

# Washington Climate Advisory Team Beyond Waste IWG

## Waste Reduction Model (WARM)

Sara Hartwell

U.S. EPA Office of Solid Waste

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# What is Waste?

- For the purposes of this discussion, waste comprises products at the end of their life cycle:
  - Packaging
  - Consumer electronics
  - Newspapers
  - Food waste
  - Everything else that we discard



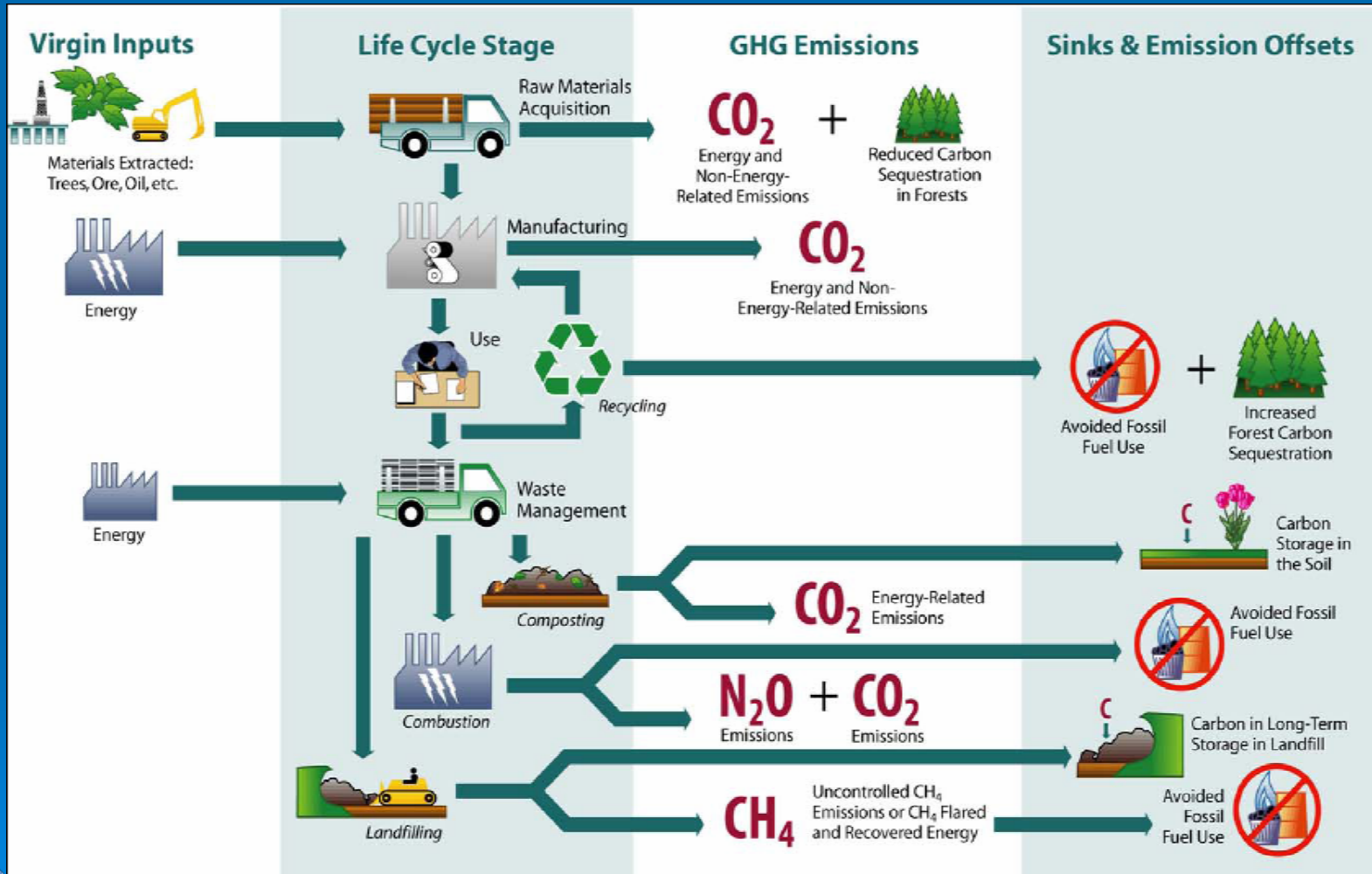
# What is the Life Cycle?

## ➤ The simplified version:

- Raw material extraction (bauxite mining, tree harvesting, oil pumped from underground, etc.)
- Raw materials are processed into manufacturing inputs (trees made into paper, etc.)
- Products are made from manufacturing inputs
- Products are used
- End-of-life products are managed as waste



# Product Life Cycle



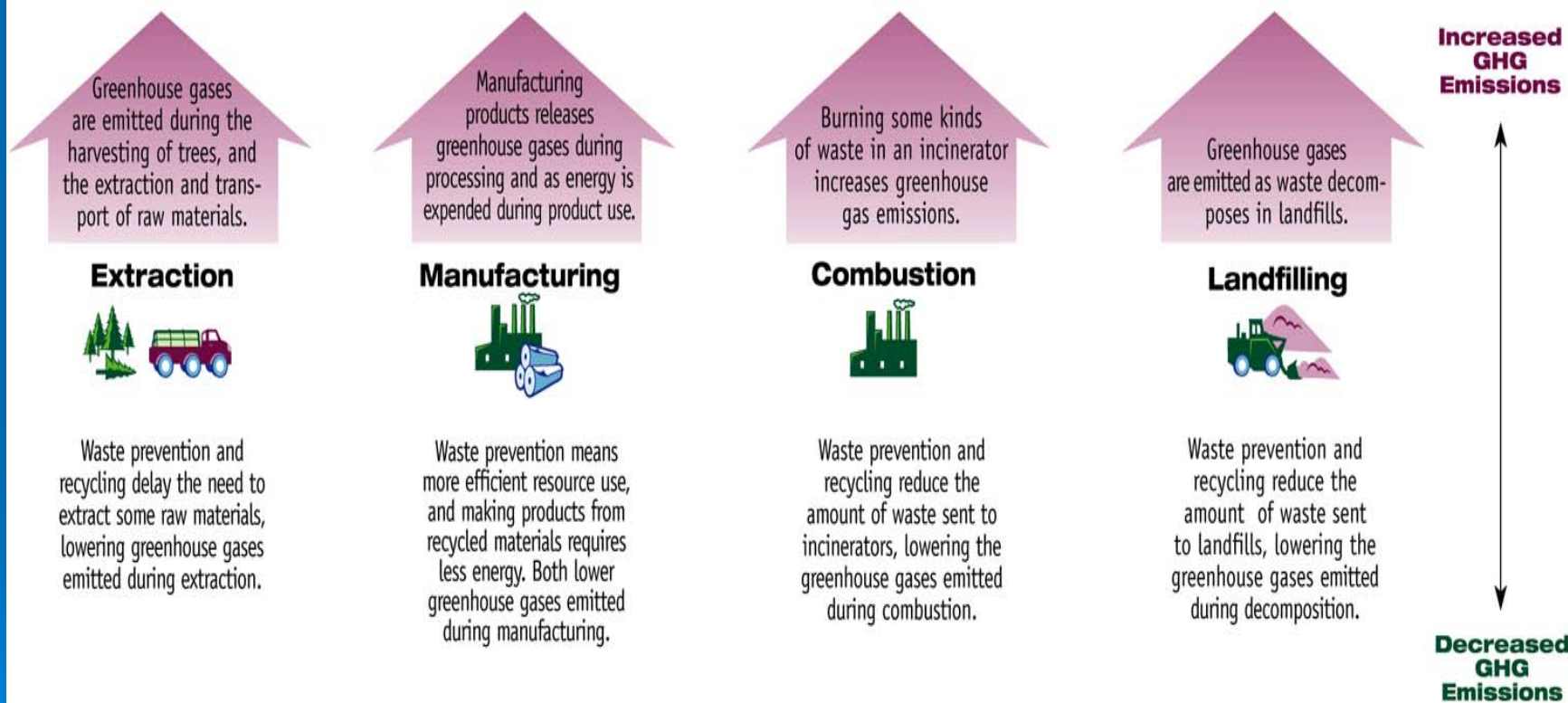
# Greenhouse Gases (GHG)

- There are many Greenhouse Gases (GHG) associated with the product life cycle ( $\text{CO}_2$ ,  $\text{CH}_4$ ,  $\text{N}_2\text{O}$ , etc.),
- Each GHG has a different impact on global warming
- We normalize the data using Global Warming Potentials (GWP)
  - a relative scale which compares the impact of the GHG to the impact of the same mass of  $\text{CO}_2$  (GWP of  $\text{CO}_2 = 1$ )
  - for example, GWP for  $\text{CH}_4 = 21$  and for  $\text{N}_2\text{O} = 310$
  - emissions of 1 million metric tons of  $\text{CH}_4$  and  $\text{N}_2\text{O}$  are equivalent to emissions of 21 and 310 million metric tons of  $\text{CO}_2$ , respectively
- Normalized GHG data are expressed as carbon dioxide equivalent, or  $\text{CO}_2 \text{ e}$



# What is the Link?

## The Link Between Waste Management and Greenhouse Gases



# How do we calculate the benefits?

## The Waste Reduction Model (WARM)

[http://epa.gov/climatechange/wycd/waste/calculators/Warm\\_home.html](http://epa.gov/climatechange/wycd/waste/calculators/Warm_home.html)

- WARM was designed to provide waste managers with a simple tool to help them understand and evaluate the greenhouse gas implications of their waste management decisions



# WARM is Based on a Life-Cycle Approach

- Incorporates the full range of GHG effects through a material's life cycle
- Uses Intergovernmental Panel on Climate Change (IPCC) accounting methods for GHG emissions and sinks



# What WARM Does:

- Assess GHG and energy impacts of waste management scenarios:
  - Landfilling
  - Recycling
  - Incineration (w/ energy capture)
  - Source Reduction
  - Composting
- Accepts user-specific inputs and provides individualized results
- Available for use online or as a downloadable spreadsheet



# Materials in WARM:

- Emissions factors for 26 material types and 6 categories of mixed materials (paper, metals, plastics, organics, MSW, and recyclables)

- Aluminum Cans
- Branches
- Corrugated Cardboard
- Dimensional Lumber
- Food Scraps
- Glass
- Grass
- HDPE
- LDPE
- Leaves

- Magazines
- Medium Density Fiberboard
- Newspaper
- Office Paper
- PET
- Phonebooks
- Steel Cans
- Textbooks
- Yard Trimmings

New in 3<sup>rd</sup> edition:

- Brick
- Carpet
- Concrete
- Copper
- Fly Ash
- PCs
- Tires



# Background on WARM

*Solid Waste Management and Greenhouse Gases: A Life-cycle Assessment of Emissions and Sinks* describes the WARM methodology, and provides background on the emissions factors

<http://epa.gov/climatechange/wycd/waste/SWMSGHGreport.html>

- There have been three editions of the report (1998, 2002, and 2006)
- The methodology presented in the 1998 report and reflected in the earliest versions of WARM has remained largely unchanged
- Data have been updated at multiple intervals
- New data are currently under development



# How do I use WARM?

- WARM is available in two versions
  - ① Excel spreadsheet
  - ② Web-based calculator



# The first screen is the input screen.

- ① Enter total **Tons Generated** for each material type.
- ② Enter current disposal method (**Recycled, Landfilled, Combusted, or Composted**). You use as many waste management scenarios as you like, but it must equal the total **Tons Generated**.

The screenshot shows the EPA Waste Reduction Model (WARM) input screen. The browser window title is "Waste Home - Waste Reduction Model (WARM) | Climate Change - What You Can Do | U.S. EPA - Microsoft Internet Explorer". The address bar shows the URL: "http://epa.gov/climatechange/wyycd/waste/calculators/Warm\_Form.html". The page header includes the EPA logo and the text "U.S. Environmental Protection Agency". The main heading is "Climate Change - Waste" and "Waste Reduction Model (WARM)". Below the heading, there is a search bar and navigation links. The page content includes a version number (8, 8/06), a description of the WARM tool, and instructions for using the worksheet. A "Tips" section provides guidance on data entry. The "Step 1. Baseline Scenario" section includes a table for entering material data.

**U.S. Environmental Protection Agency**

## Climate Change - Waste

U.S. EPA  
Address: http://epa.gov/climatechange/wyycd/waste/calculators/Warm\_Form.html

Search:

You are here: [EPA Home](#) » [Climate Change](#) » [What You Can Do](#) » [Waste](#) » [Tools](#) » [WARM](#) » WARM Online

### Waste Reduction Model (WARM)

(Version 8, 8/06)

EPA created WARM to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions and energy savings from several different waste management practices. WARM Online was last updated August 2006.

Use this worksheet to describe the baseline and alternative MSW management scenarios that you want to compare. Please follow the steps below to enter your material tonnage information in the input boxes in the tables, and select appropriate landfill and waste transport characteristics.

**Tips:**

- If the listed material is not generated in your community/organization or you do not want to analyze it, leave it blank or enter 0.
- Make sure that the total quantity generated equals the total quantity managed.
- If you have any questions, consult the [WARM User's Guide](#).

**Step 1. Baseline Scenario**

Please describe your current (or baseline) waste management scenario by entering the tons of each material type that is generated and disposed.

Material	Tons Generated	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Steel Cans	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Copper Wire	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Glass	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
HDPE	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
LDPE	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
PET	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Corrugated Cardboard	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Magazines/third-class mail	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A
Newspaper	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	N/A

① Next, enter tonnage directed to each alternate waste disposal scenario. For example, in the previous step you may have landfilled the total tonnage and in this scenario you decide to recycle half of the total and landfill the remaining half.

② Verify the totals are equal to what you entered in the previous step. You do not enter a generation amount in this step.

Waste Home - Waste Reduction Model (WARM) | Climate Change - What You Can Do | U.S. EPA - Microsoft Internet Explorer

Please enter data in short tons (1 short ton = 2,000 lbs.)  
 Please refer to the User's Guide if you need assistance completing this table.  
 1 Recycled concrete used as aggregate in the production of new concrete  
 2 Recycled fly ash is utilized to displace Portland cement in concrete production.  
 3 Recycling tires is defined in this analysis as retreading and does not include other recycling activities (i.e. crumb rubber applications).

**Step 2. Alternative Management Scenario**

Please describe your alternate waste management scenario by entering the tons of each material type that is source reduced or disposed. Please note that the baseline generation tonnages will stay the same as those entered in Step 1.

Material	Tons Source Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted
Aluminum Cans					N/A
Steel Cans					N/A
Copper Wire					N/A
Glass					N/A
HDPE					N/A
LDPE					N/A
PET					N/A
Corrugated Cardboard					N/A
Magazines/third-class mail					N/A
Newspaper					N/A
Office Paper					N/A
Phonebooks					N/A
Textbooks					N/A
Dimensional Lumber					N/A
Medium Density Fiberboard					N/A
Food Scraps	N/A	N/A			
Yard Trimmings	N/A	N/A			
Grass	N/A	N/A			

start Intel(R) PRO... 2 Windows ... C:\WINDOW... > Re: I need ... 4 Microsoft ... 5 Microsoft ... Waste Home ... 1:46 AM

As you scroll down the page there are options to change if you know about how far your waste travels and the landfills you use.

EPA Headquarters primarily uses the default options for Step 3 and Step 4. Unless you have good specific information about your landfill's management and the distance waste travels to reach a facility, it is recommend that you do not change these options. If you do change either of these options, it is important to note those changes when you report the results.

Waste Home - Waste Reduction Model (WARM) | Climate Change - What You Can Do | U.S. EPA - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address [http://epa.gov/climatechange/wywd/waste/calculators/Warm\\_Form.html](http://epa.gov/climatechange/wywd/waste/calculators/Warm_Form.html)

Please enter data in short tons (1 short ton = 2,000 lbs.)  
Please refer to the User's Guide if you need assistance completing this table.  
1 Recycled concrete used as aggregate in the production of new concrete  
2 Recycled fly ash is utilized to displace Portland cement in concrete production.  
3 Recycling tires is defined in this analysis as retreading and does not include other recycling activities (i.e. crumb rubber applications).

**Step 3. Landfill Characteristics**

The emissions from landfilling depend on whether the landfill where your waste is disposed has a landfill gas (LFG) control system. If you do not know whether your landfill has LFG control, select "National Average," which calculates emissions based on the proportions of landfills with LFG control in 2004. If your landfill does not have a LFG system, select "No LFG Recovery." If a LFG system is in place at your landfill, select "LFG Recovery" and click one of the indented buttons to indicate whether LFG is recovered for energy or flared.

- National Average
- No LFG Recovery
- LFG Recovery
- Recover for energy
- Flare

**Step 4. Waste Transport Characteristics**

Emissions that occur during transport of materials to the management facility are included in this model. You may use default transport distances, 20 miles, or provide information on the transport distances for the various MSW management options.

- Use default distance
- Define distance

Management Option	Distance (miles)
Landfill	20
Combustion	20
Recycling	20
Composting	20

**Step 5. Results Output**

- Metric Tons of Carbon Equivalent (MTCE)
- Metric Tons of Carbon Dioxide Equivalent (MTCO<sub>2</sub>E)
- Units of Energy (million BTU)

The following inputs are optional and may be used to customize your summary report.

Organization:

Name:

start Intel(R) PRO... 2 Windows ... C:\WINDOW... > Re: I need ... Microsoft ... Microsoft ... Waste Home ... 1:48 AM

① To generate your results, select the preferred output units in Step 5.  
WARM can generate results in three different units:  
MTCE — Metric tons of Carbon Equivalent;  
MTCO2E — Metric tons of Carbon Dioxide Equivalent;  
BTU — Energy, British Thermal Units.

② Click on the **Create Summary** button

on the transport distances for the various MSW management options.

- Use default distance
- Define distance

Management Option	Distance (miles)
Landfill	20
Combustion	20
Recycling	20
Composting	20

**Step 5. Results Output**

- Metric Tons of Carbon Equivalent (MTCE)
- Metric Tons of Carbon Dioxide Equivalent (MTCO2E)
- Units of Energy (million BTU)

The following inputs are optional and may be used to customize your summary report.

Organization:

Name:

Reporting Period:  /  /  To  /  /

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Last updated on Monday, November 13th, 2006.  
[http://epa.gov/climatechange/wycd/waste/calculators/Warm\\_Form.html](http://epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html)  
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# Results

WARM Summary - Microsoft Internet Explorer

File Edit View Favorites Tools Help

## GHG Emissions Analysis -- Summary Report

(Version 8, 8/06)

Analysis of GHG Emissions from Waste Management

**GHG Emissions from Baseline Waste Management (MTCE): 1,083**

Material	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE
Aluminum Cans	0	103,890	0	N/A	1,077
Glass	10	7	0	N/A	-1
PET	0	671	0	N/A	7

**GHG Emissions from Alternative Waste Management Scenario (MTCE): -384,762**

Material	Tons Reduced	Tons Recycled	Tons Landfilled	Tons Combusted	Tons Composted	Total MTCE
Aluminum Cans	0	103,890	0	0	N/A	-384,479
Glass	0	17	0	0	N/A	-1
PET	0	671	0	0	N/A	-281

**Total Change in GHG Emissions: -385,845 MTCE**

Note: A negative value indicates an emission reduction; a positive value indicates an emission increase.

- For an explanation of the methodology used to develop emission factors, see EPA report: Greenhouse Gas Emissions from Management of Selected Materials in Municipal Solid Waste (EPA530-R-98-013) -- available on the Internet at <http://www.epa.gov/epaoswer/non-hw/muncpl/ghg/greengas.pdf> (1.1 Mb PDF file). Please note that some of the emission factors used to generate these results do not match those presented in the report due to recent additions and/or revisions. A 3rd edition of the report will be available in early Fall of 2006, which will include the latest emission factors.
- Emissions estimates provided by this model are intended to support voluntary GHG measurement and reporting initiatives.
- Total emissions estimates provided by this model may not sum due to independent rounding.

Back to WARM View Emission Factors



# Interpreting Results

- ① The first set of boxes indicates the emissions from your baseline scenario in Step 1.
- ② The second set of boxes indicates the emissions from your alternate management scenario in Step 2.
- ③ The Total Change in GHG Emissions is the difference between the Total MTCE in the first set of boxes and the Total MTCE in the second set of boxes.
- A negative (-) number in the total change represents a reduction in GHG Emissions
- For example, in the summary report shown in the previous slide, GHG emissions are reduced by 384,479 MTCE when 103,890 tons of aluminum cans are recycled instead of landfilled



# Does EPA have other tools?

- <http://epa.gov/climatechange/wycd/waste/tools.html>
  - Recycled Content Tool (ReCon)
  - Waste Reduction Model (WARM)
  - Durable Goods Calculator (DGC)
  - Greenhouse Gas Equivalencies Calculator



# Recycled Content Tool (ReCon)

- Estimates GHG and energy benefits of increasing recycled content

# Durable Goods Calculator

- Assess GHG emissions benefits of different disposal methods for 14 durable goods (i.e., refrigerators, washers, dryers, PCs, autos, TVs, etc.)



# What is the Impact?

- In 2006, waste activities accounted for approximately 3% of total U.S. GHG emissions
  - Waste = 161 million MTCO<sub>2</sub>e
  - Net Emissions = 6,170.5 million MTCO<sub>2</sub>e
- Landfills were the largest source of anthropogenic CH<sub>4</sub> emissions from waste activities, accounting for 23 % of total U.S. CH<sub>4</sub> emissions



# What is the Impact?

- In 2006, the U.S. recycled 32.5 % (81.8 million tons) of MSW
  - Avoided emissions of 182.2 million MTCO<sub>2</sub>e
  - Energy benefit of 1.3 quadrillion BTUs



<http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm>

# How big is the impact?

- In the United States in 2006:
  - Waste activities resulted in emission of 161 million MTCO<sub>2</sub>e<sup>1</sup>
  - Emissions from landfills = 125.7 million MTCO<sub>2</sub>e<sup>1</sup>
  - Recycling emissions benefits = 182.2 million MTCO<sub>2</sub>e<sup>2</sup>



<sup>1</sup>[http://www.epa.gov/climatechange/emissions/downloads/08\\_CR.pdf](http://www.epa.gov/climatechange/emissions/downloads/08_CR.pdf)

<sup>2</sup><http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm>

# How big is the impact?

- In the United States in 2006:
  - residential site energy consumption is stable at about 10 quadrillion BTUs/year<sup>1</sup>
  - Recycling emissions benefits = 1.3 quadrillion BTUs<sup>2</sup>

<sup>1</sup><http://www.eia.doe.gov/>

<sup>2</sup><http://www.epa.gov/epaoswer/non-hw/muncpl/msw99.htm>



# How big is the impact?

1 quadrillion BTUs is equal to the annual energy output of 40 power plants (1,000 MW per power plant)

<http://www.aia.org/SiteObjects/files/architectsandclimatechange.pdf>

Reduced energy demand of 1.3 quadrillion BTUs represents ~50 power plants that we didn't have to build



Sara Hartwell

US EPA

703-308-7285

[hartwell.sara@epa.gov](mailto:hartwell.sara@epa.gov)

