a material's life cycle, a life cycle analysis methodology provides the most appropriate framework.

For each material type, we examined those stages of the life cycle that have the potential to affect GHG emissions as materials are converted from their raw states to products, and then disposed as waste. Figure 1 shows the steps in the life cycle in which GHGs are emitted, carbon sequestration is affected, and electric utility energy is displaced (reducing utility GHG emissions).⁴ GHG emission reductions from source reduction⁵ and recycling materials in the raw material

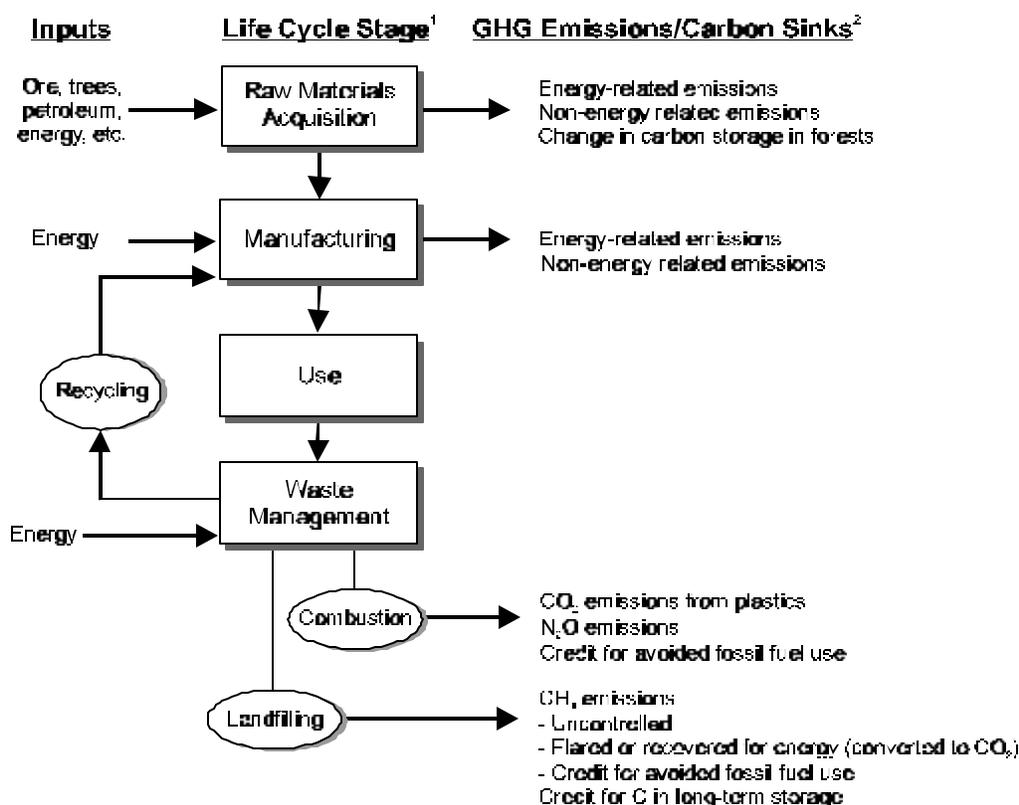
² www.epa.gov/mswclimate/.

³ For more information on GPRA, see the "reports and guidance documents" section of the US Chief Financial Officer's GPRA home page at www.financenet.gov/financenet/fed/cfo/gpra/reports.htm.

⁴ EPA's Office of Research and Development (ORD) is performing a more extensive application of life cycle assessment for various waste management options for MSW. ORD's analysis will inventory a broader set of emissions (air, water, and waste) associated with these options. For more information on this effort, please see their project website at <http://www.epa.gov/docs/crb/apb/apb.htm>.

⁵ The source reduction techniques we analyze involve using less of a given product without using more of some other product – e.g., making aluminum cans with less aluminum ("lightweighting"); double-sided rather than single-sided photocopying; or reuse of a product.

Figure 1
GHG Sources and Sinks Associated with Materials in the MSW Stream



¹ National average estimates of GHG emissions for all stages in the life cycle.
² All life cycle stages include transportation energy-related emissions, except that emissions from transportation products (such as motorcycles for consumers) were not included in the analysis.

acquisition and manufacturing stage were compared to a baseline of acquiring raw materials and manufacturing products using the current mix of virgin and recycled inputs. Similarly, changes in forest carbon were estimated based on the projected stock of carbon in forests and harvested forest products under existing recycling policies and projected market conditions. At each of the points in the life cycle, we also considered transportation-related energy emissions. We did not analyze the GHG emissions associated with consumer use of products but believe them to be negligible for the selected materials.

The IPCC has developed accounting methods for GHG emissions and sinks, to be used in developing national inventories of GHG emissions.⁶ Several aspects of the methods have important implications for the waste sector, particularly the components dealing with the use of global warming potentials, treatment of carbon cycling in forests, and accounting for CO₂ emissions from combustion facilities using biomass fuels. Our approach integrates the IPCC accounting conventions within the life cycle framework to provide emission factors that are consistent with the conventions used in developing GHG inventories and evaluating GHG mitigation.

The GHG emission factors represent U.S. national average estimates for waste management activities (source reduction, recycling, combustion, and landfilling) for 12 material types, including newspaper; office paper; corrugated cardboard; mixed paper; aluminum cans; steel cans; glass containers; high density polyethylene (HDPE) plastic; low density polyethylene (LDPE) plastic; polyethylene terephthalate (PET) plastic; dimensional lumber, and medium density

⁶ IPCC. Guidelines for National Greenhouse Gas Inventories (three volumes), 1997. IPCC, Hadley Center Meteorological Office, Bracknell, England.

fiberboard (MDF). These materials constitute nearly 42 percent of municipal solid waste generated in the US.

The emission factors are published in a report – *Greenhouse Gas Emissions from Selected Materials in the Municipal Solid Waste Stream* – widely distributed in the US and abroad.⁷ The key results of this report – life cycle GHG emissions for source reduction, recycling, combustion, and landfilling – are provided in Table 1.⁸ The values in the table indicate the net GHG emissions (i.e., emissions minus credits for (a) carbon storage and (b) displaced electricity emissions) associated with managing one ton of material using each of the listed management strategies. These factors are based on average U.S. conditions (e.g., average fuel mix for raw material acquisition and manufacturing using recycled inputs; typical efficiency of a mass burn combustion unit; national average landfill gas collection rates). GHG emissions are sensitive to several key factors that vary on a local basis, including the landfill gas recovery practices (if any), the characteristics of the energy sources being displaced by energy recovery (at combustors and landfill gas projects), and relative transportation distances. Thus site-specific emissions differ from those summarized here.

To apply these emission factors, one must specify both the baseline scenario (e.g., landfilling or combustion) and an alternative scenario (e.g., source reduction or recycling), and the amount of material that is managed in each scenario. Then, for both the baseline and the alternative scenarios, the tons managed are multiplied by the respective emission factors. The products represent the GHG emissions. The emission reduction (or increase) is the difference in the values for the two scenarios.

The primary application of the emission factors is to support climate change mitigation accounting for waste management practices. As well as measuring the progress of national programs (discussed in the next section), these factors have also been used by organizations

Table 1
Net GHG Emissions from Waste Management Options (MTCE/Wet Tonne)

Material			Recycling	Combustion	Landfilling			
	Current mix of mfggr inputs	100% virgin mfggr inputs			Without LFG Recovery	With LFG Recovery and Flaring	With LFG Recovery and Electric Gen.	Projected US Nat'l. Average
Newspaper	-1.00	-1.41	-0.94	-0.24	-0.13	-0.32	-0.36	-0.25
Office Paper	-1.12	-1.42	-0.90	-0.20	1.16	0.26	0.08	0.59
Corrugated Cardbrd	-0.86	-1.22	-0.78	-0.21	0.30	-0.10	-0.18	0.04
Mixed Paper								
Broad Definition	NA	NA	-0.73	-0.21	0.34	-0.09	-0.18	0.06
Residential Def.	NA	NA	-0.73	-0.21	0.29	-0.11	-0.20	0.03
Office Paper Def.	NA	NA	-0.93	-0.19	0.42	-0.06	-0.15	0.12
Aluminum Cans	-3.17	-5.94	-4.27	0.03	0.01	0.01	0.01	0.01
Steel Cans	-0.90	-1.23	-0.63	-0.53	0.01	0.01	0.01	0.01
Glass	-0.16	-0.18	-0.09	0.03	0.01	0.01	0.01	0.01
HDPE	-0.68	-0.77	-0.40	0.25	0.01	0.01	0.01	0.01
LDPE	-0.98	-0.98	-0.54	0.25	0.01	0.01	0.01	0.01
PET	-1.10	-1.28	-0.68	0.31	0.01	0.01	0.01	0.01
Mixed MSW as disp	NA	NA	NA	-0.03	0.19	-0.03	-0.07	0.05
Dim. Lumber	-0.61	-0.61	-0.74	-0.25	-0.05	-0.17	-0.20	-0.13
MDF	-0.67	-0.67	-0.74	-0.25	-0.05	-0.17	-0.20	-0.13

Note that more digits may be displayed than are significant.

⁷ The full report is available on the Internet at <http://www.epa.gov/mswclimate> under the "Tools" section.

⁸ The values listed here reflect some additions and recent updates to those in the original report.

accounting for waste management practices. As well as measuring the progress of national programs (discussed in the next section), these factors have also been used by organizations interested in quantifying and voluntarily reporting GHG emission reductions. For example, utilities and waste combustion facilities participate in a voluntary reporting system managed by the US Department of Energy,⁹ and have used these emission factors. The methodology presented in this report may also assist other countries involved in developing GHG emission estimates for their solid waste streams.¹⁰

In order to make GHG emission factors presented in the report more readily accessible to stakeholders, EPA developed the WASTE Reduction Model (WARM). WARM provides users with a spreadsheet tool to assess GHG emission reductions associated with solid waste management decisions. It incorporates key site-specific parameters to improve the accuracy of the emission factors for specific conditions.

Program Implementation¹¹

The U.S. Climate Change Action Plan established an overall emission reduction goal of 109 million metric tons of carbon equivalent (MMTCE) by the year 2000. Of this goal, the EPA Waste and Climate Program is allocated a target of 5 MMTCE. EPA has been implementing three programs to help hit this target – WasteWise, Pay-As-You-Throw (PAYT), and the Waste Reduction Demonstration Projects – each of which are described below.

WasteWise¹²

WasteWise is a voluntary program working with a variety of entities – American businesses; federal, state, local, and tribal governments; and institutions – to reduce municipal solid waste. Presently, the WasteWise program has over 900 partners across the United States, representing over 50 business, civic, and industrial sectors. The partners range from Fortune 1000 companies to small local governments.

The WasteWise program encourages organizations to take cost-effective actions to reduce solid waste. Organizations participating in WasteWise commit to achievements in three areas, including waste prevention, recycling collection, and buying or manufacturing recycled products. Partners track their progress in these areas over a three-year period and report annually on their accomplishments. EPA maintains a reporting system that stores information on the specific materials addressed by the partners' efforts, and the volumes of waste prevented or recycled as a result of these efforts.

The combination of written commitments and annual reporting enable EPA to quantify WasteWise program results in terms of GHG emission reductions using the material- and activity-specific emission factors developed through our research. Measurable results allow companies and organizations involved in WasteWise to report voluntary GHG emission reductions and publicize their activities to environmentally conscious customers. In addition, the ability to measure emission reductions enables EPA to enlist further support for the program based on the significant benefits of program activities in terms of climate protection.

⁹ This reporting system is authorized by Section 1605 (b) of the Energy Policy Act of 1992

¹⁰ Note that waste composition and product life cycles vary significantly among countries. Our research may assist other countries by providing a methodologic framework and benchmark data for developing GHG emission estimates for their solid waste streams.

¹¹ Information on specific activities included in EPA OSW's program implementation efforts, as well as WARM, may be found at <http://www.epa.gov/mswclimate>.

¹² Information on WasteWise can be found on the web at <http://www.epa.gov/wastewise>.

Pay-As-You-Throw (PAYT)¹³

PAYT is a national program to encourage residential waste reduction. In communities with PAYT, residents are charged for the collection of municipal solid waste (MSW) based on the amount they throw away. This pricing approach causes residents to consider the amount of waste they generate; therefore the program creates a direct financial incentive to recycle more and generate less waste.

EPA's PAYT team distributes information, provides training, and offers technical assistance to waste managers and to local planners across the US. Through these and other efforts, EPA estimates that the number of communities using PAYT in the US has risen to over 4,000 (approximately 35 million residents).

Unlike partners of the WasteWise program, PAYT communities are not required to report annual results to EPA. Therefore, EPA measurement activities are limited by data availability and program results must be indirectly measured. Through academic research on PAYT activities nationwide, EPA has developed estimates of the effect of PAYT on typical communities' waste generation, landfilling, and recycling rates. Using these estimates, along with (1) assumptions on the change in proportions of specific materials source reduced or recycled, and (2) GHG emission factors by material type and activity, we can estimate the national GHG impact of PAYT.

Waste Reduction Demonstration Projects

The EPA Climate and Waste Program is currently funding more than 30 solid waste climate change grant projects. EPA headquarters staff work with regional offices to award grant funding to state and local governments and non-governmental organizations on a competitive basis. Awards are based largely on the ability to demonstrate GHG reductions through waste reduction activities and to communicate the benefits to peers.

Demonstration projects are often effective at reducing emissions and raising local interest. However, because they are demonstration projects they often require significantly longer "payback" periods than WasteWise or PAYT. Thus it is necessary to view benefits of these activities over a longer timeframe.

EPA has developed a database to track contact information, project descriptions, materials information (types and quantities), and GHG emission reductions attributable to these projects. Project results are provided on a semiannual basis by grantees. Project data are stored in the tracking system, along with material- and activity-specific GHG emission factors, enabling the calculation of emission reduction estimates.

Findings

The link between waste prevention and climate protection is stronger than commonly recognized. A life cycle approach is, in our view, the most appropriate foundation for establishing this link. Based on the US experience, environmental scientists and engineers in the waste management field would be well-advised to carefully review the IPCC accounting methods, and how they apply to sources and sinks for materials in the wastestream, when evaluating the nature and strength of the link in their countries.

GHG emission reductions that may be achieved through waste prevention programs are significant. Our 1997 estimate of emission reductions attributable to the EPA Climate and Waste

¹³ Information on PAYT can be found at <http://www.epa.gov/payt/>.

Program exceed 2.8 MMTCE, and the program is on track to meet its 2000 target of 5 MMTCE (comparable to taking over 4 million cars off the road). When developing a GHG mitigation portfolio, national, state, local, and industry decision-makers should consider waste prevention as an effective technique that can often be accomplished at low cost (and sometimes with cost savings) and has the added benefit of lending the weight of climate change to waste reduction policies in effect or planned.

The WasteWise, PAYT, and Waste Prevention Demonstration Projects have accumulated several years of experience in “marketing” climate protection through waste programs, and have learned many lessons on how to persuade public and private sector waste managers to participate in these programs. There are also many lessons that apply in terms of measuring program benefits from a GHG perspective. Much of this experience is transferable to other nations interested in pursuing and measuring voluntary emission reduction efforts. Accordingly, EPA’s Climate and Waste Program is willing to share the benefit of the US experience with other countries designing programs to encourage GHG emission reductions through waste management activities.

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