# STOP TRASHING THE CLIMATE

**FULL REPORT**
**June 2008**

ILSR
INSTITUTE FOR LOCAL SELF-RELIANCE

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Working to Build Zero Waste Communities

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# A ZERO WASTE APPROACH IS ONE OF THE FASTEST, CHEAPEST, AND MOST EFFECTIVE STRATEGIES TO PROTECT THE CLIMATE.

Significantly decreasing waste disposed in landfills and incinerators will reduce greenhouse gas emissions the equivalent to closing 21% of U.S. coal-fired power plants. This is comparable to leading climate protection proposals such as improving national vehicle fuel efficiency. Indeed, preventing waste and expanding reuse, recycling, and composting are essential to put us on the path to climate stability.

## KEY FINDINGS:

1. A zero waste approach is one of the fastest, cheapest, and most effective strategies we can use to protect the climate and the environment. Significantly decreasing waste disposed in landfills and incinerators will reduce greenhouse gases the equivalent to closing one-fifth of U.S. coal-fired power plants. This is comparable to leading climate protection proposals such as improving vehicle fuel efficiency. Indeed, implementing waste reduction and materials recovery strategies nationally are essential to put us on the path to stabilizing the climate by 2050.
2. Wasting directly impacts climate change because it is directly linked to global resource extraction, transportation, processing, and manufacturing. When we minimize waste, we can reduce greenhouse gas emissions in sectors that together represent 36.7% of all U.S. greenhouse gas emissions.
3. A zero waste approach is essential. Through the Urban Environmental Accords, 103 city mayors worldwide have committed to sending zero waste to landfills and incinerators by the year 2040 or earlier.
4. Existing waste incinerators should be retired, and no new incinerators or landfills should be constructed.
5. Landfills are the largest source of anthropogenic methane emissions in the U.S., and the impact of landfill emissions in the short term is grossly underestimated — methane is 72 times more potent than $CO_2$ over a 20-year time frame.
6. The practice of landfilling and incinerating biodegradable materials such as food scraps, paper products, and yard trimmings should be phased out immediately. Composting these materials is critical to protecting our climate and restoring our soils.
7. Incinerators emit more $CO_2$ per megawatt-hour than coal-fired, natural-gas-fired, or oil-fired power plants. Incinerating materials such as wood, paper, yard debris, and food discards is far from "climate neutral"; rather, incinerating these and other materials is detrimental to the climate.
8. Incinerators, landfill gas capture systems, and landfill "bioreactors" should not be subsidized under state and federal renewable energy and green power incentive programs or carbon trading schemes. In addition, subsidies to extractive industries such as mining, logging, and drilling should be eliminated.
9. New policies are needed to fund and expand climate change mitigation strategies such as waste reduction, reuse, recycling, composting, and extended producer responsibility. Policy incentives are also needed to create locally-based materials recovery jobs and industries.
10. Improved tools are needed for assessing the true climate implications of the wasting sector.

# Stop Trashing The Climate

www.stoptrashingtheclimate.org
zerowaste@stoptrashingtheclimate.org

by

**Brenda Platt**
Institute for Local Self-Reliance

**David Ciplet**
Global Anti-Incinerator Alliance/Global Alliance for Incinerator Alternatives

**Kate M. Bailey and Eric Lombardi**
Eco-Cycle

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## About the Institute for Local Self-Reliance

ILSR is a nationally recognized organization providing research and technical assistance on recycling and community-based economic development, building deconstruction, zero waste planning, renewable energy, and policies to protect local main streets and other facets of a homegrown economy. Our mission is to provide the conceptual framework and information to aid the creation of ecologically sound and economically equitable communities. ILSR works with citizens, activists, policy makers, and entrepreneurs. Since our inception in 1974, we have actively addressed the burgeoning waste crisis, overdependence on fossil fuels, and other materials efficiency issues. We advocate for better practices that support local economies and healthy communities.

**For more information contact:**

927 15th Street, NW, 4th Floor
Washington, DC 20005
**(202)898-1610 • www.ilsr.org • info@ilsr.org**

## About Eco-Cycle

Founded in 1976, Eco-Cycle is one of the largest non-profit recyclers in the USA and has an international reputation as a pioneer and innovator in resource conservation. We believe in individual and community action to transform society's throw-away ethic into environmentally-friendly stewardship. Our mission is to provide publicly-accountable recycling, conservation and education services, and to identify, explore and demonstrate the emerging frontiers of sustainable resource management and Zero Waste.

**For more information contact:**

P.O. Box 19006 Boulder, CO 80308
**(303)444-6634 • www.ecocycle.org • recycle@ecocycle.org**

## About the Global Anti-Incinerator Alliance/Global Alliance for Incinerator Alternatives

GAIA is a worldwide alliance of more than 500 grassroots organizations, non-governmental organizations, and individuals in 81 countries whose ultimate vision is a just, toxic-free world without incineration. Our goal is clean production and the creation of a closed-loop, materials-efficient economy where all products are reused, repaired or recycled. GAIA's greatest strength lies in its membership, which includes some of the most active leaders in environmental health and justice struggles internationally. Worldwide, we are proving that it is possible to stop incinerators, take action to protect the climate, and implement zero waste alternatives. GAIA's members work through a combination of grassroots organizing, strategic alliances, and creative approaches to local economic development. In the United States, GAIA is a project of the Ecology Center (ecologycenter.org).

**For more information contact:**

Unit 320, Eagle Court Condominium,
26 Matalino Street, Barangay Central,
Quezon City 1101, Philippines
**Tel:** 63 (2) 929-0376 • **Fax:** 63 (2) 436-4733

1442A Walnut Street, #20
Berkeley, California 94709, USA
**Tel:** 1 (510) 883 9490 • **Fax:** 1 (510) 883-9493

**www.no-burn.org • info@no-burn.org**

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## PREFACE

How beneficial would it be to the climate if we were to shut down one-fifth of the nation's coal-fired power plants? To say it would be "very beneficial" is probably an understatement. It turns out that we can reduce greenhouse gas emissions by an amount equivalent to shutting down one-fifth of the nation's coal-fired power plants by making practical and achievable changes to America's waste management system. Indeed, taking logical steps to reduce the amount that we waste in landfills and incinerators would also have comparable climate benefits to significantly improving national vehicle fuel efficiency standards and other leading climate protection strategies.

The authors of *Stop Trashing the Climate* are building a dialogue with this report. The world is already in dialogue about energy and climate change, but the discussion of how wasting impacts global warming has only just begun. This report shines the spotlight on the immediate, cost-effective, and momentous gains that are possible through better resource management. Stemming waste is a crucial element to mitigating climate change.

Wasting occurs at every step of our one-way system of resource consumption. From resource extraction to manufacturing to transportation to disposal, each step impacts the state of our climate and our environment. *Stop Trashing the Climate* presents a bird's-eye view of this unsustainable system, showing both the cumulative impacts of our choices and the huge potential for change.

While this report focuses only on climate implications, the decisions to cut waste will also reduce human health risks, conserve dwindling resources, protect habitat, improve declining soil quality, address issues of social and environmental justice, and strengthen local economies.

One shocking revelation within the pages that follow is the grossly inaccurate way that the world has been measuring the global warming impact of methane — especially landfill methane. We have documented here that the choice of measuring the impact of methane over a 100-year timeline is the result of a policy decision, and not a scientific one. We have found that the climate crisis necessitates looking at the near-term impact of our actions. Our calculations of greenhouse gas emissions over a 20-year timeline show that the climate impacts of landfill gas have been greatly understated in popular U.S. EPA models.

But that's far from the end of the story. We also expose incinerators as energy wasters rather than generators, and as significant emitters of carbon dioxide. We describe the absurdity of the current reality in which our agricultural soil is in increasingly desperate need of organic materials while we waste valuable nutrients and space in landfills by simply failing to compost food scraps and yard trimmings. We call attention to the negative impact of misguided subsidies that fund incinerators and landfills as generators of "renewable energy." We also reveal the many fallacies behind estimated landfill gas capture rates and show how preventing methane generation is the only effective strategy for protecting our climate.

We are addressing these critical issues because few others are, and as leading organizations at the forefront of resource conservation, we see how these issues connect many of our environmental challenges — especially climate change. We've sought to provide a factual analysis and to fill in the data gaps when we could, but we don't claim that our analysis is fully conclusive or comprehensive. The authors of this report are concerned people who work at the interface of society, technology, and the environment. We welcome hard data to challenge us and refine our findings! If you disagree with our policy positions and recommendations for action, we welcome that, too! But if you agree with the findings and assertions in this report, then we expect to link arms with you, the reader, and move the discussion forward about how to change the negative impacts of our planetary wasting patterns, reduce reliance on disposal systems, capitalize on the environmental and economic opportunities in sustainable resource use, support environmental justice, and make real change in policy so that we can make real change in the world.

Significant reductions in greenhouse gas emissions are achieved when we reduce materials consumption in the first place, and when we replace the use of virgin materials with reused and recycled materials in the production process. This is the heart of a zero waste approach. The time to act is now, and this report provides a roadmap for us to address global climate change starting in our own communities.

**Eric Lombardi**
Eco-Cycle

**Brenda Platt**
Institute for Local Self-Reliance

**David Ciplet**
GAIA

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**Please email us at:** zerowaste@stoptrashingtheclimate.org

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**Neil Tangri** :: GAIA, Berkeley, CA

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**Monica Wilson** :: GAIA, Berkeley, CA

All responsibility for the views expressed in this report or for any errors in it rests with the authoring organizations.

## Executive Summary

***Stop Trashing the Climate* provides compelling evidence that preventing waste and expanding reuse, recycling, and composting programs — that is, aiming for zero waste — is one of the fastest, cheapest, and most effective strategies available for combating climate change.** This report documents the link between climate change and unsustainable patterns of consumption and wasting, dispels myths about the climate benefits of landfill gas recovery and waste incineration, outlines policies needed to effect change, and offers a roadmap for how to significantly reduce greenhouse gas (GHG) emissions within a short period.

Immediate and comprehensive action by the United States to dramatically reduce greenhouse gas emissions is desperately needed. Though the U.S. represents less than 5% of the world's population, we generate 22% of the world's carbon dioxide emissions, use 30% of the world's resources, and create 30% of the world's waste.[1] If unchecked, annual greenhouse gas emissions in the U.S. will increase to 9.7 gigatons* carbon-dioxide equivalents ($CO_2$ eq.) by 2030, up from 6.2 gigatons $CO_2$ eq. in 1990.[2] Those who are most impacted by climate change, both globally and within the U.S., are people of color and low-income and indigenous communities — the same people who are least responsible for rapidly increasing greenhouse gas emissions.[3] To effectively address global climate change, the U.S. must dramatically shift its relationship to natural resources. A zero waste approach is a crucial solution to the climate change problem.

*Stop Trashing the Climate* provides an alternative scenario to business-as-usual wasting in the U.S. By reducing waste generation 1% each year and diverting 90% of our discards from landfills and incinerators by the year 2030, we could dramatically reduce greenhouse gas emissions within the U.S. and around the world. This waste reduction scenario would put us solidly on track to achieving the goal of sending zero waste to landfills and incinerators by the year 2040, the target established by the Urban Environmental Accords, which 103 city mayors worldwide have signed.[4]

By reducing waste creation and disposal, the U.S. can conservatively decrease greenhouse gas emissions by 406 megatons‡ $CO_2$ eq. per year by 2030. This zero waste approach would reduce greenhouse gas emissions the equivalent of closing one-fifth of the existing 417 coal-fired power plants in the U.S.[5] This would achieve 7% of the cuts in U.S. greenhouse gas emissions needed to put us on the path to achieving what many leading scientists say is necessary to stabilize the climate by 2050.[6, 7, 8] Indeed, reducing waste has comparable (and sometimes complementary) benefits to the leading strategies identified for climate protection, such as significantly improving vehicle fuel efficiency and hybridizing vehicles, expanding and enhancing carbon sinks (such as forests), and retrofitting lighting and improving electronic equipment. (See Table ES-1.) Further, a zero waste approach has greater potential for protecting the climate than environmentally harmful strategies proposed to reduce carbon emissions such as the expansion of nuclear energy. Moreover, reuse, recycling, and composting facilities do not have the severe liability or permitting issues associated with building nuclear power plants or carbon capture and storage systems.[9]

**The good news is that readily available cost-competitive and effective strategies to reduce, reuse, and recover discarded materials can be implemented on a wide scale within a relatively short time period.**

* 1 gigaton = 1 billion metric tons
‡ 1 megaton = 1 million metric tons = 1 Tg (teragram)

**Table ES-1: Greenhouse Gas Abatement Strategies: Zero Waste Path Compared to Commonly Considered Options** (annual reductions in greenhouse gas emissions by 2030, megatons $CO_2$ eq.)

| Greenhouse Gas Abatement Strategy | Annual Abatement Potential by 2030 | % of Total Abatement Needed in 2030 to Stabilize Climate by 2050[1] |
|---|---|---|
| **ZERO WASTE PATH** | | |
| Reducing waste through prevention, reuse, recycling and composting | **406** | **7.0%** |
| **ABATEMENT STRATEGIES CONSIDERED BY McKINSEY REPORT** | | |
| **Increasing fuel efficiency in cars and reducing fuel carbon intensity** | **340** | **5.9%** |
| Improved fuel efficiency and dieselization in various vehicle classes | 195 | 3.4% |
| Lower carbon fuels (cellulosic biofuels) | 100 | 1.7% |
| Hybridization of cars and light trucks | 70 | 1.2% |
| **Expanding & enhancing carbon sinks** | **440** | **7.6%** |
| Afforestation of pastureland and cropland | 210 | 3.6% |
| Forest management | 110 | 1.9% |
| Conservation tillage | 80 | 1.4% |
| **Targeting energy-intensive portions of the industrial sector** | **620** | **10.7%** |
| Recovery and destruction of non-$CO_2$ GHGs | 255 | 4.4% |
| Carbon capture and storage | 95 | 1.6% |
| Landfill abatement (focused on methane capture) | 65 | 1.1% |
| New processes and product innovation (includes recycling) | 70 | 1.2% |
| **Improving energy efficiency in buildings and appliances** | **710** | **12.2%** |
| Lighting retrofits | 240 | 4.1% |
| Residential lighting retrofits | 130 | 2.2% |
| Commercial lighting retrofits | 110 | 1.9% |
| Electronic equipment improvements | 120 | 2.1% |
| **Reducing the carbon intensity of electric power production** | **800** | **13.8%** |
| Carbon capture and storage | 290 | 5.0% |
| Wind | 120 | 2.1% |
| Nuclear | 70 | 1.2% |

The McKinsey Report analyzed more than 250 opportunities to reduce greenhouse gas emissions. While the authors evaluated options for three levels of effort—low-, mid-, and high-range—they only reported greenhouse gas reduction potential for the mid-range case opportunities. The mid-range case involves concerted action across the economy. Values for select mid-range abatement strategies are listed above. The zero waste path abatement potential also represents a mid-range case, due to shortcomings in EPA's WARM model, which underestimates the reduction in greenhouse gases from source reduction and composting as compared to landfilling and incineration. A high-range zero waste path would also provide a more accelerated approach to reducing waste generation and disposal.

The authors of this report, *Stop Trashing the Climate*, do not support all of the abatement strategies evaluated in the McKinsey Report. We do not, for instance, support nuclear energy production.

1. In order to stabilize the climate, U.S. greenhouse gas emissions in 2050 need to be at least 80% below 1990 levels. Based on a straight linear calculation, this means 2030 emissions levels should be 37% lower than the 1990 level, or equal to 3.9 gigatons $CO_2$ eq. Thus, based on increases in U.S. greenhouse gases predicted by experts, 5.8 gigatons $CO_2$ eq. in annual abatement is needed in 2030 to put the U.S. on the path to help stabilize the climate by 2050.

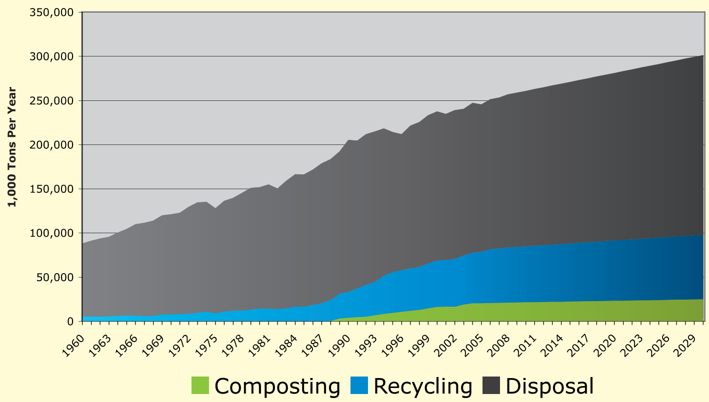
Source: Jon Creyts et al, *Reducing U.S. Greenhouse Gas Emissions: How Much and at What Cost? U.S. Greenhouse Gas Abatement Mapping Initiative, Executive Report,* McKinsey & Company, December 2007. Available online at: http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp. Abatement potential for waste reduction is calculated by the Institute for Local Self-Reliance, Washington, DC, June 2008, based on the EPA's WAste Reduction Model (WARM) to estimate GHGs and based on extrapolating U.S. EPA waste generation and characterization data to 2030, assuming 1% per year source reduction, and achieving a 90% waste diversion by 2030.

coal-fired power plant

To achieve the remarkable climate protection potential of waste reduction, we must stem the flow of materials to landfills and halt the building and use of incinerator facilities. Landfills and incinerators destroy rather than conserve materials. For every item that is landfilled or incinerated, a new one must be extracted, processed, and manufactured from raw or virgin resources. Americans destroy nearly 170 million tons of paper, metals, plastics, food scraps, and other valuable materials in landfills and incinerators each year. More than two thirds of the materials we use are still burned or buried,[10] despite the fact that we have the technical capacity to cost-effectively recycle, reuse or compost 90% of what we waste.[11] Millions of tons of valuable resources are also needlessly wasted each year because products are increasingly designed to be used only once.[12]

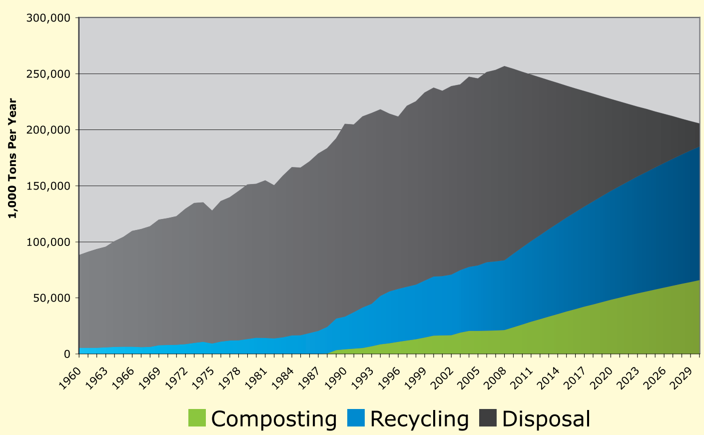
If we continue on the same wasting path with rising per capita waste generation rates and stagnating recycling and composting rates, by the year 2030 Americans could generate 301 million tons per year of municipal solid waste, up from 251 million tons in 2006. Figure ES-1, Business As Usual, visually represents the future projection of this trend based on our current wasting patterns. Figure ES-2, Zero Waste Approach, illustrates an alternate path based on rising recycling and composting rates and the source reduction of 1% of waste per year between 2008 and 2030. Under this zero waste approach, 90% of the municipal solid waste generated in the U.S. could be diverted from disposal facilities by 2030. Using the U.S. EPA's WAste Reduction Model (WARM) to estimate greenhouse gas reduction, the zero waste approach — as compared to the business-as-usual approach — would reduce greenhouse gases by an estimated 406 megatons $CO_2$ eq. per year by 2030. This reduction of 406 megatons $CO_2$ eq. per year is equivalent to closing 21% of the nation's 417 coal-fired power plants.

**Figure ES-1: Business As Usual Recycling, Composting, Disposal**




Source: Brenda Platt and Heeral Bhalala, Institute for Local Self-Reliance, Washington, DC, June 2008, using and extrapolating from U.S. EPA municipal solid waste characterization data. Waste composition in future assumed the same as 2006. The diversion level through recycling and composting flattens out at 32.5%. Takes into account U.S. Census estimated population growth.

**Figure ES-2: Zero Waste Approach**




Source: Brenda Platt and Heeral Bhalala, Institute for Local Self-Reliance, Washington, DC, June 2008. Past tonnage based on U.S. EPA municipal solid waste characterization data. Future tonnage based on reaching 90% diversion by 2030, and 1% source reduction per year between 2008 and 2030. Waste composition in future assumed the same as 2006. Takes into account U.S. Census estimated population growth.

Current assessments of greenhouse gas emissions from waste take an overly narrow view of the potential for the "waste sector" to mitigate climate change. This is largely a result of inventory methodologies used to account for greenhouse gases from waste. Conventional greenhouse gas inventory data indicate that the waste sector in the U.S. is solely responsible for 2.6% of all greenhouse gas emissions in 2005. This assessment, however, does not include the most significant climate change impact of waste disposal: We must continually extract new resources to replace those buried or burned. For every ton of discarded products and materials destroyed by incinerators and landfills, about 71 tons of manufacturing, mining, oil and gas exploration, agricultural, coal combustion, and other discards are produced.[13] More trees must be cut down to make paper. More ore must be mined for metal production. More petroleum must be processed into plastics.

By reusing instead of disposing of materials, we can keep more forests and other ecosystems intact, store or sequester large amounts of carbon, and significantly reduce our global warming footprint. For example, cutting deforestation rates in half globally over the next century would provide 12% of the global emissions reductions needed to prevent significant increases in global temperatures.[14]

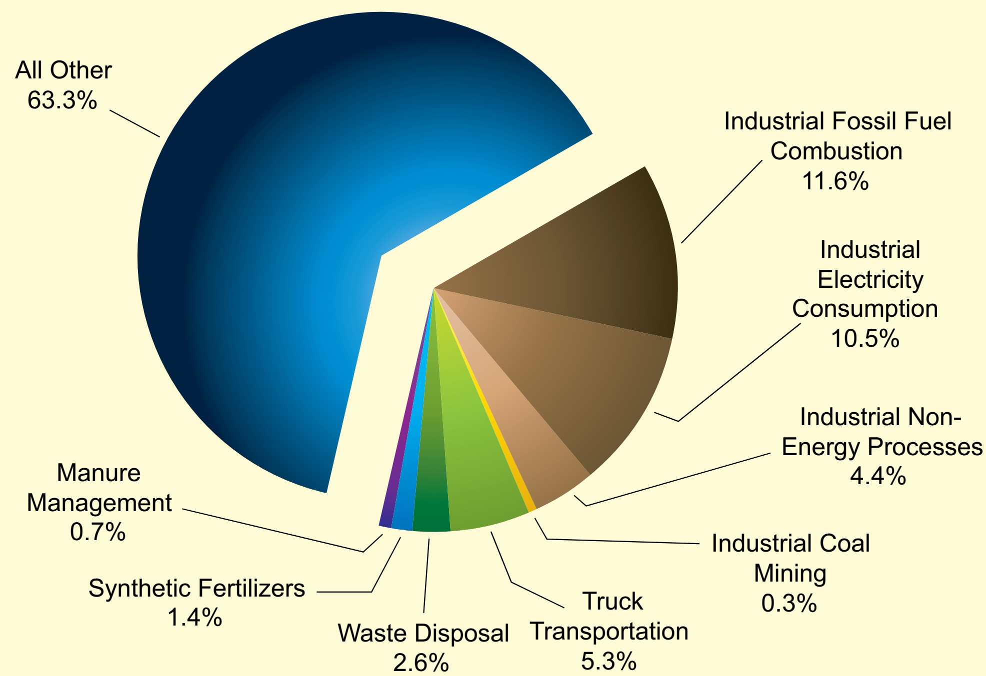
Reusing materials and reducing waste provide measurable environmental and climate benefits. According to a recent report to the California Air Resources Board, *Recommendations of the Economic and Technology Advancement Advisory Committee (ETAAC) Final Report on Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California:*

> "Recycling offers the opportunity to cost-effectively decrease GHG emissions from the mining, manufacturing, forestry, transportation, and electricity sectors while simultaneously diminishing methane emissions from landfills. Recycling is widely accepted. It has a proven economic track record of spurring more economic growth than any other option for the management of waste and other recyclable materials. Increasing the flow through California's existing recycling or materials recovery infrastructures will generate significant climate response and economic benefits."[15]

In short, unsustainable consumption and waste disposal drive a climate-changing cycle in which resources are continually pulled out of the Earth, processed in factories, shipped around the world, and burned or buried in communities. The impact of this wasteful system extends far beyond local landfills and incinerators, causing greenhouse gas emissions up to thousands of miles away from these sources. In this way, U.S. related consumption and disposal are closely tied to greenhouse gas emissions from extractive and manufacturing industries in countries such as China.

Thus, reducing the amount of materials consumed in the first place is vital for combating climate change. In addition, when recovered materials are reused, recycled, and composted within local and regional economies, the climate protection benefits are even greater because significant greenhouse gas emissions associated with the transportation of products and materials are avoided.

**Figure ES-3: Wasting Is Linked to 36.7% of Total U.S. Greenhouse Gas Emissions, 2005**




Source: Institute for Local Self-Reliance, June 2008. Based on data presented in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007. Industrial Electricity Consumption is estimated using Energy Information Administration 2004 data on electricity sales to customers. See Table ES-1, Electric Power Annual Summary Statistics for the United States, released October 22, 2007, and available online at: http://www.eia.doe.gov/cneaf/electricity/epa/epates.html. Waste disposal includes landfilling, wastewater treatment, and combustion. Synthetic fertilizers include urea production. All data reflect a 100-year time frame for comparing greenhouse gas emissions.

## Key findings of this report

**1. A zero waste approach is one of the fastest, cheapest, and most effective strategies we can use to protect the climate and environment**. By significantly reducing the amount of waste landfilled and incinerated, the U.S can conservatively reduce greenhouse gas emissions by 406 megatons $CO_2$ eq. per year by 2030, which is the equivalent of taking 21% of the existing 417 coal-fired power plants off the grid.[16] A zero waste approach has comparable (and sometimes complementary) benefits to leading proposals to protect the climate such as significantly improving vehicle fuel efficiency and hybridizing vehicles, expanding and enhancing carbon sinks (such as forests), or retrofitting lighting and improving electronic equipment (see Table ES-1.) It also has greater potential for reducing greenhouse gas emissions than environmentally harmful strategies proposed such as the expansion of nuclear energy. Indeed, a zero waste approach would achieve 7% of the cuts in U.S. emissions needed to put us on the path to climate stability by 2050.

**2. Wasting directly impacts climate change because it is directly linked to resource extraction, transportation, processing, and manufacturing.** Since 1970, we have used up one-third of global natural resources.[17] Virgin raw materials industries are among the world's largest consumers of energy and are thus significant contributors to climate change because energy use is directly correlated with greenhouse gas emissions. Our linear system of extraction, processing, transportation, consumption, and disposal is intimately tied to core contributors of global climate change such as industrial energy use, transportation, and deforestation. When we minimize waste, we reduce greenhouse gas emissions in these and other sectors, which together represent 36.7% of all U.S. greenhouse gas emissions.[18] See Figure ES-3. It is this number that more accurately reflects the impact of the whole system of extraction to disposal on climate change.

**3. A zero waste approach is essential.** Through the Urban Environmental Accords, 103 city mayors worldwide have committed to sending zero waste to landfills and incinerators by the year 2040 or earlier.[19] More than two dozen U.S. communities and the state of California have also now embraced zero waste as a goal. These zero waste programs are based on (1) reducing consumption and discards, (2) reusing discards, (3) extended producer responsibility and other measures to ensure that products can safely be recycled into the economy and environment,* (4) comprehensive recycling, (5) comprehensive composting of clean segregated organics, and (6) effective policies, regulations, incentives, and financing structures to support these systems. The existing 8,659 curbside collection programs in the U.S. can serve as the foundation for expanded materials recovery.

**4. Existing waste incinerators should be retired, and no new incinerators or landfills should be constructed.** Incinerators are significant sources of $CO_2$ and also emit nitrous oxide ($N_2O$), a potent greenhouse gas that is approximately 300 times more effective than carbon dioxide at trapping heat in the atmosphere.[20] By destroying resources rather than conserving them, all incinerators — including mass-burn, pyrolysis, plasma, and gasification[21] — cause significant and unnecessary lifecycle greenhouse gas emissions. Pyrolysis, plasma, and gasification incinerators may have an even larger climate footprint than conventional mass-burn incinerators because they can require inputs of additional fossil fuels or electricity to operate. Incineration is also pollution-ridden and cost prohibitive, and is a direct obstacle to reducing waste and increasing recycling. Further, sources of industrial pollution such as incineration also disproportionately impact people of color and low-income and indigenous communities.[22]

* Extended producer responsibility requires firms, which manufacture, import or sell products and packaging, to be financially or physically responsible for such products over the entire lifecycle of the product, including after its useful life.

**5. Landfills are the largest source of anthropogenic methane emissions in the U.S., and the impact of landfill emissions in the short term is grossly underestimated — methane is 72 times more potent than $CO_2$ over a 20-year time frame.** National data on landfill greenhouse gas emissions are based on international accounting protocols that use a 100-year time frame for calculating methane's global warming potential.‡ Because methane only stays in the atmosphere for around 12 years, its impacts are far greater in the short term. Over a 100-year time frame, methane is 25 times more potent than $CO_2$. However, methane is 72 times more potent than $CO_2$ over 20 years.[23] (See Table ES-2.) The Intergovernmental Panel on Climate Change assesses greenhouse gas emissions over three time frames — 20, 100, and 500 years. The choice of which time frame to use is a policy-based decision, not one based on science.[24] On a 20-year time frame, landfill methane emissions alone represent 5.2% of all U.S. greenhouse gas emissions. (See Table ES-3.) Furthermore, landfill gas capture systems are not an effective strategy for preventing methane emissions to the atmosphere. The portion of methane captured over a landfill's lifetime may be as low as 20% of total methane emitted.[25]

**6. The practice of landfilling and incinerating biodegradable materials such as food scraps, paper products, and yard trimmings should be phased out immediately.** Non-recyclable organic materials should be segregated at the source and composted or anaerobically digested under controlled conditions.** Composting avoids significant methane emissions from landfills, increases carbon storage in soils and improves plant growth, which in turn expands carbon sequestration. Composting is thus vital to restoring the climate and our soils. In addition, compost is a value-added product, while landfills and incinerators present long-term environmental liabilities. Consequently, composting should be front and center in a national strategy to protect the climate in the short term.

**"Scientifically speaking, using the 20-year time horizon to assess methane emissions is as equally valid as using the 100-year time horizon. Since the global warming potential of methane over 20 years is 72, reductions in methane emissions will have a larger short-term effect on temperature — 72 times the impact — than equal reductions of $CO_2$. Added benefits of reducing methane emissions are that many reductions come with little or no cost, reductions lower ozone concentrations near Earth's surface, and methane emissions can be reduced immediately while it will take time before the world's carbon-based energy infrastructure can make meaningful reductions in net carbon emissions."**

– Dr. Ed J. Dlugokencky, Global Methane Expert, NOAA Earth System Research Laboratory, March 2008

Source: "Beyond Kyoto: Why Climate Policy Needs to Adopt the 20-year Impact of Methane," Eco-Cycle Position Memo, Eco-Cycle, www.ecocycle.org, March 2008.

‡ The Intergovernmental Panel on Climate Change (IPCC) developed the concept of global warming potential (GWP) as an index to help policymakers evaluate the impacts of greenhouse gases with different atmospheric lifetimes and infrared absorption properties, relative to the chosen baseline of carbon dioxide ($CO_2$).

** Anaerobic digestion systems can complement composting. After energy extraction, nutrient rich materials from digesters make excellent compost feedstocks.

**Table ES-2: Potent Greenhouse Gases and Global Warming Potential (GWP)**

| Common Name | Chemical Formula | GWP for Given Time Horizon | | | |
|---|---|---|---|---|---|
| | | SAR[1] | 20 yr | 100 yr | 500 yr |
| Carbon Dioxide | $CO_2$ | 1 | 1 | 1 | 1 |
| Methane | $CH_4$ | 21 | 72 | 25 | 8 |
| Nitrous Oxide | $N_2 0$ | 310 | 289 | 298 | 153 |
| Hydrofluorocarbons | | | | | |
| HFC-134a | $CH_2FCF_3$ | 1,300 | 3,830 | 1,430 | 435 |
| HFC-125 | $CHF_2CF_3$ | 2,800 | 6,350 | 3,500 | 1,100 |
| Perfluorinated compounds | | | | | |
| Sulfur Hexafluoride | $SF_6$ | 23,900 | 16,300 | 22,800 | 32,600 |
| PFC-14[2] | $CF_4$ | 6,500 | 5,210 | 7,390 | 11,200 |
| PFC-116[2] | $C_2F_6$ | 9,200 | 8,630 | 12,200 | 18,200 |

1. IPCC Second Assessment Report (1996). Represents 100-year time horizon. These GWPs are used by the U.S. EPA in its *Inventory of U.S. Greenhouse Gas Emissions and Sinks.*
2. Released during aluminum production. PFC-116 has an expected lifetime of 1,000 years.

Source: Intergovernmental Panel on Climate Change (IPCC), "Table 2.14," p. 212, Forster, P., et al, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis.*

**Table ES-3: Major Sources of U.S. Greenhouse Gas Emissions (Tg $CO_2$ Eq.), 2005, 100 Year vs. 20 Year Time Horizon**

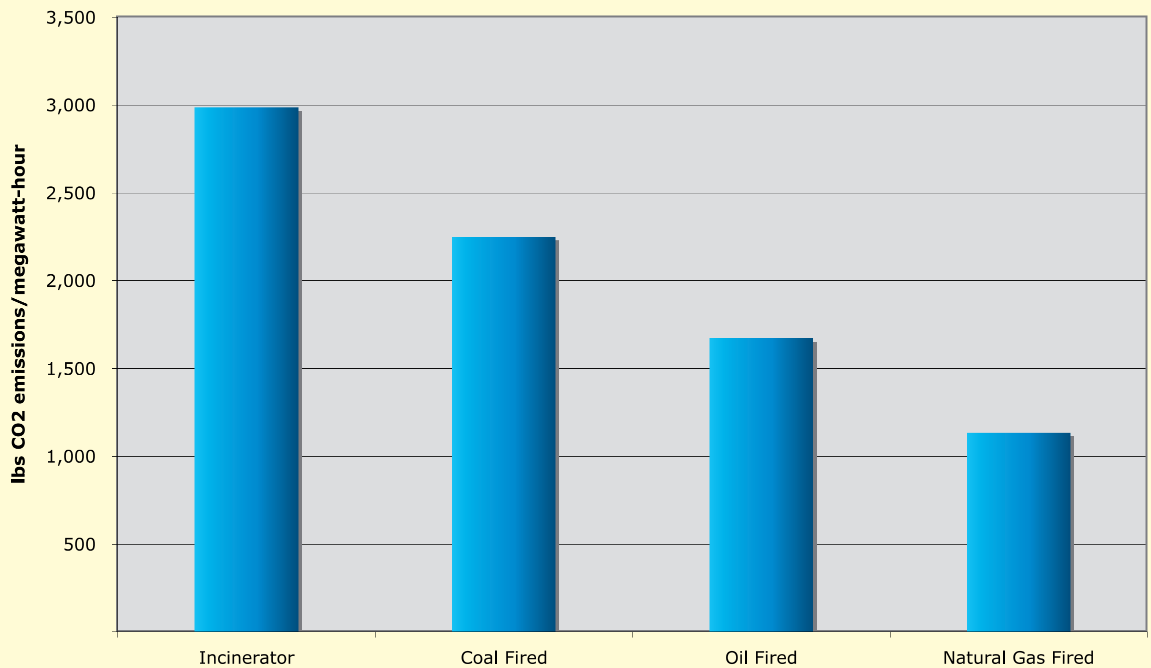
| Emission Source | 100 Yr Horizon | | 20 Yr Horizon[1] | |
|---|---|---|---|---|
| | Emissions | % of Total | Emissions | % of Total |
| Fossil Fuel Combustion ($CO_2$) | 5,751.2 | 79.2% | 5,751.2 | 65.7% |
| Agricultural Soil Mgt[2] ($N_2O$) | 365.1 | 5.0% | 340.4 | 3.9% |
| Non-Energy Use of Fuels[3] ($CO_2$) | 142.4 | 2.0% | 142.4 | 1.6% |
| Natural Gas Systems ($CO_2$ & $CH_4$) | 139.3 | 1.9% | 409.1 | 4.7% |
| Landfills ($CH_4$) | 132.0 | 1.8% | 452.6 | 5.2% |
| Substitution of ODS (HFCs, PFCs, $SF_6$) | 123.3 | 1.7% | 305.7 | 3.5% |
| Enteric Fermentation ($CH_4$) | 112.1 | 1.5% | 384.3 | 4.4% |
| Coal Mining ($CH_4$) | 52.4 | 0.7% | 179.7 | 2.1% |
| Manure Mgt ($CH_4$ & $N_2O$) | 50.8 | 0.7% | 150.5 | 1.7% |
| Iron & Steel Production ($CO_2$ & $CH_4$) | 46.2 | 0.6% | 48.6 | 0.6% |
| Cement Manufacture ($CO_2$) | 45.9 | 0.6% | 45.9 | 0.5% |
| Mobile Combustion ($N_2O$ & $CH_4$) | 40.6 | 0.6% | 44.3 | 0.5% |
| Wastewater Treatment ($CH_4$ & $N_2O$) | 33.4 | 0.5% | 94.5 | 1.1% |
| Petroleum Systems ($CH_4$) | 28.5 | 0.4% | 97.7 | 1.1% |
| Municipal Solid Waste Combustion ($CO_2$ & $N_2O$)[4] | 21.3 | 0.3% | 21.3 | 0.2% |
| Other (28 gas source categories combined) | 175.9 | 2.4% | 286.0 | 3.3% |
| **Total** | **7,260.4** | 100.0% | **8,754.2** | 100.0% |

ODS = Ozone Depleting Substances    Tg = Teragram = million metric tons

1. Methane emissions converted to 20-year time frame. Methane's global warming potential is 72 over a 20-year time horizon, compared to 21 used for the 100-year time frame. $N_2O$ emissions along with ODS, perfluorinated compounds, and hydrofluorocarbons have also been converted to the 20-year time horizon.
2. Such as fertilizer application and other cropping practices.
3. Such as for manufacturing plastics, lubricants, waxes, and asphalt.
4. $CO_2$ emissions released from the combustion of biomass materials such as wood, paper, food discards, and yard trimmings are not accounted for under Municipal Solid Waste Combustion in the EPA inventory. Biomass emissions represent 72% of all $CO_2$ emitted from waste incinerators.

Source: Institute for Local Self-Reliance, June 2008. Data for 100-year time horizon is from "Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks," *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007, p. ES-5 and p. 3-19.

**Figure ES-4: Comparison of Total $CO_2$ Emissions Between Incinerators and Fossil-Fuel-Based Power Plants (lbs $CO_2$/megawatt-hour)**




Source: U.S. EPA Clean Energy web page, "How Does Electricity Affect the Environment," http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html, browsed March 13, 2008.

**7. Incinerators emit more $CO_2$ per megawatt-hour than coal-fired, natural-gas-fired, or oil-fired power plants (see Figure ES-4). Incinerating materials such as wood, paper, yard debris, and food discards is far from "climate neutral"; rather, incinerating these and other materials is detrimental to the climate**. However, when comparing incineration with other energy options such as coal, natural gas, and oil power plants, the Solid Waste Association of North America (SWANA) and the Integrated Waste Services Association (an incinerator industry group), treat the incineration of "biomass" materials such as wood, paper, and food discards as "carbon neutral." As a result, they ignore $CO_2$ emissions from these materials. This is inaccurate. Wood, paper, and agricultural materials are often produced from unsustainable forestry and land practices that are causing the amount of carbon stored in forests and soil to decrease over time. Incinerating these materials not only emits $CO_2$ in the process, but also destroys their potential for reuse as manufacturing and composting feedstocks. This ultimately leads to a net increase of $CO_2$ concentrations in the atmosphere and contributes to climate change. The bottom line is that tremendous opportunities for greenhouse gas reductions are lost when a material is incinerated. It is not appropriate to ignore the opportunities for $CO_2$ or other emissions to be avoided, sequestered or stored through non-combustion uses of a given material. More climate-friendly alternatives to incinerating materials include options such as waste avoidance, reuse, recycling and composting. Any climate model comparing the climate impact of energy generation or waste management options should take into account lifecycle emissions incurred (or not avoided) by not utilizing a material for its "highest and best" use. These emissions are the opportunity costs of incineration.

**8. Incinerators, landfill gas capture systems, and landfill "bioreactors" should not be subsidized under state and federal renewable energy and**

**green power incentive programs or carbon trading schemes.** Far from benefiting the climate, subsidies to these systems reinforce a one-way flow of resources on a finite planet and make the task of conserving resources more difficult, not easier. Incineration technologies include mass-burn, pyrolysis, plasma, gasification, and other systems that generate electricity or fuels. All of these are contributors to climate change. Environment America, the Sierra Club, the Natural Resources Defense Council, Friends of the Earth, and 130 other organizations recognize the inappropriateness of public subsidization of these technologies and have signed onto a statement calling for no incentives for incinerators.[26] Incinerators are not the only problem though; planned landfill "bioreactors," which are being promoted to speed up methane generation, are likely to simply result in increased methane emissions in the short term and to directly compete with more effective methane mitigation systems such as composting and anaerobic digestion technologies. Preventing potent methane emissions altogether should be prioritized over strategies that offer only limited emissions mitigation. Indeed, all landfill operators should be required to collect landfill gases; they should not be subsidized to do this. In addition, subsidies to extractive industries such as mining, logging, and drilling should be eliminated. These subsidies encourage wasting and economically disadvantage resource conservation and reuse industries.

**9. New policies are needed to fund and expand climate change mitigation strategies such as waste reduction, reuse, recycling, composting, and extended producer responsibility. Policy incentives are also needed to create locally-based materials recovery jobs and industries**. Programs should be developed with the democratic participation of those individuals and communities most adversely impacted by climate change and waste pollution. Regulatory, permitting, financing, market development, and economic incentive policies (such as landfill, incinerator, and waste hauling surcharges) should be implemented to divert biodegradable organic materials from disposal. Policy mechanisms are also needed to ensure that products are built to last, constructed so that they can be readily repaired, and are safe and cost-effective to recycle back into the economy and environment. (See the list of priority policies, page 14.) Taxpayer money should be redirected from supporting costly and polluting disposal technologies to funding zero waste strategies.

**10. Improved tools are needed for assessing the true climate implications of the wasting sector.** The U.S. EPA's WAste Reduction Model (WARM), a tool for assessing greenhouse gases from solid waste management options, should be revised to more accurately account for the following: lifetime landfill gas capture rates; avoided synthetic fertilizer, pesticide, and fungicide impacts from compost use; reduced water irrigation energy needs from compost application; increased plant growth from compost use; and the timing of emissions and sinks. (For more detail, see the discussion of WARM, page 61.) New models are also needed to accurately take into account the myriad ways that the lifecycle impact of local activities contributes to global greenhouse gas emissions. This would lead to better-informed municipal actions to reduce overall greenhouse gas emissions. In addition, lifecycle models are needed to accurately compare the climate impact of different energy generation options. Models that compare incineration with other electricity generation options should be developed to account for lifecycle greenhouse gas emissions incurred (or not avoided) by not utilizing a material for its "highest and best" use.

**There will always be "discards" in our society, but how much of that becomes "waste" is a matter of choice.**

Rapid action to reduce greenhouse gas emissions, with immediate attention to those gases that pose a more potent risk over the short term, is nothing short of essential. Methane is one of only a few gases with a powerful short-term impact, and methane and carbon dioxide emissions from landfills and incinerators are at the top of a short list of sources of greenhouse gas emissions that may be quickly and cost-effectively reduced or avoided.

*Stop Trashing the Climate* answers important questions surrounding wasting and climate change, and recommends key steps to reduce waste that would result in the equivalent of taking 21% of the 417 U.S. coal-fired power plants off the grid by 2030. One strategy highlighted for its critical importance is composting. This report explains the unique benefits of composting to mitigate greenhouse gases in the short term and calls for composting as a core climate and soil revitalization strategy moving forward.

It should be noted that *Stop Trashing the Climate* does not assess human health impacts or environmental impacts that do not have a direct bearing on climate change. A full assessment of solid waste management options should consider costs, human health impacts, job and business impacts, and other environmental effects in addition to climate change. Published data addressing these other areas indicate that aiming for zero waste is not only good for the climate but also good for the economy, job creation, the environment, and public health.[27]

Resource conservation, reduced consumption, product redesign, careful materials selection, new rules and incentives, democratic participation, internalizing costs,* and materials reuse, recycling, and composting have never been such a necessity as they are today. Indeed, aiming for a zero waste economy by preventing waste and recovering materials is essential for mitigating climate change. The time to act is now. We have to redesign our production, consumption, and resource management systems so that they can be sustained for generations to come.

* For example, where the price of a product reflects its true environmental and social costs including the cost of disposal.

## A Call To Action — 12 Priority Policies Needed Now

In order for a zero waste strategy to reduce greenhouse gas emissions by 406 megatons $CO_2$ eq. per year by 2030, the following priority policies are needed:

**1. Establish and implement national, statewide, and municipal zero waste targets and plans:** Any zero waste target or plan must be accompanied by a shift in funding from supporting waste disposal to supporting zero waste jobs, infrastructure, and local strategies.

**2. Retire existing incinerators and halt construction of new incinerators and landfills:** The use of incinerators and investments in new disposal facilities — including mass-burn, pyrolysis, plasma, gasification, other incineration technologies, and landfill "bioreactors" — obstruct efforts to reduce waste and increase materials recovery. Eliminating investments in incineration and landfilling is an important step to free up taxpayer money for resource conservation, efficiency, and renewable energy solutions.

**3. Levy a per-ton surcharge on landfilled and incinerated materials:** Many European nations have adopted significant landfilling fees of $20 to $40 per ton that are used to fund recycling programs and decrease greenhouse gases. Surcharges on both landfills and incinerators are an important counterbalance to the negative environmental and human health costs of disposal that are borne by the public.

**4. Stop organic materials from being sent to landfills and incinerators:** Implement local, state, and national incentives, penalties, or bans to prevent organic materials, particularly food discards and yard trimmings, from ending up in landfills and incinerators.

**5. End state and federal "renewable energy" subsidies to landfills and incinerators:** Incentives such as the Renewable Electricity Production Tax Credit and Renewable Portfolio Standards should only benefit truly renewable energy and resource conservation strategies such as energy efficiency, and the use of wind, solar, and ocean power. Resource conservation should be incentivized as a key strategy for reducing energy use. In addition, subsidies to extractive industries such as mining, logging, and drilling should be eliminated. Instead, subsidies should support industries that conserve and safely reuse materials.

**6. Provide policy incentives that create and sustain locally-based reuse, recycling, and composting jobs:** Incentives should be directed to revitalize local economies by supporting environmentally just, community-based, and green materials recovery jobs and businesses.

**7. Expand adoption of per-volume or per-weight fees for the collection of trash:** Pay-as-you-throw fees have been proven to increase recycling and reduce the amount of waste disposed.[1]

**8. Make manufacturers and brand owners responsible for the products and packaging they produce:** Manufactured products and packaging represent 72.5% of all municipal solid waste.[2] When manufacturers are responsible for recycling their products, they use less toxic materials, consume fewer materials, design their products to last longer, create better recycling systems, are motivated to minimize waste costs, and no longer pass the cost of disposal to the government and the taxpayer.[3]

**9. Regulate single-use plastic products and packaging that have low or non-existent recycling levels:** In less than one generation, the use and disposal of single-use plastic packaging has grown from 120,000 tons in 1960 to 12,720,000 tons per year today.[4] Policies such as bottle deposit laws, polystyrene food takeout packaging bans, and regulations targeting single-use water bottles and shopping bags have successfully been implemented in several jurisdictions around the world and should be replicated everywhere.[5]

**10. Regulate paper packaging and junk mail and pass policies to significantly increase paper recycling:** Of the 170 million tons of municipal solid waste disposed each year in the U.S., 24.3% is paper and paperboard. Reducing and recycling paper will decrease releases of numerous air and water pollutants to the environment, and will also conserve energy and forest resources, thereby reducing greenhouse gas emissions.[6]

**11. Decision-makers and environmental leaders should reject climate protection agreements and strategies that embrace landfill and incinerator disposal:** Rather than embrace agreements and blueprints that call for supporting waste incineration as a strategy to combat climate change, such as the U.S. Conference of Mayors Climate Protection Agreement, decision-makers and environmental organizations should adopt climate blueprints that support zero waste. One example of an agreement that will move cities in the right direction for zero waste is the Urban Environmental Accords signed by 103 city mayors worldwide.

**12. Better assess the true climate implications of the wasting sector:** Measuring greenhouse gases over the 20-year time horizon, as published by the IPCC, is essential to reveal the impact of methane on the short-term climate tipping point. Also needed are updates to the U.S. EPA's WAste Reduction Model (WARM) as well as new models to accurately account for the impact of local activities on total global emissions and to compare lifecycle climate impact of different energy generation options.

San Francisco's "Fantastic Three" Program.

1 See the U.S. EPA's "Pay As You Throw" web site at http://www.epa.gov/epaoswer/non-hw/payt/index.htm.

2 See "Table 3: Materials Discarded in Municipal Solid Waste, 1960-2006," U.S. EPA, 2006 MSW Characterization Data Tables.

3 Beverly Thorpe, Iza Kruszewska, Alexandra McPherson, *Extended Producer Responsibility: A waste management strategy that cuts waste, creates a cleaner environment, and saves taxpayer money*, Clean Production Action, Boston, 2004. Available online at http://www.cleanproductionaction.org.

4 U.S. EPA, "Table 22: Products Discarded in the Municipal Waste Stream, 1960 to 2006 (with Detail on Containers and Packaging)," 2006 MSW Characterization Data Tables. Available online at: http://www.epa.gov/garbage/msw99.htm.

5 See, for instance, Californians Against Waste web site, "Polystyrene & Fast Food Packaging Waste," http://www.cawrecycles.org/issues/polystyrene_main.

6 U.S. EPA, "Table 3: Materials Discarded in the Municipal Waste Stream, 1960 to 2006," and "Table 4: Paper and Paperboard Products in MSW, 2006," 2006 MSW Characterization Data Tables. For catalog data, see Forest Ethics, Catalog Campaign web page at http://www.catalogcutdown.org/.

## Introduction

The Earth's climate is changing at an unprecedented rate, impacting both physical and biological systems. Temperature increases have been linked to rising tropical hurricane activity and intensity, more frequent heat waves, drought, and changes in infectious disease vectors. Damage from coastal flooding is on the rise. Fires and pests are causing more damage to forests. The allergenic pollen season starts earlier and lasts longer than before. Plant and animal species' ranges are shifting, and we may be on the brink of the largest mass extinction in history.[28] Those who are most impacted by climate change, both globally and within the U.S., are people of color and low-income and indigenous communities – the same people who are least responsible for climate-changing greenhouse gas emissions.[29]

Human activities such as transportation, deforestation, industrial processing, agriculture, and electricity use are now directly linked to climate change. These activities are tied to the production and consumption of materials, which are increasingly designed to be used once and thrown away. The United States in particular contributes a disproportionate share of the world's greenhouse gases. While we represent only 4.6% of the global population, we generate 22% of its carbon dioxide emissions.[30]

Carbon dioxide emissions are closely related to energy and resource consumption. Americans are responsible for 24% of global petroleum consumption and 22% of world primary energy consumption.[31] We use one-third of the Earth's timber and paper.[32] Meanwhile, we throw away 170 million tons of paper, glass, metals, plastics, textiles, and other materials each year.

A short window of opportunity exists to radically reduce greenhouse gas emissions and stabilize atmospheric $CO_2$ concentrations before our climate reaches a "tipping point." This tipping point is tied to the level of greenhouse gas concentrations in the atmosphere that could lead to widespread and rapid climate change. More than two hundred scientists at

## Greenhouse Gases and Global Warming Potential

Gases in the atmosphere contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs when chemical transformations of the substance produce other greenhouse gases, when a gas influences the atmospheric lifetimes of other gases, or when a gas affects atmospheric processes that alter the radiative balance of the Earth. The Intergovernmental Panel on Climate Change (IPCC) developed the Global Warming Potential concept to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to carbon dioxide.

Direct greenhouse gases include the following:

**Carbon Dioxide ($CO_2$)** — $CO_2$ is the primary greenhouse gas, representing 83.9% of total U.S. greenhouse gas emissions in 2005. Fossil fuel combustion is the largest source of $CO_2$.

**Methane ($CH_4$)** — The largest U.S. sources of $CH_4$ emissions are decomposition of waste in landfills, natural gas systems, and enteric fermentation associated with domestic livestock. $CH_4$ traps more heat in the atmosphere than $CO_2$. The latest IPCC assessment report revised the Global Warming Potential of $CH_4$ to 25 times that of $CO_2$ on a 100-year time horizon, and 72 times that of $CO_2$ on a 20-year time horizon.

**Nitrous Oxide ($N_2O$)** — $N_2O$ is produced by biological processes that occur in soil and water and by a variety of human activities such as fertilizer application, waste incineration, animal manure management, and wastewater treatment. While total $N_2O$ emissions are much lower than $CO_2$ emissions, $N_2O$ is 298 times more powerful than $CO_2$ at trapping heat in the atmosphere (on a 100-year time horizon).

**Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), Sulfur Hexafluoride ($SF_6$)** — HFCs and PFCs are families of synthetic chemicals that are used as alternatives to ozone-depleting substances. These compounds, along with $SF_6$, can be thousands of times more potent than $CO_2$. $SF_6$ and PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere once emitted.

Indirect greenhouse gases include **carbon monoxide (CO), nitrogen oxide (NOx), non-methane volatile organic compounds (NMVOCs),** and **sulfur dioxide ($SO_2$)**. Fuel combustion accounts for the majority of these emissions. Other sources are municipal waste combustion and industrial processes (such as the manufacture of chemical and allied products, metals processing, and industrial uses of solvents).

Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005*, (Washington, DC, April 15, 2007), pp. ES-2-4, ES-8-10, ES-16-17. For GWP, see IPCC, "Table 2.14," p. 212, Forster, P., et al, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis.*

the 2007 United Nations Climate Change Conference in Bali declared that global emissions must peak and decline over the next 10 to 15 years in order to limit global warming to 2.0°C above pre-industrial levels.[33] Amplified or uncontrolled climate change will lead to widespread devastation, both economically and environmentally.[34]

This report, *Stop Trashing the Climate*, makes the case that working to prevent waste and expand reuse, recycling, and composting — that is, aiming for zero waste — is one of the fastest, cheapest, and most effective strategies for reducing climate change in the short term.

*Stop Trashing the Climate* documents the link between climate change and unsustainable human patterns of consumption and wasting. It argues that the disposal of everyday materials such as paper, plastics, and food scraps in landfills and incinerators is a core contributor to the climate crisis. In addition to documenting the significant greenhouse gas emissions released directly by landfills and incinerators, the report details how waste disposal drives a lifecycle climate-changing system that is steeped in unsustainable patterns of consumption, transportation, energy use, and resource extraction. This report does not assess human health impacts or environmental impacts from wasting that do not have a direct bearing on climate change. A full assessment of solid waste management options would consider economic benefits and costs, human health impacts, and impacts on the environment such as resource depletion, loss of biodiversity, eutrophication, and air pollution.

*Stop Trashing the Climate* answers important questions surrounding wasting and climate change, debunks common myths that perpetuate our linear cycle of wasting, outlines policies needed to effect change, and offers a roadmap for how to significantly reduce greenhouse gas emissions within a short period. The report provides an alternative scenario to business-as-usual wasting in the U.S. that would put us solidly on track to achieve the goal of sending zero waste to landfills and incinerators by the year 2040, the target established by the Urban Environmental Accords. Originally drafted as part of the United Nations World Environment Day in 2005, these Accords have been signed by 103 city mayors worldwide.[35] By reducing waste generation 1% each year and diverting 90% of our waste from landfills and incinerators by the year 2030, *Stop Trashing the Climate* shows that we could dramatically reduce greenhouse gas emissions within the U.S. and beyond. The report provides key recommendations for attaining this waste reduction scenario that would, in turn, avoid 406 megatons* $CO_2$ eq. per year of greenhouse gas emissions, the equivalent of taking 21% of the 417 coal-fired power plants in the U.S. off the grid by 2030.[36] Reducing waste also has comparable (and sometimes complementary) climate protection benefits to leading strategies identified to reduce greenhouse emissions such as significantly improving vehicle fuel efficiency and hybridizing vehicles, expanding and enhancing carbon sinks (for example, enhancing forests), or retrofitting lighting and improving the energy efficiency of electronic equipment (see Table 11, p. 52). One strategy highlighted in this report for its critical importance is composting. *Stop Trashing the Climate* explains the unique benefits of composting as a tool to mitigate greenhouse gas emissions in the short term and calls for composting as a core climate and soil revitalization strategy moving forward.

Finished compost. Biodegradable materials are a liability when landfilled or burned, but an asset when composted.

* 1 megaton = 1 million metric tons = 1 Tg (teragram)

Resource conservation, product redesign, thoughtful materials selection, new rules and incentives, democratic participation, cost internalization,* and materials reuse, recycling, and composting have never been such a necessity as they are today. Indeed, aiming for a zero waste economy by preventing waste and recycling our resources is essential for mitigating climate change. The time to act is now. There will always be "discards" in our society, but how much of those become "waste" is a matter of choice.

**Global emissions must peak and decline over the next 10 to 15 years in order to limit global warming to 2.0ºC above pre-industrial levels.**

Zero waste station at Boulder's Farmers Market. Courtesy of Eco-Cycle.

**There will always be "discards" in our society, but how much of those become "waste" is a matter of choice.**

* For example, where the price of a product reflects its true environmental and social costs including the cost of disposal.

## Wasting = Climate Change

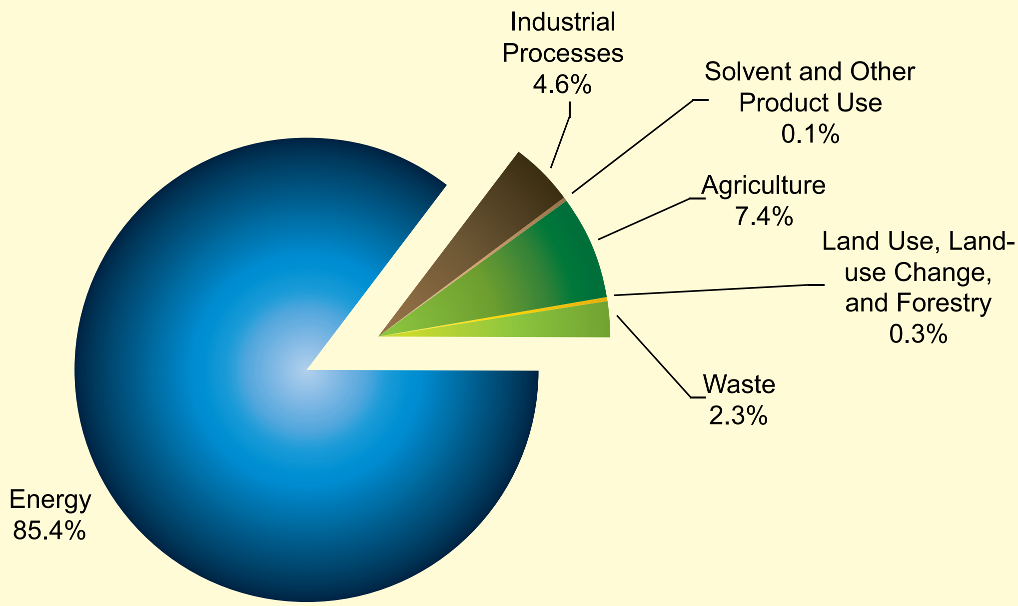
We waste an awful lot, and the amount we waste has been steadily increasing. Recycling levels have not been able to keep pace with our consumption habits. From 1960 to 2006, the amount of municipal solid waste generated in the U.S. more than doubled, increasing from 88.1 million to 251.3 million tons per year.[37] In 1960, single-use plastic packaging was 0.14% of the waste stream (120,000 tons). In less than one generation, it has grown to 5.7% and 14.2 million tons per year. Today we landfill or incinerate 3.6 million tons of junk mail, 1.2 million tons of paper plates and cups, 870,000 tons of aluminum cans, 870,000 tons of polystyrene plates and cups, 4.3 million tons of plastic bags and wraps, and 12.7 million tons of plastics in containers and other packaging.[38] The whole lifecycle of these products (from choice of materials to mining, manufacturing, transportation, consumption, and handling after intended use) impacts energy consumption and the release of major greenhouse gases – carbon dioxide, methane, and nitrous oxide – into the atmosphere.

The Intergovernmental Panel on Climate Change (IPCC) recognizes that changing the types and amounts of products we consume, along with preventing waste and recycling and composting more, will reduce the upstream lifecycle greenhouse gas impact of materials processing and production. In its Fourth Assessment Report, the IPCC acknowledged "changes in lifestyle and behaviour patterns can contribute to climate change mitigation across all sectors (*high agreement, medium evidence*)." Its summary document for policymakers states that "changes in lifestyles and consumption patterns that emphasize resource conservation can contribute to developing a low-carbon economy that is both equitable and sustainable."[39] The report also states that "the waste sector can positively contribute to greenhouse gas mitigation at low cost and promote sustainable development *(high agreement, much evidence).*" By way of example, it notes that waste minimization and recycling provide important indirect mitigation benefits through the conservation of energy and materials.

Despite these findings, the IPCC report concludes that "greenhouse gas emissions (GHG) from post-consumer waste and wastewater are a small contributor (about 3%) to total global anthropogenic GHG emissions."[40] Similarly, in its U.S. inventory report (2007) on greenhouse gas emissions, the U.S. EPA listed the waste sector — landfills and wastewater treatment — as emitting 165.4 Tg $CO_2$ eq.,* only 2.3% of overall greenhouse gas emissions in 2005 (or 2.6% including emissions from municipal waste combustors).[41] (See Figure 1.) Unfortunately, these assessments are based on an overly narrow and flawed view of the waste sector's contribution to climate change. Not only do they grossly underestimate landfill gas emissions, but even more importantly, the international and national assessments do not account for the connection between wasting and energy consumption, industrial processing, deforestation, industrial agriculture, and other core contributors to climate change.

* A teragram is Tg = $10^9$ kg = $10^6$ metric tons = 1 million metric tons = 1 megaton

**Figure 1: Conventional View – U.S. EPA Data on Greenhouse Gas Emissions by Sector, 2005**




Source: Table ES-4: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks by Chapter/IPCC Sector, *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007, p. ES-11.

Wasting directly impacts climate change in three core areas:

**1. Lifecycle impacts:** Materials in products and packaging represent 72.5% of all municipal solid waste disposed. In the U.S., we burn and bury 123 million tons per year of manufactured commodities such as paper, metals, plastics, and glass.[42] This forces us to mine and harvest virgin materials in order to manufacture new products to take the place of those we discard. These "lifecycle" activities consume tremendous amounts of energy, and energy consumption is the leading source of U.S. greenhouse gas emissions, contributing 85% of total emissions. In addition, wasting is intricately linked to deforestation, which accounts for as much as 30% of global greenhouse gas emissions.[43]

**2. Landfill impacts:** Each year we landfill 42.9 million tons per year of biodegradable food scraps and yard trimmings. We also landfill 41.3 million tons of paper products.[44] These materials are directly responsible for methane emissions from landfills, which is one of the leading contributors to U.S. greenhouse gas emissions despite being grossly underestimated in the short term.

**3. Waste incineration impacts:** We burn 31.4 million tons of municipal solid waste annually.[45] These incinerators emit more carbon dioxide per megawatt-hour than coal-fired and other fossil-fuel-fired power plants. Pyrolysis, plasma, and gasification incinerators may have a larger climate footprint than conventional mass-burn incinerators because they can require inputs of additional fossil fuels or electricity to operate. In addition, incinerators, as well as landfills, encourage a throwaway culture and an unsustainable one-way linear system from mine to manufacturer to transport to disposal. Incinerators rely on minimum tonnage guarantees through "put or pay" contracts that require communities to pay fees whether their waste is burned or not. These contracts remove any incentive to reduce overall consumption levels, avoid single-use disposable products or minimize waste.

The following sections discuss each of these impacts in detail.

## Lifecycle Impacts of Wasting: Virgin Material Mining, Processing, and Manufacturing

The lifecycle impact of waste disposal is its most significant effect on climate change. Landfills and incinerators destroy rather than conserve resources. Consequently, for every item that is landfilled or incinerated, a new one must be extracted, processed, and manufactured from virgin resources. Thus, the amount of municipal materials wasted represents only the tip of a very big iceberg. We bury or burn close to 170 million tons of municipal discards every year, but we extract from the environment billions of tons of raw materials to make these products. For every ton of municipal discards wasted, about 71 tons of waste are produced during manufacturing, mining, oil and gas exploration, agriculture, and coal combustion.[46] This requires a constant flow of resources to be pulled out of the Earth, processed in factories, shipped around the world, and burned or buried in our communities. The destructive impact of this wasteful cycle reaches far beyond local disposal projects.

Mining activities alone in the U.S. (excluding coal) produce between 1 and 2 billion tons of mine waste annually. More than 130,000 of these non-coal mines are responsible for polluting over 3,400 miles of streams and over 440,000 acres of land. About seventy of these sites are on the National Priority List for Superfund remediation.[47]

In addition, many of the materials that we use and discard are increasingly extracted and manufactured in other countries with expanding climate footprints. China is now the leading exporter of goods to the U.S., and just recently it surpassed the U.S. to become the country with the largest $CO_2$ emissions.[48] In the past four years alone, the value of paper, wood, plastics, and metals imported into the U.S. from China has increased by $10.8 billion.[49] Meanwhile, some of our biggest national exports are scrap materials. For example, the number one export out of the nation's second largest port at Long Beach, California, is "waste products" such as petroleum byproducts, scrap paper, and scrap iron.[50] This fact highlights the reality that America's consumption-driven economy is intimately linked to greenhouse gas emissions from extractive, manufacturing, transportation, and waste handling industries in countries around the world.

The current state of wasting is based on a linear system: virgin materials are extracted and made into products that are increasingly used only once before being destroyed. This system developed at a time when natural resources seemed limitless, but we now know that this is not the case. Since 1970, we have consumed one-third of our global natural resources.[51] This alarming trend is clearly not sustainable, even in the short term.

Industry consumes more energy than any other sector, representing more than 50% of worldwide energy consumption in 2004. Forecasts indicate that it will grow 1.8% per year.[52] Within that sector, virgin raw materials industries are among the world's largest consumers of energy. The mining industry alone accounts for 7 to 10 percent of world energy use.[53] In the U.S., four primary materials industries — paper, metals, plastics, and glass — consume 30.2% of the energy used for all U.S. manufacturing.[54] This high energy demand is a major contributor to global warming.

Let us take the case of paper as an example. Table 1 compares the greenhouse gas emissions related to harvesting and transporting virgin trees to make paper that is landfilled or burned with the emissions related to making paper from recycled fiber. It shows that at every step of papermaking, from harvest to mill to end-of-life management, greenhouse gases are emitted. Making and burning a ton of office paper, for instance, releases almost 12,000 pounds of $CO_2$. Of this, 89% is emitted upstream during harvesting and making the paper, and the remainder is produced downstream when the paper is thrown away and then burned.[55]

**Table 1: Impact of Paper Recycling on Greenhouse Gas Emissions** (lbs of $CO_2$ eq./ton of paper)

| | Newsprint | Office Paper | Corrugated Boxes | CUK Paperboard | SBS Paperboard |
|---|---|---|---|---|---|
| ***Virgin Production & Landfilling*** | | | | | |
| Tree Harvesting/Transport | 183.8 | 305.0 | 262.5 | 290.1 | 305.0 |
| Virgin Mfg Energy | 5,946.0 | 10,163.0 | 6,918.2 | 7,757.0 | 10,799.0 |
| Collection Vehicle & Landfill | 84.1 | 84.1 | 84.1 | 84.1 | 84.1 |
| MSW Landfill[1] | 9,301.4 | 9,301.4 | 9,301.4 | 9,301.4 | 9,301.4 |
| **Total** | **15,515.3** | **19,853.5** | **16,566.2** | **17,432.6** | **20,489.5** |
| ***Virgin Production & Incineration*** | | | | | |
| Tree Harvesting/Transport | 183.8 | 305.0 | 262.5 | 290.1 | 305.0 |
| Virgin Mfg Energy | 5,946.0 | 10,163.0 | 6,918.2 | 7,757.0 | 10,799.0 |
| MSW Collection | 47.3 | 47.3 | 47.3 | 47.3 | 47.3 |
| Combustion Process | 2,207.1 | 2,207.1 | 2,207.1 | 2,207.1 | 2,207.1 |
| Avoided Utility Energy | (1,024.8) | (896.7) | (896.7) | (977.2) | (977.2) |
| **Total** | **7,359.4** | **11,825.7** | **8,538.4** | **9,324.3** | **12,381.2** |
| ***Recycled Production & Recycling*** | | | | | |
| Recycled Paper Collection | 157.7 | 157.7 | 157.7 | 157.7 | 157.7 |
| Recycling Paper Processing/Sorting | 31.7 | 31.7 | 31.7 | 31.7 | 31.7 |
| Residue Landfill Disposal | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 |
| Transportation to Market | 33.0 | 33.0 | 33.0 | 33.0 | 33.0 |
| Recycled Mfg Energy | 3,232.0 | 3,345.0 | 2,951.0 | 2,605.0 | 2,605.0 |
| **Total** | **3,461.1** | **3,574.1** | **3,180.1** | **2,834.1** | **2,834.1** |

CUK = coated unbleached kraft SBS = solid bleached sulfate Mfg = manufacturing MSW = municipal solid waste

1. Based on 20% landfill gas captured.

Source: Based on data presented in *Paper Task Force Recommendations for Purchasing and Using Environmentally Friendly Paper*, Environmental Defense Fund, 1995, pp. 108-112. Available at www.edf.org. MSW Landfill greenhouse gas emissions reduced to reflect 20% gas capture (up from 0%).

For the five grades of paper shown in Table 1, recycling reduces greenhouse gas emissions by 4.5 to 7 times more than disposal. In addition, recycling a ton of virgin paper saves between 12 and 24 trees, which can then continue to absorb carbon dioxide from the atmosphere. (This only reflects recycling that paper once; the fibers in fine paper, for instance, can be recycled a dozen times, multiplying the benefits.[56]) The amount of $CO_2$ absorbed by each tree varies, but is consistently significant over the life of a tree. Recycling one ton of paper saves trees that could continue absorbing 600 to 1,200 pounds of $CO_2$ per year. The recycling benefits of conserving trees that can continue to absorb carbon dioxide are not taken into account in Table 1.[57]

The U.S. EPA found increased recycling of paper products resulted in incremental forest carbon sequestration of about 0.55 metric tons carbon equivalent (MTCE) per ton of paper recovered for mechanical pulp papers and 0.83 MTCE per ton for chemical pulp papers. Papers made from mechanical pulp include newspaper, telephone books, magazines, and junk mail; papers made from chemical pulp include office paper, corrugated cardboard, and textbooks. When paper is source reduced,* the impacts on carbon sequestration are even greater. The EPA found the incremental forest carbon sequestration is 1.04 MTCE for each ton of mechanical pulp paper avoided and 1.98 MTCE for each ton of chemical pulp paper avoided when inputs are considered to be 100% virgin, and from 0.8 to 1.90 MTCE per ton for various paper grades and a mix of virgin and recycled inputs.[58] Furthermore, the EPA found the effect of paper recycling on carbon sequestration appears to be persistent — that is, it lasts for several decades.[59]

* Source reduction means preventing the extraction, processing, and consumption of a given material or product.

**For every ton of municipal discards wasted, about 71 tons of waste are produced during manufacturing, mining, oil and gas exploration, agriculture, and coal combustion.**

Other commodities have similar high-energy inputs and thus high greenhouse gas impacts upstream. Aluminum production is one of the most energy-intensive of these, with many upstream impacts involved in bauxite mining, alumina refining, and smelting. (See sidebar, Upstream Impacts of Aluminum Can Production, page 23.) Table 2 shows the greenhouse gas emissions resulting from primary aluminum production. For every ton of aluminum produced, 97% of greenhouse gas emissions take place before aluminum ingot casting, which is the point at which scrap aluminum would enter the process.[60] In addition, for every ton of virgin aluminum recycled, 2.7 tons of solid waste related to mining, extraction, and virgin material manufacturing are avoided.[61] Yet in the U.S., only 21.2% of the 3.26 million tons of aluminum discarded each year is recycled.[62]

Clearly, the impact of waste on global warming is hardly confined to the small slice of pie shown in Figure 1. The industrial sector alone, which makes many of the products that we discard, contributes 28% of all greenhouse gases produced in the U.S.[63] Our ability to reduce greenhouse gas emissions by stemming wasting is significant, and certainly much larger than the 2.3% reflected in the U.S. EPA inventory.

Reducing post-consumer waste* is one of the most important tactics for combating global warming quickly, and not just in the U.S. It is worth noting here that U.S. consumer products that eventually become municipal solid waste increasingly come from overseas. Because China relies heavily on coal and generally uses energy less efficiently than the U.S.,[64] the greenhouse gas emissions associated with the manufacture of a material in China may well be higher than for the same material made in this country.[65]

Source reduction, reuse, and recycling can avoid significant greenhouse gas emissions in many parts of the energy sector, such as in industrial electricity consumption and truck transportation. For every pound of post-consumer waste avoided or reclaimed, many more pounds of upstream industrial waste are reduced — the result of less mining, less transportation of raw materials to manufacturing facilities, less energy consumption and fewer greenhouse gas emissions at production plants, less shipping of products to consumers, and less waste collected and transported to often distant disposal facilities. A recent report for the California Air Resources Board, *Recommendations of the Economic and Technology Advancement Advisory Committee (ETAAC): Final Report on Technologies and Policies to Consider for Reducing Greenhouse Gas Emissions in California*, recognized the lifecycle climate benefits of recycling:

> "Recycling offers the opportunity to cost-effectively decrease GHG emissions from the mining, manufacturing, forestry, transportation, and electricity sectors while simultaneously diminishing methane emissions from landfills. Recycling is widely accepted. It has a proven economic track record of spurring more economic growth than any other option for the management of waste and other recyclable materials. Increasing the flow through California's existing recycling or materials recovery infrastructures will generate significant climate response and economic benefits."[66]

Figure 2 shows the greenhouse gas emissions from the wasting sector as well as emissions from other sectors that are integrally linked to wasting: truck transportation, industrial consumption of fossil fuels and electricity, non-energy industrial processes, wastewater treatment, livestock manure management, and the production and application of synthetic fertilizers.

* Post-consumer waste refers to materials that have been used by consumers and then discarded.

All in all, these sectors linked to wasting represent 36.7% of all U.S. greenhouse gas emissions. These are the sectors that would be impacted if more post-consumer materials were reused, recycled, and composted. According to the ETAAC final report, "Development of the appropriate protocols for the recycling sector will result in GHG emission reductions far beyond the limited success available through minimizing fugitive methane emissions from landfills. Recycling itself can truly act as mitigation measure to reduce GHG emissions across all sectors of the economy."[67] In addition, wastewater and livestock manure could be biologically managed in anaerobic digesters with post-consumer organic materials. Compost could also replace synthetic fertilizers, thereby reducing their impact on climate change. The ETAAC final report noted:

"Composting offers an environmentally superior alternative to landfilling these same organics. Composting avoids these landfill emissions, offers greater carbon sequestration in crop biomass and soil, a decrease in the need for GHG emission-releasing fertilizers and pesticides, and a decline in energy-intensive irrigation. Compost has been proven to provide effective erosion control and to drastically improve the quality of ground water aquifers, both of which could be crucial elements of mitigating the impacts of climate change."[68]

**Table 2: Primary Aluminum Production, Greenhouse Gas Emissions**
(kg of $CO_2$ eq. per 1000 kg of aluminum output)

| | Bauxite | Refining | Anode | Smelting | Casting | Total |
|---|---|---|---|---|---|---|
| Process | - | - | 388 | 1,625 | - | 2,013 |
| Electricity | - | 58 | 63 | 5,801 | 77 | 5,999 |
| Fossil Fuel | 16 | 789 | 135 | 133 | 155 | 1,228 |
| Transport | 32 | 61 | 8 | 4 | 136 | 241 |
| Ancilliary | - | 84 | 255 | - | - | 339 |
| PFC | - | - | - | 2,226 | - | 2,226 |
| Total | 48 | 992 | 849 | 9,789 | 368 | 12,046 |

PFC = perfluorocarbons

Source: "Appendix C: $CO_2$ Emission Data," *Life Cycle Assessment of Aluminum: Inventory Data for the Worldwide Primary Aluminum Industry*, International Aluminum Institute, March 2003, p. 43. Available online at http://www.world-aluminum.org/environment/lifecycle/lifecycle3.html.

**Since 1970, we have consumed one-third of our global natural resources.**

## Upstream Impacts of Aluminum Can Production

**Step 1 - Bauxite Mining:** Most bauxite "ore" is mined from open pit or strip mines in Australia, Jamaica, and Brazil (99% of U.S. needs are imported). Bauxite mining results in land clearance, acid mine drainage, pollution of streams, and erosion. Significant fossil fuel energy is consumed in mining and transporting bauxite ore. For each ton of useful ore extracted, many tons of "over-burden" have to be removed in the process. Five tons of mine "tailings" (waste) are produced per ton of bauxite ore removed.

**Step 2 - Alumina Refining:** Bauxite ore is mixed with caustic soda, lime, and steam to produce a sodium aluminate slurry. "Alumina" is extracted from this slurry, purified, and shipped to smelters. Leftover "slag" waste contains a variety of toxic minerals and chemical compounds. The alumina refining process is also fossil fuel energy-intensive.

**Step 3 - Smelting:** Powdered alumina is heated (smelted) in order to form aluminum alloy ingots. Aluminum smelting uses massive amounts of electricity (usually from coal). One ton of aluminum production requires the energy equivalent of 5 barrels of oil (210 gallons of gasoline). Aluminum smelting also produces 7.4 tons of air pollutants (particulate matter, sulfur oxides, VOCs) for every 1 ton of aluminum produced.

**Step 4 - Tertiary Processing:** Aluminum ingots are smelted (requiring more energy) and are extruded as sheets. The finishing process for rolled sheets involves several chemicals (strong acids and bases) that are toxic.

**Step 5 - Finishing/Assembly:** Aluminum sheet is fed into extrusion tubes and cut into shallow cups. Cups are fed into an ironing press where successive rings redraw and iron the cup. This reduces sidewall thickness, making a full-length can. The bottom is "domed" for strength. Cans are necked in at the top and flanged to accept the end. There is little chemical pollution at this stage, just electricity use.

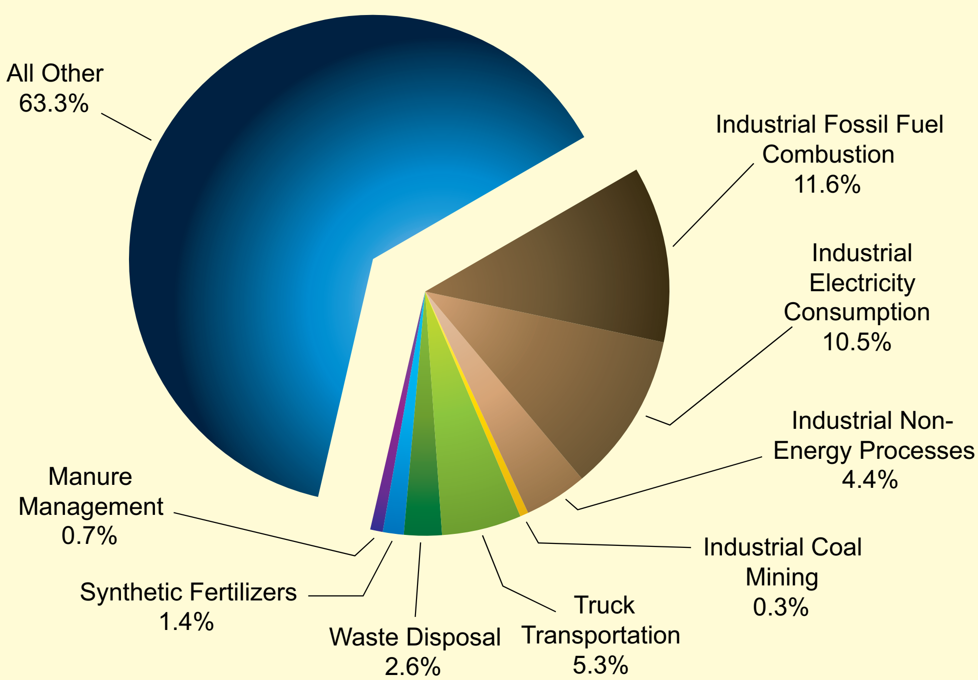
**Step 6 - Filling/Distribution:** Cans are shipped without the end portion to the beverage company. The end is attached. The beverage is then injected under pressure; outward force strengthens the can. After filling, the can is labeled and packaged. Cardboard and plastic are used, and some toxic waste is generated from making paint and ink that are used for labels. Finally, the product in the can is trucked (using diesel fuel) to a wholesaler/distributor and then to the retailer (this requires multiple trips).

**All of these stages use significant amounts of fossil fuel energy. Most of these stages generate large quantities of hazardous and toxic waste products.**

**Source:** Allegheny College, Dept. of Environmental Science, "Environmental Costs of Linear Societies," PowerPoint, October 9, 2006, reading course material for Introduction to Environmental Science, ES110, Spring 2007, available online at: webpub.allegheny.edu/dept/envisci/ESInfo/ES110sp2007/ppts/ES110_S07_AlumCan.ppt

## Sectors linked to wasting represent 36.7% of all U.S. greenhouse gas emissions.

**Figure 2: Wasting Is Linked to 36.7% of Total U.S. Greenhouse Gas Emissions, 2005**



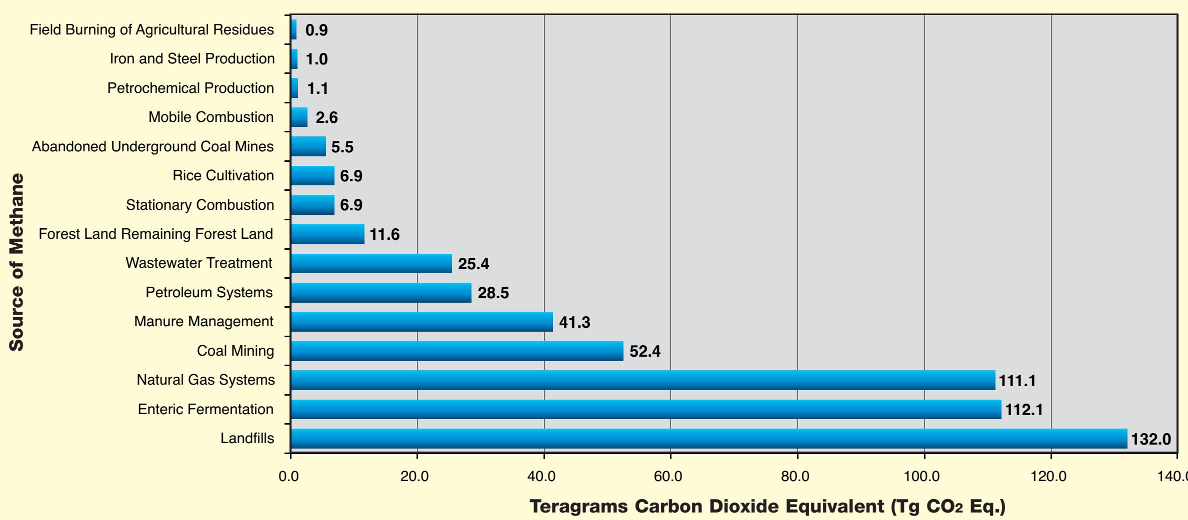

Source: Institute for Local Self-Reliance, June 2008. Based on data presented in the *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007. Industrial Electricity Consumption is estimated using Energy Information Administration 2004 data on electricity sales to customers. See Table ES-1, Electric Power Annual Summary Statistics for the United States, released October 22, 2007, and available online at: http://www.eia.doe.gov/cneaf/electricity/epa/epates.html. Waste disposal includes landfilling, wastewater treatment, and combustion. Synthetic fertilizers include urea production. All data reflect a 100-year time frame for comparing greenhouse gas emissions.

## Landfills Are Huge Methane Producers

Landfills are the number one source of anthropogenic* methane emissions in the U.S., accounting for approximately 24% of total U.S. anthropogenic methane emissions.[69] Figure 3 compares landfill emissions to other major anthropogenic methane emissions in 2005. Landfills are also a large source of overall greenhouse gas emissions, contributing at least 1.8% to the U.S. total in 2005. In its 2005 inventory of U.S. greenhouse gases, the U.S. EPA listed landfills as the fifth largest source of all greenhouse gases.[70] (See Table 5, page 28.)

According to the U.S. EPA, landfills begin producing significant amounts of methane one or two years after waste disposal and continue methane production for 10 to 60 years. Aerobic bacteria initially decompose biodegradable materials such as paper, food scraps, and yard trimmings. When oxygen is depleted, anaerobic bacteria start to thrive on the remaining waste, breaking it down first into cellulose, amino acids, and sugars, and then through fermentation into gases and short-chain organic compounds.[71] These anaerobic bacteria produce a biogas that consists on average of approximately 45% carbon dioxide ($CO_2$) and 50% methane ($CH_4$) by volume. The remaining 5% is mostly nitrogen but also consists of non-methane organic compounds such as benzene, toluene, carbon tetrachloride, and chloroform. These compounds are dangerous enough to be regulated by the Clean Air Act; they interact with nitrous oxides to form ozone, a primary cause of smog, and they are indirect greenhouse gases.[72] Table 3 details the variability of landfill gas constituents.

**Figure 3: U.S. Methane Emissions by Source, 2005**




Source: U.S. EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005* (Washington, DC: April 15, 2007), p. ES-9.

* In this report, "anthropogenic" refers to greenhouse gas emissions and removals that are a direct result of human activities or are the result of natural processes that have been affected by human activities.

**Table 3: Landfill Gas Constituent Gases, % by volume**

| Constituent Gas | Concentration in Landfill Gas | |
|---|---|---|
| | Range | Average |
| Methane ($CH_4$) | 35 - 60% | 50% |
| Carbon Dioxide ($CO_2$) | 35 - 55% | 45% |
| Nitrogen ($N_2$) | 0 - 20% | 5% |
| Oxygen ($O_2$) | 0 - 2.5% | <1% |
| Hydrogen Sulfide ($H_2S$) | 1 - 0.017% | 0.0021% |
| Halides | NA | 0.0132% |
| Water Vapor ($H_2O$) | 1 - 10% | NA |
| Nonmethane Organic Compounds (NMOCs) | 0.0237 - 1.43% | 0.27% |

Source: Energy Information Administration. US Department of Energy. Growth of landfill gas industry; 1996. Available online at: http://www.eia.doe.gov/cneaf/solar.renewables/renewable.energy.annual/chap10.html.

**Table 4: Potent Greenhouse Gases and Global Warming Potential (GWP)**

| Common Name | Chemical Formula | GWP for Given Time Horizon | | | |
|---|---|---|---|---|---|
| | | SAR[1] | 20 yr | 100 yr | 500 yr |
| Carbon Dioxide | $CO_2$ | 1 | 1 | 1 | 1 |
| Methane | $CH_4$ | 21 | 72 | 25 | 8 |
| Nitrous Oxide | $N_20$ | 310 | 289 | 298 | 153 |
| Hydrofluorocarbons | | | | | |
| HFC-134a | $CH_2FCF_3$ | 1,300 | 3,830 | 1,430 | 435 |
| HFC-125 | $CHF_2CF_3$ | 2,800 | 6,350 | 3,500 | 1,100 |
| Perfluorinated compounds | | | | | |
| Sulfur Hexafluoride | $SF_6$ | 23,900 | 16,300 | 22,800 | 32,600 |
| PFC-14[2] | $CF_4$ | 6,500 | 5,210 | 7,390 | 11,200 |
| PFC-116[2] | $C_2F_6$ | 9,200 | 8,630 | 12,200 | 18,200 |

1. IPCC Second Assessment Report (1996). Represents 100-year time horizon. These GWPs are used by the U.S. EPA in its *Inventory of U.S. Greenhouse Gas Emissions and Sinks.*
2. Released during aluminum production. PFC-116 has an expected lifetime of 1,000 years.

Source: Intergovernmental Panel on Climate Change (IPCC), "Table 2.14," p. 212, Forster, P., et al, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis.*

However, for two main reasons, these figures greatly understate the impact of landfilling on climate change, especially in the short term. First, international greenhouse gas accounting protocols rely on a 100-year time horizon to calculate the global warming potential of methane. This timeline masks methane's short-term potency. Over a 100-year time frame, methane is a greenhouse gas that is 25 times more potent than $CO_2$; on a 20-year time horizon, however, methane is 72 times more potent than $CO_2$.[73] Table 4 compares the global warming potential of greenhouse gases over different time horizons. When we convert greenhouse gas emissions to a 20-year analytical time frame, then landfills account for a full 5.2% of all U.S. greenhouse gas emissions. (See Table 5.) Second, overall landfill gas capture efficiency rates may be grossly overestimated. Of the 1,767 landfills in the U.S., only approximately 425 have installed systems to recover and utilize landfill gas.[74] The U.S. EPA assumes that those landfills with gas capture systems are able to trap 75% of gas emissions over the life of the landfill. However, this is likely a gross overestimation for the reasons explained below.

***1. Landfill methane emissions on a 20-year time horizon are almost three times greater than on a 100-year time horizon.*** Landfills emit methane, which is a greenhouse gas with an average lifetime of 12 years. Because different greenhouse gases have different efficiencies in heat adsorption and different lifetimes in the atmosphere, the Intergovernmental Panel on Climate Change (IPCC) developed the concept of global warming potential as a standard methodology to compare greenhouse gases. Carbon dioxide is used as a baseline and all gases are adjusted to values of $CO_2$. One of the assumptions embedded in the calculated value of a gas's global warming potential is the choice of time frame. The IPCC publishes global warming potential values over three time horizons, as seen in Table 4. The decision to use a particular time horizon is a matter of policy, not a matter of science.[75] Kyoto Protocol policymakers chose to evaluate greenhouse gases over the 100-year time horizon based on their assessments of the short and long-term impacts of climate change. This decision diluted the short-term impact of methane on climate change and put less emphasis on its relative contribution.

**"Scientifically speaking, using the 20-year time horizon to assess methane emissions is as equally valid as using the 100-year time horizon. Since the global warming potential of methane over 20 years is 72 [times greater than that of $CO_2$], reductions in methane emissions will have a larger short-term effect on temperature — 72 times the impact — than equal reductions of $CO_2$. Added benefits of reducing methane emissions are that many reductions come with little or no cost, reductions lower ozone concentrations near Earth's surface, and methane emissions can be reduced immediately while it will take time before the world's carbon-based energy infrastructure can make meaningful reductions in net carbon emissions."**

– Dr. Ed J. Dlugokencky, Global Methane Expert, NOAA Earth System Research Laboratory, March 2008

Source: "Beyond Kyoto: Why Climate Policy Needs to Adopt the 20-year Impact of Methane," Eco-Cycle Position Memo, Eco-Cycle, www.ecocycle.org, Boulder, Colorado, March 2008.

Although methane is more damaging in the short term, the U.S. greenhouse gas inventory also uses the 100-year time horizon to calculate the global warming potential of methane and other gases. When viewed from a 20-year time horizon, the global warming potential of methane almost triples to 72 (compared to $CO_2$ over the same period of time).[76] On a 100-year time horizon, U.S. landfill methane emissions are 132 Tg $CO_2$ eq.; on a 20-year time period, they jump to 452.6 Tg $CO_2$ eq.[77] As a result, as shown in Table 5, when viewed from a 20-year time horizon, landfill methane emissions represent 5.2% of all U.S. greenhouse gases emitted in 2005.

The use of similar timeline variations in an Israeli study resulted in similarly significant differences in emissions numbers. Using the 100-year time frame, this study found Israeli landfills and wastewater treatment contributed 13% of the nation's total $CO_2$ eq. emissions. When these waste sector emissions were calculated on a 20-year time period, however,

**Table 5: Major Sources of U.S. Greenhouse Gas Emissions (Tg $CO_2$ Eq.), 2005, 100 Year vs. 20 Year Time Horizon**

| Emission Source | 100 Yr Horizon | | 20 Yr Horizon[1] | |
|---|---|---|---|---|
| | Emissions | % of Total | Emissions | % of Total |
| Fossil Fuel Combustion ($CO_2$) | 5,751.2 | 79.2% | 5,751.2 | 65.7% |
| Agricultural Soil Mgt[2] ($N_2O$) | 365.1 | 5.0% | 340.4 | 3.9% |
| Non-Energy Use of Fuels[3] ($CO_2$) | 142.4 | 2.0% | 142.4 | 1.6% |
| Natural Gas Systems ($CO_2$ & $CH_4$) | 139.3 | 1.9% | 409.1 | 4.7% |
| Landfills ($CH_4$) | 132.0 | 1.8% | 452.6 | 5.2% |
| Substitution of ODS (HFCs, PFCs, $SF_6$) | 123.3 | 1.7% | 305.7 | 3.5% |
| Enteric Fermentation ($CH_4$) | 112.1 | 1.5% | 384.3 | 4.4% |
| Coal Mining ($CH_4$) | 52.4 | 0.7% | 179.7 | 2.1% |
| Manure Mgt ($CH_4$ & $N_2O$) | 50.8 | 0.7% | 150.5 | 1.7% |
| Iron & Steel Production ($CO_2$ & $CH_4$) | 46.2 | 0.6% | 48.6 | 0.6% |
| Cement Manufacture ($CO_2$) | 45.9 | 0.6% | 45.9 | 0.5% |
| Mobile Combustion ($N_2O$ & $CH_4$) | 40.6 | 0.6% | 44.3 | 0.5% |
| Wastewater Treatment ($CH_4$ & $N_2O$) | 33.4 | 0.5% | 94.5 | 1.1% |
| Petroleum Systems ($CH_4$) | 28.5 | 0.4% | 97.7 | 1.1% |
| Municipal Solid Waste Combustion ($CO_2$ & $N_2O$)[4] | 21.3 | 0.3% | 21.3 | 0.2% |
| Other (28 gas source categories combined) | 175.9 | 2.4% | 286.0 | 3.3% |
| **Total** | **7,260.4** | 100.0% | **8,754.2** | 100.0% |

ODS = Ozone Depleting Substances    Tg = Teragram = million metric tons

1. Methane emissions converted to 20-year time frame. Methane's global warming potential is 72 over a 20-year time horizon, compared to 21 used for the 100-year time frame. $N_2O$ emissions along with ODS, perfluorinated compounds, and hydrofluorocarbons have also been converted to the 20-year time horizon.
2. Such as fertilizer application and other cropping practices.
3. Such as for manufacturing plastics, lubricants, waxes, and asphalt.
4. $CO_2$ emissions released from the combustion of biomass materials such as wood, paper, food discards, and yard trimmings are not accounted for under Municipal Solid Waste Combustion in the EPA inventory. Biomass emissions represent 72% of all $CO_2$ emitted from waste incinerators.

Source: Institute for Local Self-Reliance, June 2008. Data for 100-year time horizon is from "Table ES-2: Recent Trends in U.S. Greenhouse Gas Emissions and Sinks," *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007, p. ES-5 and p. 3-19.

**With the rapid state of climate change and the need for immediate, substantial reductions to greenhouse gas emissions in the short term, the 20-year time horizon for greenhouse gas emissions should be considered in all greenhouse gas inventories.**

**When viewed from a 20-year time horizon, landfill methane emissions represent 5.2% of all U.S. greenhouse gases emitted in 2005.**

the waste sector's contribution to overall greenhouse emissions jumped to more than 25%.[78]

With the rapid state of climate change and the need for immediate, substantial reductions to greenhouse gas emissions in the short term, the 20-year time horizon for greenhouse gas emissions should be considered in all greenhouse gas inventories. Prioritizing the reduction of methane in the next few years will have a substantial effect upon climate change over the coming decade. Removing one ton of methane will have the same effect as removing 72 tons of $CO_2$ in the short term. The immediacy of our situation demands we consider both the short- and long-term climate impacts of wasting.

***2. Landfill methane gas capture rates are overestimated, resulting in underreported methane emissions released to the atmosphere.*** In its WAste Reduction Model (WARM), the U.S. EPA assumes landfills with gas recovery systems capture 75% or more of the methane gas generated. According to one expert, though, this capture rate has no factual basis and typical lifetime capture rates for landfills that have gas recovery systems are closer to 16%, but no greater than 20%.[79] For an explanation of why capture rates are low, see the Myth and Fact on this issue, page 34.

The Intergovernmental Panel on Climate Change has now recognized extremely low lifetime landfill gas capture rates:

> "Some sites may have less efficient or only partial gas extraction systems, and there are fugitive emissions from landfilled waste prior to and after the implementation of active gas extraction; therefore estimates of 'lifetime' recovery efficiencies may be as low as 20%."[80]

Average landfill lifetime capture efficiency rates as low as 20% raise questions about the effectiveness of focusing on end-of-pipe solutions to collect landfill gas as compared to preventing methane emissions completely by keeping biodegradable materials from entering landfills in the first place. The increased potency of methane over the short term offers further impetus for preventing, rather than partially mitigating, emissions.

In addition to preventing methane emissions, there are other important reasons to reduce landfill use. One is the protection of our water supplies; even "state-of-the-art" landfills will eventually leak and pollute nearby groundwater.[81] Compounding this problem is the fact that regulations protecting groundwater quality do not adequately or reliably address the wide variety of constituents in municipal solid waste leachate, the liquid that results when moisture enters landfills. Another important reason is landfill air emissions are toxic and can increase the risk of certain types of cancer. Escaping gases will typically carry toxic chemicals such as paint thinner, solvents, pesticides, and other hazardous volatile organic compounds. Unsurprisingly, then, studies link living near landfills with cancer.[82] Women living near solid waste landfills where gas is escaping, for example, have been found to have a four-fold increased chance of bladder cancer and leukemia. The negative environmental and social impacts of landfill use are minimized when a zero waste path is chosen.

## Waste Incinerators Emit Greenhouse Gases and Waste Energy

In terms of their impact on greenhouse gas concentrations, incinerators are worse than alternatives such as waste avoidance, reuse, recycling, composting, and anaerobic digestion. The Integrated Waste Services Association, an incineration trade group, falsely claims that waste incineration "does the most to reduce greenhouse gas releases into the atmosphere" when compared to other waste management options, and that incineration "plants are tremendously valuable contributors in the fight against global warming."[83] These statements are based on the narrow view that incinerators recycle some metals, avoid coal combustion, and reduce the methane released from landfills. They ignore the fact that the materials that incinerators destroy could otherwise be reduced at the source, reused, recycled, or composted, with resulting far superior benefits to the climate.

***1. Incinerators emit significant quantities of direct greenhouse gases.*** Not only do incinerators emit toxic chemicals, but the U.S. EPA's most recent inventory of U.S. greenhouse gas emissions also lists U.S. incinerators among the top 15 major sources of direct greenhouse gases to the environment, contributing

21.3 Tg $CO_2$ eq. in 2005. Of this, $CO_2$ emissions represented 20.9 Tg $CO_2$ eq. and $N_2O$ emissions, 0.4 Tg $CO_2$ eq.[84] (See Table 5, page 28.) In the 15-year period from 1990 to 2005, the EPA reported that incinerator $CO_2$ emissions rose by 10 Tg $CO_2$ eq. (91%), as the amount of plastics and other fossil-fuel-based materials in municipal solid waste has grown.[85]

***2. Comparisons of waste and energy options often wrongly ignore the majority of $CO_2$ emissions released by incinerators.*** In the U.S. EPA greenhouse gas inventory mentioned above, $CO_2$ emissions released from the combustion of biomass materials such as wood, paper, food scraps, and yard trimmings are not included under "municipal solid waste combustion." In fact, of the total amount of incinerator emissions, only the fossil-based carbon emissions — those created by burning plastics, synthetic rubber/leather, and synthetic textiles — are included under "municipal solid waste combustion" in the inventory. These emissions account for less than one-third of the overall $CO_2$ emissions from incinerators.

When all emissions are correctly taken into account, it becomes clear that on a per megawatt-hour basis, incinerators emit more $CO_2$ than any fossil-fuel-based electricity source. (See Figure 4 on page 40.) Coal-fired power plants, for example, emit 2,249 pounds of $CO_2$ per megawatt-hour, compared to the 2,899 pounds emitted by waste incinerators.[86] Clearly, as discussed in further detail in the Myth and Fact on this issue, page 41, simply ignoring $CO_2$ emissions from incinerating biomass materials is inappropriate and leads to flawed climate impact comparisons with other waste management and energy generation options.

***3. Tremendous opportunities for greenhouse gas reductions are lost when a material is incinerated.*** It is wrong to ignore the opportunities for $CO_2$ or other emissions to be avoided, sequestered or stored through non-incineration uses of a given material. More climate-friendly alternatives to incinerating materials often include source reduction, reuse, recycling, and composting. When calculating the true climate impact of incineration as compared to other waste management and energy generation options, it is essential that models account for the emissions avoided when a given material is used for its highest and best use. This means, for instance, taking into account emissions that are avoided and carbon sequestered when materials are reused, recycled or composted as compared to incinerated.

**Table 6: Direct and Indirect U.S. Greenhouse Gas Emissions from Municipal Waste Incinerators, 2005**

| Direct Greenhouse Gases | |
|---|---|
| $CO_2$ | 20.9 Tg $CO_2$ eq. |
| $N_2O$ | 0.4 Tg $CO_2$ eq. |
| **Indirect Greenhouse Gases** | |
| NOx | 98 Gg |
| CO | 1,493 Gg |
| NMVOCs | 245 Gg |
| $SO_2$ | 23 Gg |

Tg = teragram = 1 million metric tons
Gg = gigagram = 1,000 metric tons

NMVOCs = nonmethane volatile organic compounds

Note: $CO_2$ emissions represent U.S. EPA reported data, which exclude emissions from biomass materials.

Source: Table ES-2 and Table ES-10: Emissions of NOx, CO, NMVOCs, and $SO_2$, *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007, p. ES-17.

***4. Incinerators are large sources of indirect greenhouse gases.*** Indirect greenhouse gases emitted by incinerators include carbon monoxide (CO), nitrogen oxide (NOx), non-methane volatile organic compounds (NMVOCs), and sulfur dioxide ($SO_2$). (See Table 6.) According to the U.S. EPA, "these gases do not have a direct global warming effect, but indirectly affect terrestrial absorption by influencing the formation and destruction of tropospheric and stratospheric ozone, or, in the case of $SO_2$, by affecting the absorptive characteristics of the atmosphere. In addition, some of these gases may react with other chemical compounds in the atmosphere to form compounds that are greenhouse gases."[87] These indirect greenhouse gases are not quantifiable as $CO_2$ eq. and are not included in $CO_2$ eq. emissions totals in inventories.

***5. Incinerators waste energy by destroying materials.*** The energy sector is the single largest contributor to greenhouse gases, representing 85% of U.S. greenhouse gas emissions in 2005.[88] Incinerators destroy highly recyclable and compostable materials, thus also destroying the energy-saving potential of recycling or composting those materials. Incinerators also recover few resources (with the exception of ferrous metals) and are net energy losers when the embodied energy of the materials incinerated is taken into account.

Recycling is far better for the climate as it saves 3 to 5 times the energy that waste incinerator power plants generate.[89] In other words, incinerating trash is akin to spending 3 to 5 units of energy to make 1 unit. When a ton of office paper is incinerated, for example, it generates about 8,200 megajoules; when this same ton is recycled, it saves about 35,200 megajoules. Thus recycling office paper saves four times more energy than the amount generated by burning it.[90] Recycling other materials offers similar energy savings. The U.S. EPA found recycling to be more effective at reducing greenhouse gas emissions than incineration across all 18 product categories it evaluated.[91] While incinerator advocates describe their installations as "resource recovery," "waste-to-energy" (WTE) facilities, or "conversion technologies," these facts indicate that incinerators are more aptly labeled "wasted energy" plants or "waste of energy" (WOE) facilities.[92]

***6. Incinerators exacerbate global warming by competing with more climate-friendly systems for public financing.*** Federal and state public financing programs, such as the Federal Renewable Energy Production Tax Credit and several state renewable energy portfolio standards, reward incinerators and landfills for generating electricity. As a result, these programs encourage increased levels of waste disposal, pollution, and greenhouse gas emissions. They also have the negative effect of subsidizing these dirty waste management systems, thereby giving them a distinct competitive advantage over more climate-friendly options such as recycling and composting programs. State renewable portfolio standards provide eligible industries with access to favorable markets in which to sell their electricity at competitive prices. These laws thus provide electricity generators with tangible economic rewards, favorable electricity contracts, and the long-term stability necessary to attract capital investment. Qualifying incinerators for renewable energy incentives contributes to greenhouse gas emissions and ensures that less funding is available for real solutions to climate change such as conservation, efficiency, and wind, solar and ocean power.

Bridgeport, CT, trash incinerator. Courtesy of Timothy J. Pisacich.

**Incinerating trash is akin to spending 3 to 5 units of energy to make 1 unit.**

## Sample Renewable Energy Standards and Tax Credits That Favor Disposal Over Resource Conservation

**Federal Renewable Energy Production Tax Credit:** Originally enacted as part of the Energy Policy Act of 1992, the Production Tax Credit (PTC) provides a highly sought-after tax reward for so-called "renewable" energy generation. The PTC — which originally supported only wind and select bioenergy resources — is now available to several dirty electricity generators including incinerators, landfills, refined coal, "Indian coal,"* and others. Eligible electricity generators receive a tax credit of 1.9 cents per kilowatt-hour (kWh) of electricity that they generate. The PTC is set to expire on January 1, 2009, and should be extended to support only truly renewable electricity sources such as wind, solar, and ocean power — not incinerators, landfills, and other dirty electricity generators.

**Renewable Portfolio Standard:** A renewable portfolio standard (RPS) — also called a renewable electricity standard (RES) — is a law that requires a certain amount of electricity to be generated by what are deemed to be "renewable" resources by a particular year. For example, the state of New Jersey requires that 22.5% of its electricity comes from electricity sources such as solar, wind, landfills, biomass, and tidal by the year 2020. To date, twenty-seven states have passed some version of an RPS law. These laws vary greatly in terms of how much electricity is required and what qualifies as a "renewable" source of electricity. While some states such as Oregon have passed relatively strict requirements for what qualifies as a renewable resource, other states, such as Pennsylvania, have passed RPS laws that qualify electricity sources including coal, incinerators, and landfills as "renewable." All state RPS laws (including Oregon's) qualify landfills as sources of renewable electricity. Approximately half of state RPS laws qualify municipal solid waste incinerators as a source of renewable electricity.

**Alternative Fuels Mandate:** This measure was included as part of the Renewable Fuels, Consumer Protection, and Energy Efficiency Act of 2007 (H.R. 6). It mandates the generation of 36 billion gallons of fuel from so-called "renewable" biomass by the year 2022. As part of this mandate, several dirty fuel sources may qualify as "advanced renewable biofuels" and "biomass-based diesel," including municipal solid waste incineration, wastewater sludge incineration, and landfill gas.

* "Indian coal" is coal produced from coal reserves owned by an Indian tribe, or held in trust by the United States for the benefit of an Indian tribe or its members.

Source: Database of State Incentives for Renewables and Efficiency, available online at http://www.dsireusa.org/; and David Ciplet, Global Anti-Incinerator Alliance/Global Alliance for Incinerator Alternatives, March 2008.


GrassRoots Recycling Network, Garbage is NOT Renewable Energy, www.grrn.org

In addition to its negative impact on the climate, the use of incinerators has several other negative environmental, social, and health consequences. For one, incinerators are disproportionately cited in communities of color, tribal communities, and poor or rural communities, which are often areas of least political resistance. Incinerators are also prohibitively expensive, compete with recycling and composting for financing and materials, sustain only 1 job for every 10 at a recycling facility,[93] produce toxic solid and liquid discharges, and cause significant emissions of dioxin and other chlorinated organic compounds that have well known toxic impacts on human health and the environment. Emissions from incinerators are transported long distances and have been positively identified to cause cancer.[94]

Moreover, incinerators are inadequately regulated. For example, the U.S. EPA does not effectively regulate toxins in solid and liquid discharges from incinerators. Emissions of nanoparticles, for instance, are completely unregulated. Nanoparticles are particles that range in size between 1 and 100 nanometers (a nanometer is one billionth of a meter). Nanoparticles emitted by incinerators include dioxins and other toxins. They are too small to measure, and are difficult to capture in pollution control devices. Studies of nanoparticles or ultra-fines reveal increased cause for concern about incinerator emissions of dioxin, heavy metals, and other toxins.[95] Due to their small size, nanoparticles from incinerators and other sources may be able to enter the body through inhalation, consumption or skin contact, and can penetrate cells and tissues causing biochemical damage in humans or animals. Toxic pollutants in nanoparticle size can be lethal to humans in many ways, causing cancer, heart attacks, strokes, asthma, and pulmonary disease, among others.[96] (For additional information on the public health impacts of incinerators, see *Incineration and Public Health: State of Knowledge of the Impacts of Waste Incineration on Human Health.*[97])

## Debunking Common Myths

Despite claims to the contrary, waste incinerators, landfill gas recovery systems, and wet landfill designs (labeled as "bioreactors" by their proponents) will not solve the problem of greenhouse gas emissions from wasting. The following eight common myths stand in the way of effective solutions to address our unsustainable rate of resource consumption and rising greenhouse gas emissions.

**MYTH:** Landfill gas capture recovery systems are an effective way to address methane emissions from landfills.

**FACT:** Landfill gas capture systems do a poor job of recovering methane emissions.

The best way to mitigate landfill methane emissions is to <u>prevent</u> biodegradable materials such as food discards, yard trimmings, and paper products from entering landfills, as methane gas recovery systems actually do a poor job of capturing landfill gas. In fact, most gases generated in landfills escape uncontrolled. Lifetime landfill capture efficiency rates may be closer to 20% than the 75% rate assumed by the U.S. EPA in its WAste Reduction Model (WARM).[98] One study indicates that keeping organics out of landfills is at least 25 times more effective in reducing greenhouse gas emissions than landfill gas-to-energy schemes.[99] These uncontrolled emissions are even more important when evaluating the global warming impact of methane over the short term, rather than diluting it over 100 years, as is current practice.

The U.S. EPA overestimates the capture rates from landfill gas recovery systems due to the following factors:

- There are no field measurements of the efficiency of landfill gas collection systems over the lifetime of the landfill.[100] In order to do this, a giant "bubble," similar to an indoor tennis court bubble, would have to be installed over the entire landfill to capture and measure all of the gas created over an indefinite period of time. In addition, such a system would have to account for emissions released before the gas collection system is installed. It would also have to account for fugitive emissions that escape through cracks in the landfill liner and other pathways. Such an installation is not technically or economically feasible.
- The U.S. EPA's estimated 75% capture rate is an assumption based on what the best gas collection systems might achieve rather than what the average systems actually experience.[101] One study estimated that the average capture rate for 25 landfills in California was 35%.[102]

**The best way to mitigate landfill methane emissions is to prevent biodegradable materials such as food discards, yard trimmings, and paper products from entering landfills. Most gases generated in landfills escape uncontrolled.**

- The U.S. EPA's estimated 75% capture rate is based on instantaneous collection efficiency estimates of a system running at peak efficiency rather than on the system's performance over the entire lifetime that the landfill generates gas. One expert reports that correcting this alone would lower the estimated capture rate from 75% to 27%.[103]

- New landfill gas recovery systems currently space collection wells 350 feet apart, instead of the previous industry practice of 150 feet between wells. This practice results in fewer wells and less landfill gas collected.[104]

- Gas generated inside landfills escapes all day, every day from every landfill in America. No one actually knows how much is escaping since landfills are not fully contained or monitored systems. We do know that gas escapes through a variety of routes, and that it is not stored but instead seeks the path of least resistance to release into the atmosphere. Through ruptures in the final cover, or before the cap is installed, gas escapes directly into the atmosphere from the top and sides of a landfill. Gas also escapes indirectly through subsurface routes, including via the landfills' own leachate collection system and through ruptures in the bottom liner and its seals, sometimes reaching into adjoining structures through underground utility lines.[105]

- Landfill gas managers often "throttle back" on the wells where low methane concentrations are recorded in order to give that surrounding field time to recharge.[‡] When this happens, more landfill gases escape uncontrolled into the atmosphere. While there is no reporting of how often throttling is utilized, anecdotal evidence suggests that about 15% of the fields at a landfill with a gas recovery system will be throttled back or turned down at any point in time. This may reduce lifetime capture rates further to 16%.[106]

- Landfill gas recovery systems are not generally operational during peak methane releases. Theoretically, at least 50% of the "latent" methane in municipal solid waste can be generated within one year of residence time in a landfill.[107] However, regulations in EPA's landfill air rule do not require gas collection for the first five years of a landfill's life.[108] This means that any food discards and other biodegradable materials that decompose within those five years will have emitted methane directly into the atmosphere.

- EPA landfill rules allow the removal of gas collection systems from service approximately 20 years after the landfill closes. Landfill barriers will ultimately fail at some point during the post-closure period when the landfill is no longer actively managed. Once the barriers fail, precipitation will re-enter the landfill, and, in time, accumulating moisture will cause a second wave of decomposition and gas generation without any controls.[109]

* Throttle back = The operator controls how much negative pressure to apply to each gas well. If there is more than 5% oxygen in the gas collected in a well, he or she will reduce the vacuum forces in order to avoid sucking in so much air.

‡ Recharge = When a gas field has its wells throttled back for the related purpose of recharging moisture levels, the landfill operator is reacting to the fact that 50% of the gas withdrawn is moisture, and methanogenic microbes need more than 40% moisture levels to optimize methane production. The vacuum forces are reduced or the well is completely turned off for a while to provide time for new rainfall to infiltrate cells that have not had final covers installed and thereby recoup sufficient moisture to keep the future gas methane rich above 50% and as close to 60% as feasible.

**MYTH:** Wet landfills or "bioreactor" designs will improve landfill gas capture rates and help reduce methane emissions from landfills.

**FACT:** Wet landfills are schemes to speed methane generation, but because lifetime gas capture efficiency rates may approximate 20%, actual methane emissions may be greater with the reactor design than without.

The idea behind wet landfill designs, called "bioreactors" by their proponents, is to compress the time period during which gas is actively produced in the landfill and to thereby implement early gas extraction.[110] Instead of preventing water from entering landfills, these systems re-circulate and redistribute liquids — called leachate — throughout the landfill.[111] This moisture aids decomposition, which then leads to methane generation. Landfill operators prefer these systems because they encourage materials to settle and thus boost landfill capacity, which in turn raises profits.

By adding and circulating liquid to speed anaerobic conditions, however, these systems may actually increase rather than decrease overall methane emissions. The U.S. EPA acknowledges that bioreactors in the early years may increase methane generation 2 to 10 times.[112] And because gas recovery systems do a poor job of recovering methane, these increased emissions will largely escape uncontrolled. See previous myth for more on the flaws of landfill gas recovery systems. Wet landfill systems will likely further reduce the efficiency of landfill gas capture because the pipes used for re-circulating leachate are the same as those used for extracting gas. This makes gas collection challenging. Furthermore, in order to let in more precipitation, bioreactor systems involve delaying the installation of a final cover on the landfill for years — yet it is the cover, the impermeable cap, that is essential for the proper functioning of gas collection systems.[113]

Investing millions of dollars in systems that add to methane generation in the short term is thus ill-advised and counterproductive to climate protection efforts, as such technologies will only hasten the onset of climate change by releasing potent emissions over a short time period.

**MYTH:** Landfills and incinerators are sources of renewable energy.

**FACT:** Landfills and incinerators waste valuable resources and are not generators of "renewable" energy. They inefficiently capture a small amount of energy by destroying a large number of the Earth's diminishing resources that could be conserved, reused, or recycled.

Some federal renewable energy rules and many state green energy programs qualify municipal solid waste as a source of renewable energy, thus allowing landfills and often waste incinerators to receive public financing and tax credits. However, waste is not a source of renewable energy. It is created using exhaustible resources such as fossil fuels and diminishing forests. Since 1970, one-third of global natural resources have been depleted.[114] This pattern of production, consumption, and wasting is hardly part of a sustainable or "renewable" system. The fact is that incinerators and landfills promote wasteful behavior and the continued depletion of finite material resources. This is entirely contrary to any conception of renewable energy.

**MYTH:** Subsidizing landfill gas capture recovery systems through renewable portfolio standards, alternative fuels mandates, and green power incentives is good for the climate.

**FACT:** Subsidies to landfills encourage waste disposal at the expense of waste reduction and materials recovery options that are far better for the climate.

Renewable energy or tax credits for landfill gas capture systems represent subsidies that distort the marketplace and force recycling, composting, and anaerobic digestion programs to compete with landfill disposal systems on an uneven economic playing field. The same holds true for financial incentives offered to waste incinerators.

The critical point to remember when evaluating the eligibility of these systems for "green" incentives is that it is our use of landfills that creates the methane problem in the first place. There is no methane in the materials we discard. It is the decision to landfill biodegradable materials that causes methane, because lined landfills create the unique oxygen-starved conditions that lead to anaerobic decomposition and its resulting methane production. Normally, decomposition of organic matter would occur aerobically through a process that does not produce significant methane.[115] Landfill operators should indeed be required to capture methane, but these gas recovery systems should not qualify as renewable energy in portfolios, renewable tax credits, emission offset trading programs, or other renewable energy incentives. This is akin to giving oil companies tax credits for agreeing to partially clean up their oil spills.

In addition, gas capture systems are highly ineffective and poorly regulated. Current landfill regulations requiring gas recovery only apply to 5% of landfills, and for those to which the regulations do apply, collection systems only need to be in place beginning five years after waste is disposed.[116] The rules also allow the removal of collection systems approximately 20 years after the site's closure.[117] Yet, according to the U.S. EPA, methane emissions can continue for up to 60 years.[118] At some point, all landfill liners and barriers will ultimately fail and leak; EPA has acknowledged this fact.[119] Once barriers fail, precipitation will re-enter the landfill. In time, accumulating moisture during the post-closure period when landfills are no longer actively managed may cause a second wave of decomposition and gas generation without any pollution controls.[120] The bottom line is that no landfill design is effective in preventing greenhouse gas emissions or eliminating the other health and environmental risks of landfilling. This is one principal reason that the European Union committed to reducing the amount of biodegradable waste sent to landfills in its Landfill Directive, and why the German government outlawed the landfilling of untreated mixed waste. In the U.S., the current trend to weaken landfill bans on yard trimmings is the complete opposite of what is needed to reverse climate change, and is contrary to growing international sentiment.[121]

It is extremely important to our climate protection efforts that we dramatically reduce methane emissions from landfills. However, the current strategy in the U.S. of providing subsidies to landfills for gas capture and energy generation leads to increased, not decreased, greenhouse gas emissions. This is because these subsidies provide perverse incentives to landfill more organic materials and to mismanage landfills for increased gas production. This means we are providing incentives to create the potent greenhouse gases we so critically need to eliminate. These subsidies also unfairly disadvantage far more climate-friendly solutions, such as source separation and the composting and anaerobic digestion of organic materials. Rather than providing subsidies for landfill gas capture and energy production, we should, at a minimum, undertake the following: (1) immediately phase out the landfilling and incinerating of organic materials; (2) strengthen landfill gas capture rules and regulations; and (3) provide incentives to expand and strengthen our organics collection infrastructure, including support for the creation of composting and anaerobic digestion facility jobs.

**The bottom line is that no landfill design is effective in preventing greenhouse gas emissions or eliminating the other health and environmental risks of landfilling.**

**MYTH:** Subsidizing waste incinerators through renewable electricity portfolio standards, alternative fuels mandates, and other green power incentives is good for the climate.

**FACT:** Subsidies to incinerators encourage waste disposal at the expense of waste reduction and materials recovery options that are far better for the climate.

Subsidies to incinerators — including mass-burn, pyrolysis, plasma, gasification, and other incineration technologies that generate electricity or fuels — squander taxpayer money intended for truly renewable energy, waste reduction, and climate solutions. Environment America, the Sierra Club, the Natural Resources Defense Council, Friends of the Earth, and 130 other organizations have recognized this fact and endorsed a statement calling for no incentives to be awarded to incinerators.[122] Subsidies to incinerators at the local and national level are encouraging proposals for the construction and expansion of expensive, pollution-ridden, and greenhouse-gas-intensive disposal projects. With limited resources available to fix the colossal climate problem, not a dime of taxpayer money should be misused to subsidize incinerators.

Because of the capital-intensive nature of incinerators, their construction locks communities into long-term energy and waste contracts that obstruct efforts to conserve resources, as recyclers and incinerators compete for the same materials. Incinerator operators covet high-Btu materials such as cardboard, other paper, and plastics for generating electricity. For every ton of paper or plastics incinerated, one less ton can be recycled, and the far greater energy saving benefits of recycling are squandered. Waste incinerators rely on minimum tonnage guarantees through "put or pay" contracts, which require communities to pay fees whether their waste is burned or not. This directly hinders waste prevention, reuse, composting, recycling, and their associated community economic development benefits.

The undermining of recycling by incineration has also been noted in countries with more reliance on incineration than the U.S. Germany's top environmental and waste official acknowledged in 2007 that paper recycling is threatened because of incinerators' "thirst" for combustible materials, and he called for policies to ensure that paper recycling is a priority.[123]

Subsidies for incineration also encourage the expansion of existing incinerators and the construction of a new generation of disposal projects that are harmful to the climate. These subsidies erode community efforts to protect health, reduce waste, and stop global warming, and reverse decades of progress achieved by the environmental justice and health movements. By investing public money in recycling and composting infrastructure, jobs, and other zero waste strategies — rather than incineration — we could reuse a far greater percentage of discarded materials and significantly reduce our climate footprint.

**Environment America, the Sierra Club, the Natural Resources Defense Council, Friends of the Earth, and 130 other organizations have recognized this fact and endorsed a statement calling for no incentives to be awarded to incinerators.**

**MYTH:** Incinerating "biomass" materials such as wood, paper, yard trimmings, and food discards is "climate neutral." $CO_2$ emissions from these materials should be ignored when comparing energy generation options.

**FACT:** Incinerating materials such as wood, paper, yard trimmings, and food discards is far from "climate neutral." Rather, incinerating these and other materials is detrimental to the climate. Any model comparing the climate impacts of energy generation options should take into account additional lifecycle emissions incurred (or not avoided) by not utilizing a material for its "highest and best" use. In addition, calculations should take into account the timing of releases of $CO_2$.

Incinerators emit more $CO_2$ per megawatt-hour than coal-fired, natural-gas-fired, or oil-fired power plants (see Figure 4, page 40). However, when comparing incineration with other energy options such as coal, natural gas, and oil power plants, the Solid Waste Association of North America (SWANA) and the Integrated Waste Services Association (an incinerator industry group) treat the incineration of materials such as wood, paper, yard trimmings, and food discards as "carbon neutral." SWANA ignores $CO_2$ emissions from these materials, concluding that "WTE power plants [incinerators] emit significantly less carbon dioxide than any of the fossil fuel power plants."[124] This is simply inaccurate.

Wood, paper, and agricultural materials are often produced from unsustainable forestry and land management practices that are causing the amount of carbon stored in forests and soil to decrease over time. Incinerating these materials not only emits $CO_2$ in the process, but also destroys their potential for reuse or use as manufacturing and composting feedstocks. This ultimately leads to a net increase of $CO_2$ concentrations in the atmosphere and contributes to climate change. The U.S. is the largest global importer of paper and wood products,[125] and these products are often imported from regions around the world that have unsustainable resource management practices resulting in deforestation, forest degradation, and soil erosion. Deforestation alone accounts for as much as 30% of global carbon emissions.[126] A comprehensive lifecycle analysis is necessary to assess the overall climate impact of any material used as a fuel source, and would include $CO_2$ emissions from wood, paper, food discards, and other "biomass materials."

The rationale for ignoring $CO_2$ emissions from biomass materials when comparing waste management and energy generation options often derives from the Intergovernmental Panel on Climate Change (IPCC) methodology recommended for accounting for national $CO_2$ emissions. In 2006, the IPCC wrote:

> "Consistent with the 1996 Guidelines (IPCC, 1997), only $CO_2$ emissions resulting from oxidation, during incineration and open burning of carbon in waste of fossil origin (e.g., plastics, certain textiles, rubber, liquid solvents, and waste oil) are considered net emissions and should be included in the national $CO_2$ emissions estimate. The $CO_2$emissions from combustion of biomass materials (e.g., paper, food, and wood waste) contained in the waste are biogenic emissions and should not be included in national total emission estimates. *However, if incineration of waste is used for energy purposes, both fossil and biogenic $CO_2$ emissions should be estimated. Only fossil $CO_2$ should be included in national emissions under Energy Sector while biogenic $CO_2$ should be reported as an information item also in the Energy Sector.* Moreover, if combustion, or any other factor, is causing long term decline in the total carbon embodied in living biomass (e.g., forests), this net release of carbon should be evident in the calculation of $CO_2$ emissions described in the Agriculture, Forestry and Other Land Use (AFOLU) Volume of the 2006 Guidelines."[127] *[emphasis added]*

There is no indication that the IPCC ever intended for its national inventory accounting protocols to be used as a rationale to ignore emissions from biomass materials when comparing energy or waste management options outside of a comprehensive greenhouse gas inventory. Rather, the guidelines state "…if incineration of waste is used for energy purposes both fossil and biogenic $CO_2$ emissions should be estimated."

The bottom line is that tremendous opportunities for greenhouse gas reductions are lost when a material is incinerated. When calculating the true climate impact of incineration as compared to other waste management and energy generation options, it is essential that models account for the emissions avoided when a given material is used for its highest and best use. This means, for instance, taking into account emissions that are avoided and carbon sequestered when materials are reused, recycled or composted as compared to incinerated. More climate-friendly alternatives to incinerating materials often include options such as source reduction, waste avoidance, reuse, recycling, and composting.

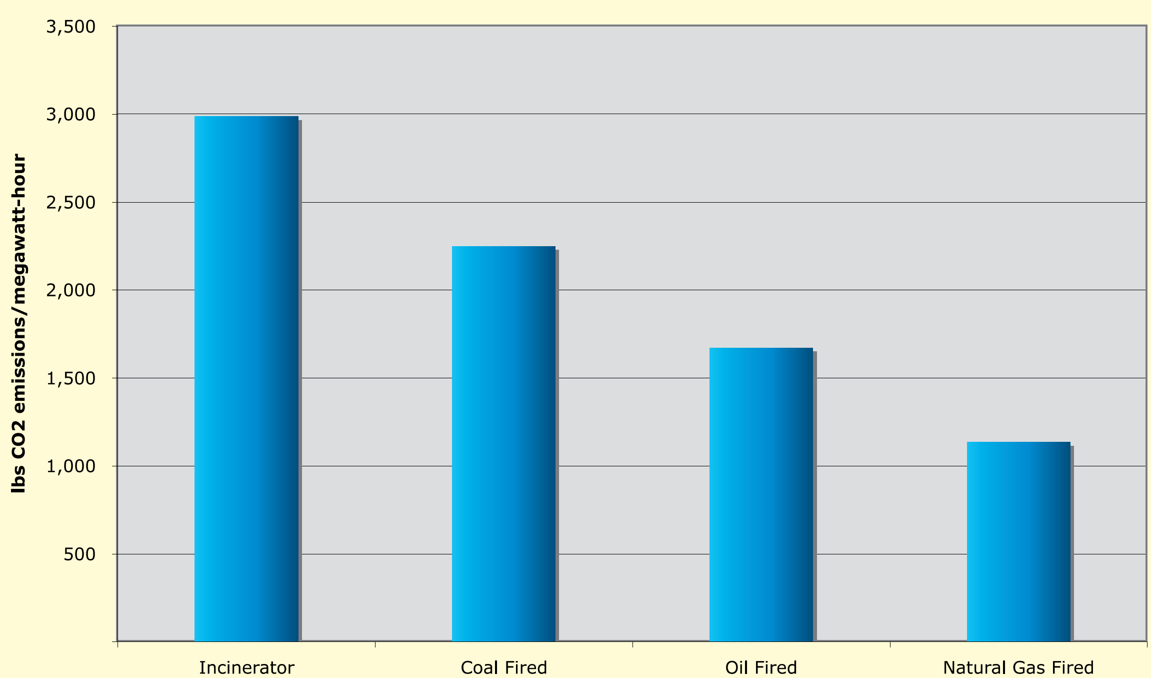
When wood and paper are recycled or source reduced, rather than incinerated, forests sequester more carbon. In other words, when we reduce the amount of materials made from trees, or when we reuse or recycle those materials, fewer trees are cut down to create new products. This leads to increased amounts of carbon stored in trees and soil rather than released to the atmosphere. As the EPA writes in its 2006 report *Solid Waste Management and Greenhouse Gases*, "… forest carbon sequestration increases as a result of source reduction or recycling of paper products because both source reduction and recycling cause annual tree harvests to drop below otherwise anticipated levels (resulting in additional accumulation of carbon in forests)."[128]

When wood, paper or food materials are reused, recycled or composted rather than incinerated, the release of the $CO_2$ from these materials into the atmosphere can be delayed by many years. Materials such as paper and wood can be recycled several times, dramatically increasing the climate protection benefits.

Storing $CO_2$ in materials over time does not have the same impact on climate change as releasing $CO_2$ into the atmosphere instantaneously through incineration.

A recent editorial in the *International Journal of LifeCycle Assessment* emphasizes the importance of timing in "How to Account for $CO_2$ Emissions from Biomass in an LCA":

**Figure 4: Comparison of Total $CO_2$ Emissions Between Incinerators and Fossil-Fuel-Based Power Plants (lbs $CO_2$/megawatt-hour)**




Source: Institute for Local Self-Reliance, June 2008. Based on data reported on the U.S. EPA Clean Energy web page, "How Does Electricity Affect the Environment," http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html, browsed March 13, 2008.

> "The time dimension is crucial for systems with a long delay between removal and emission of $CO_2$, for example, the use of wood for buildings, furniture and wood-based materials. Such $CO_2$ is sequestered for decades or centuries, but eventually much or all of it will be re-emitted to the atmosphere. Different processes for the re-emission may have very different time scales. It is not appropriate to neglect such delays…"[129]

Similarly, in their paper, "The Potential Role of Compost in Reducing Greenhouse Gases," researchers Enzo Favoino and Dominic Hogg argue that one shortcoming of some lifecycle assessments is the following:

> "their failure to take into account the dynamics — or dimension of time — in the assessment of environmental outcomes. In waste management systems, this is of particular significance when comparing biological processes with thermal ones. This is because the degradation of biomass tends to occur over an extended period of time (over 100 years), whereas thermal processes effectively lead to emissions of carbon dioxide instantaneously."[130]

Any model comparing the climate impacts of energy generation options should take into account additional lifecycle emissions incurred (or not avoided) by failing to recover a material for its "highest and best" use. These emissions are the opportunity cost of incineration.

**MYTH:** Incinerators are tremendously valuable contributors in the fight against global warming. For every megawatt of electricity generated through the combustion of solid waste, a megawatt of electricity from coal-fired or oil-fired power plants is avoided, creating a net savings of emissions of carbon dioxide and other greenhouse gases.[131]

**FACT:** Incinerators increase — not reduce — greenhouse gas emissions. Municipal solid waste incinerators produce more carbon dioxide per unit of electricity generated than either coal-fired or oil-fired power plants.[132]

The Integrated Waste Services Association, an incinerator industry group, makes the above claim that waste incinerators that produce electricity reduce greenhouse gases. The reality is quite different. First of all, incinerators emit significant quantities of $CO_2$ and $N_2O$, which are direct greenhouse gases. Second, the majority of $CO_2$ emissions from incinerators are often ignored when incineration is compared with other energy generation options. As discussed above, often only $CO_2$ emissions from fossil-fuel-based plastics, tires, synthetic rubber/leather, and synthetic textiles are counted. These materials represent only one-quarter of all waste combusted[133] and only 28% of $CO_2$ emitted by incinerators in the U.S.

Figure 4 shows all $CO_2$ emissions from incinerators, not just fossil-based carbon. Third, incinerators also emit substantial quantities of indirect greenhouse gases: carbon monoxide (CO), nitrogen oxide ($NO_x$), non-methane volatile organic compounds (NMVOCs), and sulfur dioxide ($SO_2$). These indirect greenhouse gases are not quantifiable as $CO_2$ eq. and are not included in $CO_2$ eq. emission totals in inventories. Fourth, incinerators waste energy by burning discarded products with high-embodied energy, thus preventing recycling and the extensive greenhouse gas reduction benefits associated with remanufacturing and avoided resource extraction. The bottom line is that by destroying resources rather than conserving or recycling them, incinerators cause significant and unnecessary lifecycle greenhouse gas emissions.

Thus, because incinerators emit direct and indirect greenhouse gases to the atmosphere, and because they burn materials that could be reused or recycled in ways that conserve far more energy and realize far greater greenhouse gas reduction benefits, incinerators should never be considered "valuable contributors in the fight against global warming." In fact, the opposite is true.

**MYTH:** Anaerobic digestion technologies have less potential than landfill methane recovery and incineration systems to mitigate greenhouse gases and offset fossil-fuel-generated energy sources.[134]

**FACT:** Anaerobic digestion systems that process segregated and clean biodegradable materials produce a biogas under controlled conditions. Due to highly efficient capture rates, these systems can offset fossil-fuel-generated energy. The "digestate" byproduct can be composted, further sequestering carbon. Anaerobic digestion is much better for protecting the climate than landfill gas recovery projects or waste incineration.

Anaerobic digestion is an effective treatment for managing source-separated biodegradable materials such as food scraps, grass clippings, other garden trimmings, food-contaminated paper, sewage, and animal manures. "Anaerobic" literally means "in the absence of oxygen." Anaerobic digesters are contained systems, commonly used at wastewater treatment plants, that use bacteria to decompose organic materials into smaller molecule chains. The biogas that results is about 60% methane and 40% $CO_2$.[135] After the main period of gas generation is over, the remaining digestate can be composted and used as soil amendment. One benefit of anaerobic digestion is that it can operate alongside and prior to composting; in this way, organic materials that cannot be easily digested can exit the system for composting.

While these enclosed systems are generally more expensive than composting, they are far cheaper than landfill gas capture systems and incinerators. In fact, thousands of inexpensive small-scale systems have been successfully operating in China, Thailand, and India for decades,[136] and anaerobic digestion is widely used across Europe. Denmark, for example, has farm cooperatives that utilize anaerobic digesters to produce electricity and district heating for local villages. In Sweden, biogas plants produce vehicle fuel for fleets of town buses. Germany and Austria have several thousand on-farm digesters treating mixtures of manure, energy crops, and restaurant scraps; the biogas is used to produce electricity. In England, a new Waste Strategy strongly supports using anaerobic digestion to treat food discards and recommends separate weekly food scrap collection service for households.[137] Many other countries can benefit from similar projects.

**The bottom line is that by destroying resources rather than conserving or recycling them, incinerators cause significant and unnecessary lifecycle greenhouse gas emissions.**

## A Zero Waste Approach is One of the Fastest, Cheapest, and Most Effective Strategies for Mitigating Climate Change in the Short and Long-Term

Zero waste goals or plans have now been adopted by dozens of communities and businesses in the U.S. and by the entire state of California.[138] In addition, in 2005, mayors representing 103 cities worldwide signed onto the Urban Environmental Accords, which call for sending zero waste to landfills and incinerators by the year 2040, and for reducing per capita solid waste disposed in landfills and incinerators by 20% within seven years.[139]

According to the California state government's web page, Zero Waste California, "Zero waste is based on the concept that wasting resources is inefficient and that efficient use of our natural resources is what we should work to achieve. It requires that we maximize our existing recycling and reuse efforts, while ensuring that products are designed for the environment and have the potential to be repaired, reused, or recycled. The success of zero waste requires that we redefine the concept of 'waste' in our society. In the past, waste was considered a natural by-product of our culture. Now, it is time to recognize that proper resource management, not waste management, is at the heart of reducing waste…"[140]

Indeed, embracing a zero waste goal means investing in the workforce, infrastructure, and local strategies needed to significantly reduce the amount of materials that we waste in incinerators and landfills. It means ending taxpayer subsidization of waste projects that contaminate environments and the people who live within them. It means investing public money in proven waste reduction, reuse, and recycling programs, and requiring that products be made and handled in ways that are healthy for people and the environment. In short, zero waste reduces costs, creates healthy jobs and businesses, and improves the environment and public health in myriad ways.

When a pound of municipal discards is recycled, it eliminates the need to produce many more pounds of mining and manufacturing wastes that are the byproducts of the extraction and processing of virgin materials into finished goods.

Workers for Second Chance, a building material reuse and deconstruction company

**"Zero waste is based on the concept that wasting resources is inefficient and that efficient use of our natural resources is what we should work to achieve."**

– California State Government Zero Waste California web page, www.zerowaste.ca.gov

Using recycled materials to make new products saves energy and resources, which in turn has the ripple effects of reducing greenhouse gas emissions and industrial pollution, and stemming deforestation and ecosystem damage.

Similarly, when organic discards — such as food scraps, leaves, grass clippings, and brush — are composted, landfill methane emissions are avoided. By using the resulting product to substitute for synthetic fertilizers, compost can reduce some of the energy and greenhouse gas emissions associated with producing synthetic fertilizers. Moreover, compost sequesters carbon in soil, and by adding carbon and organic matter to agricultural soils, their quality can be improved and restored. Anaerobic digestion complements composting and offers the added benefit of generating energy.

In summary, a zero waste approach — based on waste prevention, reuse, recycling, composting, and anaerobic digestion — reduces greenhouse gas emissions in all of the following ways:

- reducing energy consumption associated with manufacturing, transporting, and using the product or material;
- reducing non-energy-related manufacturing emissions, such as the $CO_2$ released when limestone is converted to the lime that is needed for aluminum and steel production;
- reducing methane emissions from landfills;
- reducing $CO_2$ and nitrous oxide ($N_2O$) emissions from incinerators;
- increasing carbon uptake by forests, which absorb $CO_2$ from the atmosphere and store it as carbon for long periods (thus rendering the carbon unavailable to contribute to greenhouse gases);
- increasing carbon storage in products and materials; and
- increasing carbon storage in soils by restoring depleted stocks of organic matter.[141]

## Communities Embracing Zero Waste

**California**

Del Norte County
San Luis Obispo County
Santa Cruz County
City of Oakland
San Francisco City and County
Berkeley
Palo Alto
State of California
Marin County, CA Joint Powers Authority
Fairfax
Novato
Fresno
El Cajon
Culver City (in Sustainable Community Plan)
Ocean Beach
Rancho Cucamonga
San Jose
Apple Valley
San Juan Capistrano

**Other USA**

Boulder County, CO
City of Boulder, CO
Central Vermont Solid Waste Management District
King County, WA
Seattle, WA
Summit County, CO
Matanuska-Susitna Borough, AK
Logan County, OH

**Other North America**

Halifax, Nova Scotia
Regional District Nelson, British Columbia
Regional District Kootenay Boundary, British Columbia
Regional District Central Kootenay, British Columbia
Smithers, British Columbia
Regional District Cowichan Valley, British Columbia
Nanaimo, British Columbia
Toronto, Ontario
Sunshine Coast Regional District, British Columbia

Source: "List of Zero Waste Communities," Zero Waste International web site at http://www.zwia.org/zwc.html, updated May 14, 2008.

Within the zero waste approach, the most beneficial strategy for combating climate change is reducing the overall amount of materials consumed and discarded, followed by materials reuse, then materials recycling. Energy consumption represents 85.4% of all greenhouse gas emissions in the U.S. (2005 data). Fossil fuel consumption alone represents 79.2%, and of this, almost one-third is associated with industrial material processing and manufacturing.[142] Reducing consumption avoids energy use and emissions, while extensive lifecycle analyses show that using recycled materials to make new products decreases energy use, and subsequently greenhouse gases.

Mining and smelting aluminum into cans is an especially energy-intensive process that demonstrates the energy-savings potential of using recycled materials. Manufacturing a ton of aluminum cans from its virgin source, bauxite, uses 229 million Btus. In contrast, producing cans from recycled aluminum uses only 8 million Btus per ton, resulting in an energy savings of 96%.[143] Likewise, extracting and processing petroleum into common plastic containers (polyethylene terephthalate, PET (#1), and high-density polyethylene, HDPE (#2)) takes four to eight times more energy than making plastics from recycled plastics.[144] (See Figure 5.) Net carbon emissions are four to five times lower when materials are produced from recycled steel, copper, glass, and paper. For aluminum, they are 40 times lower.[145]

It should be noted that none of these figures account for the significant greenhouse gas emissions that result from transporting materials from mine to manufacturer to distributor to consumer and then to disposal facility. Truck transportation alone, for instance, accounts for 5.3% of total annual U.S. greenhouse gas emissions. Accordingly, there are significant climate benefits to be realized by ensuring that reuse and recycling industries become more locally based, thereby reducing greenhouse gas emissions associated with the transportation of products and materials.

Thus, the real greenhouse gas reduction potential is reached when we reduce materials consumption in the first place, and when we replace the use of virgin materials with reused and recycled materials in the production process. This is the heart of a zero waste approach. Aiming for zero waste entails minimizing waste, reducing consumption, maximizing recycling and composting, keeping industries local, and ensuring that products are made to be reused, repaired or recycled back into nature or the marketplace.

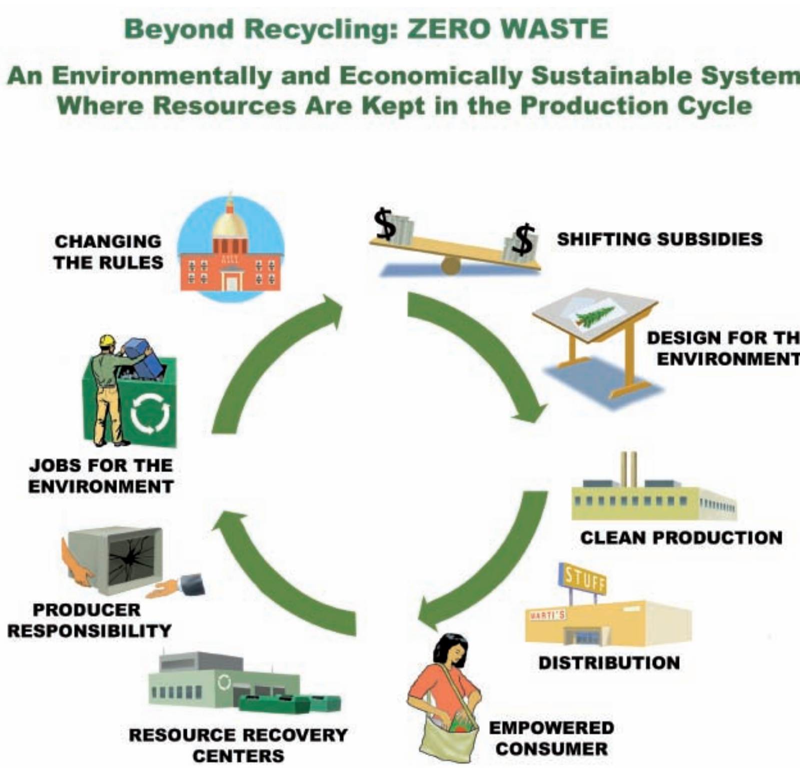
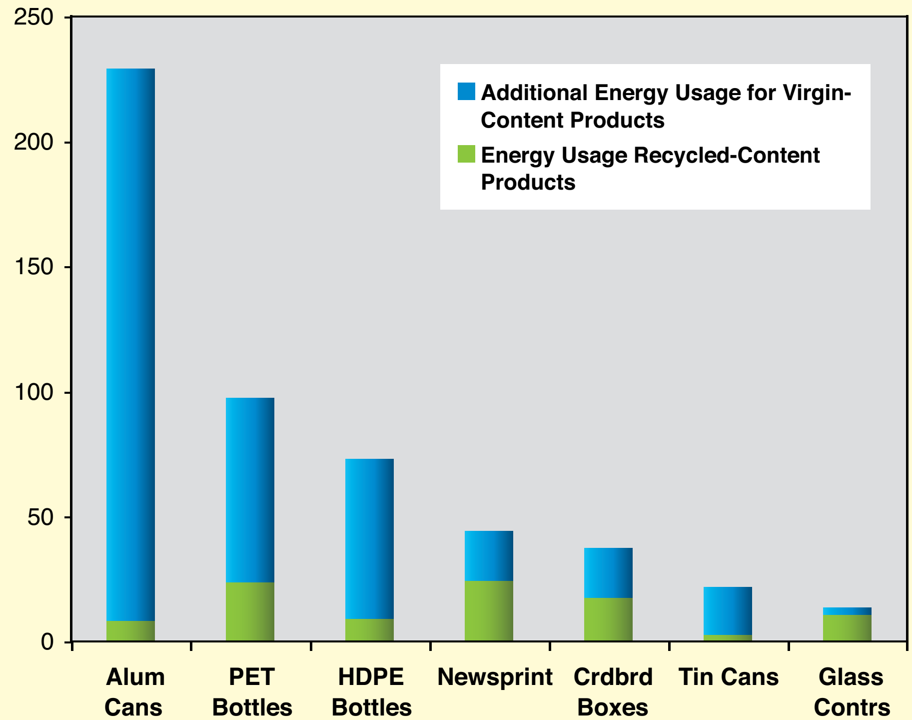


**Figure 5: Energy Usage for Virgin vs. Recycled-Content Products (million Btus/ton)**




Source: Jeff Morris, Sound Resource Management, Seattle, Washington, personal communication, January 8, 2008, available online at www.zerowaste.com; and Jeff Morris, "Comparative LCAs for Curbside Recycling Versus Either Landfilling or Incineration with Energy Recovery," *International Journal of LifeCycle Assessment* (June 2004).

We need better tools, studies, policies, and funding to adequately assess and understand the climate protection benefits of reducing waste, recycling, and composting. A 32-page 2008 article, "Mitigation of global greenhouse gas emissions from waste: conclusions and strategies," by the Intergovernmental Panel on Climate Change devotes little ink to this subject:

> "In general, existing studies on the mitigation potential for recycling yield variable results because of differing assumptions and methodologies applied; however, recent studies are beginning to quantitatively examine the environmental benefits of alternative waste strategies, including recycling."[146]

In the absence of international and national leadership on this issue, local governments are now filling the void. Alameda County, California, for example, worked closely with the International Council for Local Environmental Initiatives (ICLEI) to formulate values for greenhouse gas reductions from select reuse, recycling, and composting practices. (See Table 7.) In addition, as mentioned previously, the California ETAAC final report makes specific recommendations to the California Air Resources Board for waste reduction, reuse, recycling, and composting technologies and policies to consider for reducing greenhouse gas emissions in California and beyond (see pages 21-22).

On the national level, the U.S. EPA's WAste Reduction Model (WARM) is a popular tool designed for waste managers to weigh the greenhouse gas and energy impacts of their waste management practices. WARM focuses exclusively on waste sector greenhouse gas emissions.

Unfortunately, the model falls short of its goal to allow adequate comparison among available solid waste management options. For a list of the tool's shortcomings, see sidebar, p. 61. Despite these weaknesses, the data on which WARM is based indicate recycling better protects the climate than the use of landfills and incinerators for all materials examined. (See Table 8.) For composting, however, the model falsely shows that composting yard trimmings, grass or branches produces a smaller greenhouse gas reduction than incinerating these materials. This flawed comparison leads to the inaccurate conclusion that incineration fares better than composting in managing organic materials. One reason for this error is the model does not fully take into account the benefits associated with compost use. WARM relies on data that use very low compost application rates in unrealistic scenarios, for instance, in applications to field corn rather than to high-value crops or to home gardens and lawns, which undervalue the climate protection benefits of composting.[147]

The following section compares the greenhouse gas impact of a business-as-usual wasting scenario with a zero waste approach. Despite its shortcomings, the authors of this report used the WARM tool to estimate the difference in emissions of greenhouse gases between the two scenarios because it is the best model available to date. Accordingly, the comparative results should be considered to be a conservative estimate of the greenhouse gas reduction potential of a national zero waste strategy.

**Table 7: Select Resource Conservation Practices Quantified**

| Practice | Emissions Reduced (Tons $CO_2$ eq.) |
|---|---|
| Divert 1 ton of food scraps from landfill | 0.25 |
| Every acre of Bay-Friendly landscape[1] | 4 |
| Reuse 1 ton of cardboard boxes | 1.8 |
| Recycle 1 ton of plastic film | 2.5 |
| Recycle 1 ton of mixed paper | 1 |

1. Bay-Friendly landscaping is a holistic approach to gardening and landscaping that includes compost use.

Source: Debra Kaufman, "Climate Change and Composting: Lessons Learned from the Alameda County Climate Action Project," StopWaste.Org, presented at the Northern California Recycling Association's Recycling Update '07 Conference, March 27, 2007, available online at: http://www.ncrarecycles.org/ru/ru07.html.

**We need better tools, studies, policies, and funding to adequately assess and understand the climate protection benefits of reducing waste, recycling, and composting.**

**Table 8: U.S. EPA WARM GHG Emissions by Solid Waste Management Option (MTCE per ton)**

| Material | Landfilled | Combusted | Recycled | Composted | SR |
|---|---|---|---|---|---|
| Aluminum Cans | 0.010 | 0.017 | -3.701 | NA | -2.245 |
| Carpet | 0.010 | 0.106 | -1.959 | NA | -1.090 |
| Mixed Metals | 0.010 | -0.290 | -1.434 | NA | NA |
| Copper Wire | 0.010 | 0.015 | -1.342 | NA | -2.001 |
| Mixed Paper, Broad | 0.095 | -0.178 | -0.965 | NA | NA |
| Mixed Paper, Resid. | 0.069 | -0.177 | -0.965 | NA | NA |
| Mixed Paper, Office | 0.127 | -0.162 | -0.932 | NA | NA |
| Corrugated Cardboard | 0.109 | -0.177 | -0.849 | NA | -1.525 |
| Textbooks | 0.530 | -0.170 | -0.848 | NA | -2.500 |
| Magazines/third-class mail | -0.082 | -0.128 | -0.837 | NA | -2.360 |
| Mixed Recyclables | 0.038 | -0.166 | -0.795 | NA | NA |
| Office Paper | 0.530 | -0.170 | -0.778 | NA | -2.182 |
| Newspaper | -0.237 | -0.202 | -0.761 | NA | -1.329 |
| Phonebooks | -0.237 | -0.202 | -0.724 | NA | -1.724 |
| Medium Density Fiberboard | -0.133 | -0.212 | -0.674 | NA | -0.604 |
| Dimensional Lumber | -0.133 | -0.212 | -0.670 | NA | -0.551 |
| Personal Computers | 0.010 | -0.054 | -0.616 | NA | -15.129 |
| Tires | 0.010 | 0.049 | -0.498 | NA | -1.086 |
| Steel Cans | 0.010 | -0.418 | -0.489 | NA | -0.866 |
| LDPE | 0.010 | 0.253 | -0.462 | NA | -0.618 |
| PET | 0.010 | 0.295 | -0.419 | NA | -0.571 |
| Mixed Plastics | 0.010 | 0.270 | -0.407 | NA | NA |
| HDPE | 0.010 | 0.253 | -0.380 | NA | -0.487 |
| Fly Ash | 0.010 | NA | -0.237 | NA | NA |
| Glass | 0.010 | 0.014 | -0.076 | NA | -0.156 |
| Concrete | 0.010 | NA | -0.002 | NA | NA |
| Food Scraps | 0.197 | -0.048 | NA | -0.054 | NA |
| Yard Trimmings | -0.060 | -0.060 | NA | -0.054 | NA |
| Grass | -0.002 | -0.060 | NA | -0.054 | NA |
| Leaves | -0.048 | -0.060 | NA | -0.054 | NA |
| Branches | -0.133 | -0.060 | NA | -0.054 | NA |
| Mixed Organics | 0.064 | -0.054 | NA | -0.054 | NA |
| Mixed MSW | 0.116 | -0.033 | NA | NA | NA |
| Clay Bricks | 0.010 | NA | NA | NA | -0.077 |

MTCE = metric tons of carbon equivalent SR = Source Reduction

Source: U.S. EPA, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, EPA 530-R-06-004, September 2006, p. ES-14.

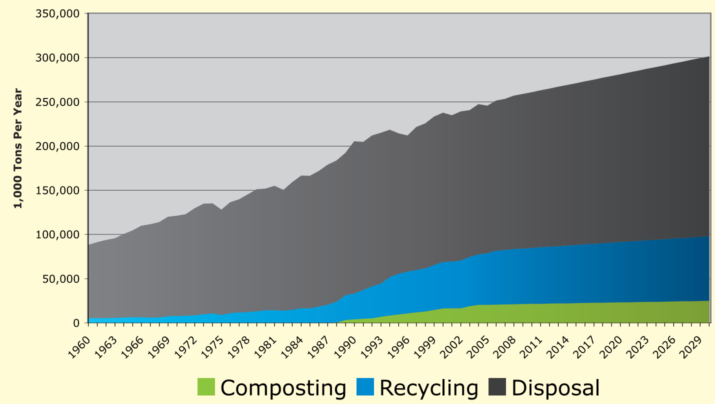
**The real greenhouse gas reduction potential is reached when we reduce materials consumption in the first place, and when we replace the use of virgin materials with reused and recycled materials in the production process. This is the heart of a zero waste approach.**

## Zero Waste Approach Versus Business As Usual

If we continue on the same wasting path, with rising per capita waste generation rates and stagnating recycling and composting rates, by the year 2030 Americans could generate 301 million tons per year of municipal solid waste — up from 251 million tons in 2006. Figure 6, Business As Usual, visually demonstrates the results of our current wasting patterns on the future.

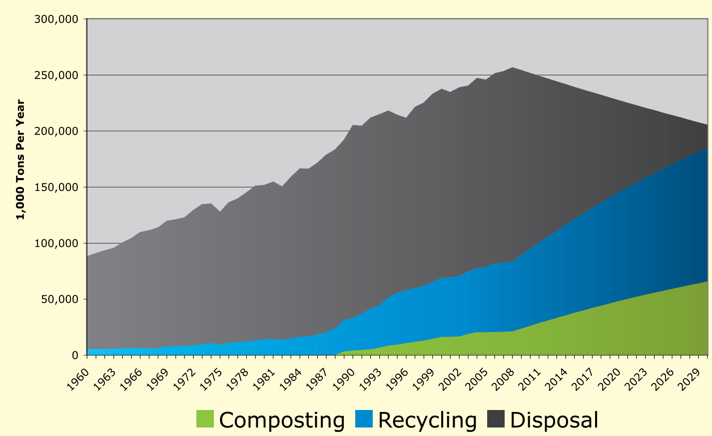
Figure 7 illustrates the impact of one zero waste approach that is based on rising reuse, recycling and composting rates, and source reducing waste by 1% per year between now and 2030. In addition to expanded curbside collection programs and processing infrastructure, product redesign and policies spurring such design will be needed. Under the zero waste approach, by 2030, 90% of the municipal solid waste generated would be diverted from disposal facilities. To achieve this target, cities and states should set interim diversion goals, such as 75% by 2020. This scenario is in line with the Urban Environmental Accords, which call for sending zero waste to landfills and incinerators by the year 2040, and for reducing per capita solid waste disposed in landfills and incinerators by 20% within seven years. San Francisco is one large city that has embraced a zero waste goal by 2020 and an interim 75% diversion goal by 2010. Its zero waste manager estimates that 90% of the city's municipal solid waste could be recycled and composted today under its existing infrastructure and programs.[148]

**Figure 6: Business As Usual Recycling, Composting, Disposal**




Source: Brenda Platt and Heeral Bhalala, Institute for Local Self-Reliance, Washington, DC, June 2008, using and extrapolating from U.S. EPA municipal solid waste characterization data. Waste composition in future assumed the same as 2006. The diversion level through recycling and composting flattens out at 32.5%. Takes into account U.S. Census estimated population growth.

**Figure 7: Zero Waste Approach**




Source: Brenda Platt and Heeral Bhalala, Institute for Local Self-Reliance, Washington, DC, June 2008. Past tonnage based on U.S. EPA municipal solid waste characterization data. Future tonnage based on reaching 90% diversion by 2030, and 1% source reduction per year between 2008 and 2030. Waste composition in future assumed the same as 2006. Takes into account U.S. Census estimated population growth.

**Table 9: Zero Waste by 2030, Materials Diversion Tonnages and Rates**

| | Generated (tons) | Disposed (tons) | Recycled (tons) | Composted (tons) | % Recycled | % Composted | % Diverted |
|---|---|---|---|---|---|---|---|
| Paper | 69,791,864 | 6,979,186 | 47,186,280 | 15,626,398 | 67.6% | 22.4% | 90.0% |
| Glass | 10,801,414 | 1,080,141 | 9,721,272 | | 90.0% | | 90.0% |
| Metals | 15,653,868 | 1,565,387 | 14,088,481 | | 90.0% | | 90.0% |
| Plastics | 24,131,341 | 2,413,134 | 16,349,602 | 5,368,605 | 67.8% | 22.2% | 90.0% |
| Wood | 11,398,765 | 1,139,877 | 10,258,889 | | 90.0% | | 90.0% |
| Food Discards | 25,571,530 | 2,557,153 | | 23,014,376 | | 90.0% | 90.0% |
| Yard Trimmings | 26,512,562 | 2,651,256 | | 23,861,306 | | 90.0% | 90.0% |
| Other | 21,807,400 | 2,180,740 | 19,626,660 | | 90.0% | | 90.0% |
| **Totals** | **205,668,744** | **20,566,874** | **117,231,184** | **67,870,685** | **58.0%** | **33.0%** | **90.0%** |

Source: Institute for Local Self-Reliance, June 2008. Plastics composted represent compostable plastics, which have already been introduced into the marketplace and are expected to grow.

**Table 10: Source Reduction by Material, Total Over 23-Year Period (2008-2030)**

| Material | Tons Source Reduced | Sample Target Strategies |
|---|---|---|
| Paper | 32,375,971 | 3rd class mail, single-sided copying, cardboard & other packaging, single-use plates & cups, paper napkins & towels, tissues |
| Glass | 5,010,703 | single-use bottles replaced with refillables |
| Metals | 7,261,723 | single-use containers, packaging, downguage metals in appliances |
| Plastics | 11,194,365 | packaging, single-use water bottles, take-out food containers, retail bags |
| Wood | 5,287,810 | reusable pallets, more building deconstruction to supply construction |
| Food Discards | 11,862,459 | more efficient buying, increased restaurant/foodservice efficiency |
| Yard Trimmings | 12,298,997 | more backyard composting, xeriscaping, grasscycling |
| Other | 10,116,305 | high mileage tires, purchase of more durable products |
| **Totals** | **95,408,332** | |

Source: Institute for Local Self-Reliance, June 2008.

Table 9 summarizes the materials recovered and the recovery rates needed to reach this 90% diversion level by the year 2030. (Waste composition is based on 2006 data.)

Table 10 summarizes the materials and tonnages that are source reduced — that is, avoided in the first place — over the 23-year period 2008-2030. It also lists some suggested techniques for achieving this source reduction.

According to calculations performed using the U.S. EPA's WARM model, the zero waste approach would reduce greenhouse gas emissions by an estimated 5,083 Tg $CO_2$ eq. over this 23-year period. By the year 2030, annual greenhouse abatement would reach 406 Tg $CO_2$ eq. This translates to the equivalent of taking 21% of the 417 coal-fired power plants operating in the U.S. completely off the grid.[149] This would also achieve 7% of the cuts in U.S. greenhouse gas emissions needed to put us on the path to achieving what many leading scientists say is necessary to stabilize the climate by 2050.[150, 151, 152] See Table 11.

**Table 11: Greenhouse Gas Abatement Strategies: Zero Waste Path Compared to Commonly Considered Options** (annual reductions in greenhouse gas emissions by 2030, megatons $CO_2$ eq.)

| Greenhouse Gas Abatement Strategy | Annual Abatement Potential by 2030 | % of Total Abatement Needed in 2030 to Stabilize Climate by 2050[1] |
|---|---|---|
| **ZERO WASTE PATH** | | |
| Reducing waste through prevention, reuse, recycling and composting | **406** | **7.0%** |
| **ABATEMENT STRATEGIES CONSIDERED BY McKINSEY REPORT** | | |
| **Increasing fuel efficiency in cars and reducing fuel carbon intensity** | **340** | **5.9%** |
| Improved fuel efficiency and dieselization in various vehicle classes | 195 | 3.4% |
| Lower carbon fuels (cellulosic biofuels) | 100 | 1.7% |
| Hybridization of cars and light trucks | 70 | 1.2% |
| **Expanding & enhancing carbon sinks** | **440** | **7.6%** |
| Afforestation of pastureland and cropland | 210 | 3.6% |
| Forest management | 110 | 1.9% |
| Conservation tillage | 80 | 1.4% |
| **Targeting energy-intensive portions of the industrial sector** | **620** | **10.7%** |
| Recovery and destruction of non-$CO_2$ GHGs | 255 | 4.4% |
| Carbon capture and storage | 95 | 1.6% |
| Landfill abatement (focused on methane capture) | 65 | 1.1% |
| New processes and product innovation (includes recycling) | 70 | 1.2% |
| **Improving energy efficiency in buildings and appliances** | **710** | **12.2%** |
| Lighting retrofits | 240 | 4.1% |
| Residential lighting retrofits | 130 | 2.2% |
| Commercial lighting retrofits | 110 | 1.9% |
| Electronic equipment improvements | 120 | 2.1% |
| **Reducing the carbon intensity of electric power production** | **800** | **13.8%** |
| Carbon capture and storage | 290 | 5.0% |
| Wind | 120 | 2.1% |
| Nuclear | 70 | 1.2% |

The McKinsey Report analyzed more than 250 opportunities to reduce greenhouse gas emissions. While the authors evaluated options for three levels of effort—low-, mid-, and high-range—they only reported greenhouse gas reduction potential for the mid-range case opportunities. The mid-range case involves concerted action across the economy. Values for select mid-range abatement strategies are listed above. The zero waste path abatement potential also represents a mid-range case, due to shortcomings in EPA's WARM model, which underestimates the reduction in greenhouse gases from source reduction and composting as compared to landfilling and incineration. A high-range zero waste path would also provide a more accelerated approach to reducing waste generation and disposal.

The authors of this report, *Stop Trashing the Climate*, do not support all of the abatement strategies evaluated in the McKinsey Report. We do not, for instance, support nuclear energy production.

1. In order to stabilize the climate, U.S. greenhouse gas emissions in 2050 need to be at least 80% below 1990 levels. Based on a straight linear calculation, this means 2030 emissions levels should be 37% lower than the 1990 level, or equal to 3.9 gigatons $CO_2$ eq. Thus, based on increases in U.S. greenhouse gases predicted by experts, 5.8 gigatons $CO_2$ eq. in annual abatement is needed in 2030 to put the U.S. on the path to help stabilize the climate by 2050.

Source: Jon Creyts et al, *Reducing U.S. Greenhouse Gas Emissions: How Much and at What Cost? U.S. Greenhouse Gas Abatement Mapping Initiative, Executive Report,* McKinsey & Company, December 2007. Available online at: http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp. Abatement potential for waste reduction is calculated by the Institute for Local Self-Reliance, Washington, DC, June 2008, based on the EPA's WAste Reduction Model (WARM) to estimate GHGs and based on extrapolating U.S. EPA waste generation and characterization data to 2030, assuming 1% per year source reduction, and achieving a 90% waste diversion by 2030.

Scientific experts are now in general agreement that developed nations such as the U.S. need to reduce greenhouse gas emissions 80% below 1990 levels by 2050 in order to stabilize atmospheric greenhouse gas concentrations. However, it is important to note that emissions cuts by developed nations such as the U.S. may have to be even greater than this target. Achieving this target may leave us vulnerable to a 17-36% chance of exceeding a 2°C increase in average global temperatures. In addition, there is ample evidence that climate change is already negatively impacting the lives of many individuals and communities throughout the world. To prevent climate-related disasters, the U.S. should and must take immediate and comprehensive action relative to its full contribution to climate change.[150, 152]

Zero waste strategies also mitigate other negative effects of landfilling and incinerating materials. For landfills, these effects include groundwater pollution, hazardous air pollutants, and monitoring and remediation costs that will likely span centuries. The use of incinerators may even be worse, as pollution is borne directly to the air through smokestacks as well as to the land as ash, and the amount of energy wasted by failing to recycle the materials that are burned is far greater than the amount of energy produced via incineration. Polluting industries such as landfills and incinerators are also disproportionately sited in low-income communities of color, a practice that perpetuates environmental injustice.

Zero waste is much bigger than merely a set of policies or technologies; it is a model that is integrally tied to democratic participation in fostering sustainable community-based economic development that is both just and healthy. Zero waste requires that those who are most adversely impacted by waste disposal and climate change — often people of color and tribal and low-income communities both at home and abroad — have decision-making power in determining what is best for their communities. Zero waste strategies are less capital-intensive and harmful than waste disposal, and they provide critical opportunities for the development of green jobs, businesses, and industries that benefit all community members. Further, because zero waste necessitates the elimination of polluting disposal industries that disproportionately have a negative impact on marginalized communities, it can be an important strategy toward achieving economic and environmental justice.

The emerging trend of zero waste community planning involves the process of creating local strategies for achieving high recycling and composting rates. Many communities across America are actively seeking ways to increase their discard recovery rates, and a growing number of groups across the country and around the world are turning to the strategic planning option of zero waste as the most cost-effective and financially sustainable waste management system. In fact, after achieving high recycling and composting rates, it is difficult to keep using the term "waste" to describe the materials that Americans routinely throw away. There is a market for 90% of these materials, and their associated economic value can lead to a significant local economic development addition to any community.

The short timeline needed for moving away from landfills and incinerators is one of the most attractive elements that make the zero waste approach one of the best near-term programs for reducing greenhouse gas emissions. A ten-year "bridge strategy" toward achieving zero waste involves several essential components. The first is democratic public participation in the development of policies and the adoption of technologies that support communities in getting to a 70% landfill and incinerator diversion rate within five years. Many communities are well on their way to reaching this goal, and the largest obstacle in other areas is the political will to implement the necessary changes.

**There is a market for 90% of discarded materials, and their associated economic value can lead to a significant local economic development addition to any community.**

Further reducing waste by another 20% will require new regulations and the full participation of industry and business through what is known as "extended producer responsibility" (EPR). The EPR approach, which has been embraced in several ways in the European Union and Canada, requires the redesign of products and packaging to be non-toxic and either reusable, recyclable or compostable. EPR also includes "take-back" laws that require industries to take back or be financially responsible for hard-to-recycle products — such as electronics, batteries, and even entire vehicles — at the end of their useful lives, rather than placing this burden on taxpayers. When industry, rather than the public, is held accountable for the costs of dealing with these products at the end of their life, industry will design products that are more cost-effective to recycle.[153] These take-back laws can also benefit industries by providing them with opportunities to recover valuable materials. Regulations and oversight are then needed to ensure that industries reuse or recycle these materials in ways that are safe for the public and planet.

Once we have established a 70% landfill and incinerator diversion rate and a system of extended producer responsibility that will further reduce the amount we collectively waste by an estimated 20%, the opportunities to solve the last 10% of the waste stream may present themselves in the future in ways that we may not imagine today. However, one likely result of achieving 90% diversion is that America may never need to build another new landfill or incinerator again.

One serious issue to address in this "bridge strategy" concerns the question of what to do with all the mixed waste that is not being source-separated for recycling or composting along the ten-year journey to 90% or beyond. The answer is to process this material in as safe, inexpensive, and flexible of a manner as possible, so that, as recovery rates rise above 70%, the mixed waste system can be shut down in favor of more sustainable solutions. Incineration of any kind is never the most safe, inexpensive or flexible way to process this material.

## Zero Waste Planning Resources

**Community groups, consultants, government planners, and many others who are working on zero waste issues are active around the world. The following links provide additional information about their efforts:**

- The GrassRoots Recycling Network (www.grrn.org) is the nation's leading voice for a zero waste future;
- Eco-Cycle Inc. (www.ecocycle.org) is the nation's largest comprehensive zero waste non-profit corporation, located in Boulder, Colorado, with a staff of 60 and annual revenues over $4 million;
- Global Alliance for Incinerator Alternatives (www.no-burn.org) is a global network with members in 81 countries that are working for a just and toxic-free world without incinerators. Information about GAIA's Zero Waste for Zero Warming campaign is at www.zerowarming.org;
- Zero Waste International Alliance (www.zwia.org) is a global networking hub for practitioners around the world;
- Zero Waste California (www.zerowaste.ca.gov) is the largest state agency with a policy and goal of zero waste;
- Oakland Public Works (www.zerowasteoakland.com) is a large city department at the cutting edge of creating the zero waste systems of the future;
- Sound Resource Management (www.zerowaste.com) offers economic and lifecycle assessments to track environmental impacts; and
- Institute for Local Self-Reliance (www.ilsr.org/recycling) provides research, technical assistance, and information on zero waste planning, recycling-related economic development, and model recycling and composting practices and policies.

## Composting Is Key to Restoring the Climate and Our Soils

Composting may be one of the most vital strategies for curbing greenhouse gas emissions. It is an age-old process whose success has been well demonstrated in the U.S. and elsewhere. Composting facilities are far cheaper than landfills and incinerators, and also take far less time to site and build; widespread implementation could take place within 2 to 8 years. Adopting this approach would provide a rapid and cost-effective means to reduce methane and other greenhouse gas emissions, increase carbon storage in soils, and could have a substantial short-term impact on global warming.

Organic discards — food scraps, leaves, brush, grass clippings, and other yard trimmings — comprise one-quarter of all municipal solid waste generated. Of this amount, 38% of yard trimmings end up in landfills and incinerators; for food scraps, the wasting rate is 97.8%.[154] Paper products comprise one-third of all municipal solid waste generated. While 52% of paper products are recovered, paper is still the number one material sent to landfills and incinerators. This waste represents a tremendous opportunity to prevent methane emissions from landfills through expanded recycling, composting, and anaerobic digestion programs. At the same time, compost can also restore depleted soils with nutrient-rich humus and organic matter, providing ancillary benefits that are not realized when systems of incineration and landfilling are used.

Composting reduces our impact on climate change in all of the following ways:

- *Avoiding landfill methane emissions:* While the composting process produces $CO_2$, just like natural decomposition, this gas is far less potent than the methane that is emitted from landfills. Methane is 72 times more potent than $CO_2$ over the short term. The amount of avoided landfill methane emissions provides the greatest climate protection benefit of composting, greatly outweighing any of the following benefits.[155]

- *Decreasing emissions of carbon from soils:* While much attention is paid to the carbon sequestration benefits of trees and other biomass, soil is actually the biggest carbon store in the world, holding an estimated 1,500 gigatons.[156] However, reserves of carbon in agricultural and nonagricultural soils have been depleted over time; one European study indicated that most agricultural soils will have lost about half of their organic content after 20 years of tillage.[157] On over half of America's best cropland, the erosion rate is more than 27 times the natural rate.[158] In fact, a large portion of the $CO_2$ currently found in the atmosphere originated from the mineralization of soil organic carbon. Factors responsible for this include urbanization, land use changes, conventional agricultural practices, open pit mining, and other activities that degrade soils. As a result of these factors, more carbon entered the atmosphere from soils than from fossil fuel combustion from the 1860s until the 1970s.[159]

- *Storing carbon in soils:* Proper soil management, in combination with the addition of organic matter, increases the carbon inputs into the soil while reducing the amount of carbon that is mineralized into the atmosphere. Approximately half of the carbon in composted organic materials is initially stored in the humus product, making it unavailable to the atmosphere for a period of time.[160] This helps reduce atmospheric emissions of $CO_2$. The European Commission's Working Group on Organic Matter has in part concluded: "Applying composted EOM [exogeneous organic matter] to soils should be recommended because it is one of the effective ways to divert carbon dioxide from the atmosphere and convert it to organic carbon in soils, contributing to combating greenhouse gas effect."[161] The addition of compost to soil also improves soil health, which increases plant yield and decreases our dependence on synthetic fertilizers. One study found that organic matter content in a loam soil continued to increase even after 50 years of compost application; for sandy soils, organic matter levels reached equilibrium after about 25 years. This increase in soil organic carbon represents stored carbon that is not contributing to greenhouse gases in the atmosphere.[162] While that original molecule of carbon contained in the first compost application may not persist for 100 years, it will foster soil retention of many more molecules of carbon over that time frame.[163]

- *Displacing chemical fertilizers and other chemical plant/soil additives:* Compost can have similar benefits to soil properties as those provided by fertilizers, herbicides, some pesticides, lime, and gypsum. Its use in agricultural applications decreases the need to produce and apply these chemicals to the land, resulting in the avoidance of greenhouse gas emissions related to those activities. Synthetic fertilizers, for instance, are huge emitters of $N_2O$ emissions; in the U.S., these emissions represented 88.6 Tg $CO_2$ eq. or 1.2% of all greenhouse gas emissions in 2005.[164] As a recent report to the California Air Resources Board stated, "Greater agricultural use of compost has been proven to reduce the demand for irrigation and fertilizers and pesticides, while increasing crop yields. This is a cost-effective way to reduce agricultural GHG emissions while sustaining California's agricultural industry by returning organic nutrients to the soil."[165]

- *Energy savings from displaced chemical additives:* In addition to direct greenhouse gas avoidance, using compost instead of chemical fertilizers reduces energy consumption. Synthetic chemical fertilizers consume large amounts of energy; in fact, the energy used to manufacture fertilizer represents 28% of the energy used in U.S. agriculture.[166] For example, the production of ammonia and urea, a nitrogenous fertilizer containing carbon and nitrogen, is highly energy-intensive. As a result, these processes are also significant emitters of $CO_2$; in 2005 these processes added an additional 16.3 Tg $CO_2$ eq. to the atmosphere.[167] According to soil scientist Dr. Sally Brown of the University of Washington, "With nitrogen fertilizer production, atmospheric N is fixed and processed into commercial fertilizers using the Haber-Bosch process — an energy-intensive process that consumes a great deal of fossil fuel. In fact, producing the chemical equivalent of one unit of nitrogen requires 1.4 units of carbon. Expressed on the same basis as nitrogen and taking into account transportation costs, about 3 units of carbon are required to manufacture, transport and apply 1 unit of phosphorus as $P_2O_5$ fertilizer."[168] Another study estimated that a single application of 10 metric tons of dry compost per hectare, which has a potential displacing power of some 190 kg of nitrogen, might save 160 to 1,590 kWh of energy, not accounting for either the displacement of phosphorus and potassium or the $CO_2$ eq. related to other emissions such as $N_2O$.[169]

- *Improving soil properties and related plant growth:* Plants remove $CO_2$ from the atmosphere during photosynthesis. If plants are healthier, the amount of $CO_2$ removed increases. One study indicated that applying 10 tons of compost to each hectare of farmland raised soil fertility and increased crop yield 10-20%. These figures translate to an increased carbon fixation on the order of 2 tons $CO_2$/ton of dry compost.[170]

- *Rehabilitating marginal land and mitigating land degradation and erosion:* Compost applications increase soil organic matter, thereby reducing soil erosion, water logging, nutrient loss, surface crusting, siltation of waterways, and more. Mitigating these environmental problems by other methods requires the use of machinery. Avoiding these problems reduces the need for engineering work, infrastructure development and maintenance, and equipment use, and avoids their associated greenhouse gas emissions.[171]

- *Using compost as a peat substitute in horticulture:* The use of peat results in the mineralization of the carbon kept in peat bogs. Peatlands are estimated to contain between 329 and 528 billion metric tons of carbon (more than 160 to 260 times annual U.S. emissions). Much of this carbon can remain sequestered for near-geological timescales as long as these bogs are left undisturbed. Increased use of compost as a peat substitute will help conserve and preserve peat bogs.[172]

Better and more comprehensive data documenting these and other greenhouse gas benefits of composting are lacking. Models used to compare composting to other resource management strategies commonly fail to quantify these benefits. This should be a priority for investigation by the U.S. EPA and state agencies.

In addition to the benefits of reduced greenhouse gas emissions related to composting, applying compost to soils can improve the soils' ability to retain water, thereby cutting water use related to irrigation as well as storm water runoff (depending on where the compost is applied). For example, compost can reduce

Cedar Grove, a compost facility, in Everett, WA, demonstrates the benefits of compost in soil products.

the water used for growing corn by 10%.[173]

Compost has another important and related benefit as well, aside from its climate mitigation benefits. Adding carbon and organic matter to agricultural soils can improve and restore soil quality. Organic matter improves soil fertility, stability and structure, as well as the capacity of soils to retain moisture. The European Commission, as part of its strategy to protect soil, recently established a goal to promote the use of high-quality composted products for such purposes as fighting desertification and erosion, avoiding floods, and promoting the build-up of carbon in soil.[174]

The Commission has highlighted compost's unique ability to increase soil carbon levels: "Concerning measures for combating the decline in soil organic matter, not all types of organic matter have the potential to address this threat. Stable organic matter is present in compost and manure and, to a much lesser extent, in sewage sludge and animal slurry, and it is this stable fraction which contributes to the humus pool in the soil, thereby improving soil properties."[175]

In all of these ways, composting represents a win-win opportunity to protect soils and mitigate climate change, while providing a cost-effective discard management system. Composting systems also benefit from relatively short set-up-to-implementation time periods.

## The Benefits of Compost Are Many

- Composting reduces greenhouse gases by preventing methane generation in landfills, storing carbon in the compost product, reducing energy use for water pumping, substituting for energy-intensive chemical fertilizers and pesticides, improving the soil's ability to store carbon, and improving plant growth and thus carbon sequestration.
- Compost encourages the production of beneficial micro-organisms, which break down organic matter to create a rich nutrient-filled material called humus.
- Compost is a value-added product with many markets, including land reclamation, silviculture, horticulture, landscaping, and soil erosion control.
- Compost increases the nutrient content in soils.
- Compost helps soils retain moisture.
- Compost reduces the need for chemical fertilizers, pesticides, and fungicides.
- Compost suppresses plant diseases and pests.
- Compost promotes higher yields of agricultural crops.
- Compost helps regenerate poor soils.
- Compost has the ability to clean up (remediate) contaminated soil.
- Compost can help prevent pollution and manage erosion problems.
- Composting extends municipal landfill life by diverting organic materials from landfills.
- Composting sustains at least four times more jobs than landfill or incinerator disposal on a per-ton basis.
- Composting is a proven technology.
- Composting is far cheaper than waste incineration.

Source: Institute for Local Self-Reliance, June 2008.

Perhaps most importantly, though, composting can significantly reduce greenhouse gas emissions quickly and at a low cost. An Israeli study evaluated the investment cost required to abate 1 ton of $CO_2$ eq. from landfills. (See Table 12, in which calculations are based on a time horizon of 20 years.) The study concluded that constructing composting plants was the lowest-cost option for mitigating the greenhouse gas emissions from Israel's waste sector. According to the study's authors, "The composting option does not require high investments, produces a product that can be readily utilized by the agricultural sector, and seems to be an available interim solution to mitigate greenhouse gas emissions by most countries . . . The time needed for implementation is short and the effect is significant."[176]

Current programs and facilities can serve as the foundation for expanding collection beyond yard trimmings to other organic materials such as food discards and soiled paper. In the U.S., 8,659 communities have curbside recycling programs, and many of these include the collection of yard trimmings.[177] There are 3,474 compost facilities handling yard trimmings in the U.S.,[178] and in 2006, 62% of the 32.4 million tons of yard trimmings generated was composted.[179] In addition, more than 30 communities have already instituted programs for diverting source-separated organics that include food scraps. Half of these are in California; Washington, Minnesota, and Michigan also have programs,[180] and Canada has many more. Approximately 120 compost facilities in the U.S. accept food discards.[181] Although compost can be used in many ways and markets are growing,[182] regulatory, financing, and institutional hurdles still exist for siting and building additional composting facilities. New rules are needed to facilitate expanded infrastructure development.

**Table 12: Investment Cost Estimates for Greenhouse Gas Mitigation from Municipal Solid Waste**

| | Investment costs of reduction[1] (US$/ton $CO_2$ eq.) |
|---|---|
| Landfilling with landfill gas flare | 6 |
| Landfilling with energy recovery | 16 |
| Incineration | 67 |
| Aerobic composting | 3 |
| Anaerobic composting | 13 |

1. Calculated for a representative Israeli city producing 3,000 tons of MSW per day for 20 years; global warming potential of methane of 56 was used. Note: compostables comprise a higher portion of waste in Israel than in the U.S.

Source: Ofira Ayalon, Yoram Avnimelech (Technion, Israel Institute of Technology) and Mordechai Shechter (Department of Economics and Natural Resources & Environmental Research Center, University of Haifa, Israel), "Solid Waste Treatment as a High-Priority and Low-Cost Alternative for Greenhouse Gas Mitigation," *Environmental Management* Vol. 27, No. 5, 2001, p. 700.


Green bins filled with organics await collection for composting on a San Francisco street.

**"The composting option does not require high investments, produces a product that can be readily utilized by the agricultural sector, and seems to be an available interim solution to mitigate greenhouse gas emissions by most countries . . . The time needed for implementation is short and the effect is significant."**

Source: Ofira Ayalon, et al, "Solid Waste Treatment as a High-Priority and Low-Cost Alternative for Greenhouse Gas Mitigation," *Environmental Management* Vol. 27, No. 5, 2001, p. 701.


Organic materials collected for composting in Boulder.

## New Policies and Tools Are Needed

Wasting and resource extraction are so firmly entrenched in our economy and lifestyle that they receive unfair competitive advantage over conservation and waste minimization in myriad ways. The most critical of these is that wasting and resource extraction receive billions of dollars in taxpayer subsidies, which create perverse economic incentives that encourage the extraction and destruction of natural resources.[183] As a result of these subsidies, reuse businesses, recyclers, and composters can find it challenging to compete economically with disposal and extractive industries.

The amount of greenhouse gas emissions produced by the waste sector is driven upward by the numerous policy and regulatory strategies that encourage gas recovery from landfills and burning waste for its Btu value, as well as the policies that wrongly promote these disposal systems as renewable. In contrast, few national policies and fewer research and development dollars are invested in promoting waste minimization, reuse, recycling, composting, and extended producer responsibility. Only when policies and funding are redirected toward reducing waste rather than managing and disposing of it, will greenhouse gas emissions related to the waste sector begin to decline.

In addition, local and national policymakers tend to narrowly focus on continued landfilling and incineration as the only viable waste management options. For example, to address significant methane emissions from landfills, policy efforts and subsidies are centered on landfill gas capture systems. Because these systems may only capture about 20% of emitted methane and because methane is such a powerful greenhouse gas, these policies only serve to barely limit the damage, not fix the problem.[184] Yet there are no plans to tighten federal landfill gas emissions regulations. A cheaper, faster, and more-effective method for reducing landfill methane emissions is to <u>stop the disposal of organic materials</u>, particularly putrescibles such as food discards. There are currently no federal rules in place to keep organic materials out of landfills, and only 22 states ban yard trimmings from landfills.[185]

**Only when policies and funding are redirected toward reducing waste rather than managing and disposing of it, will greenhouse gas emissions related to the waste sector begin to decline.**

Other governments are acting, however. Nova Scotia banned organics from landfill disposal in 1995. The European Union has also taken a firm approach to reducing the amount of organics destined for landfills. Its Landfill Directive calls for reducing biodegradable waste disposed in landfills to 50% of 1995 levels by 2009 and 35% by 2016. (Biodegradable waste is defined as "any waste that is capable of undergoing aerobic or anaerobic decomposition, such as food and garden waste, and paper and paperboard.") The Directive also requires improvements in the environmental standards of landfills, in particular by requiring greater use of landfill gas collection and energy recovery systems for the methane emitted, in order to reduce the greenhouse gas impact of this waste management option.[186] For the EU-15, landfill methane emissions decreased by almost 30% between 1990 and 2002 due to their early implementation of the Directive. By 2010, waste-related greenhouse gas emissions in the EU are projected to be more than 50% below 1990 levels.[187] It is crucial that similar state and federal rules put into place in the U.S. also keep organic materials out of incinerators and direct these materials toward composting and anaerobic digestion facilities.

In the U.S., subsidies that qualify waste disposal as a renewable energy source, such as renewable portfolio standards, the alternative fuels mandate, and the renewable energy production tax credits, skew the economics to unfairly favor disposal over the conservation of resources. Qualifying waste incinerators of any kind for renewable power subsidies makes even less sense, as incinerators represent the most expensive and polluting solid waste management option available, and require huge amounts of waste in order to operate. Environment America, the Sierra Club, the Natural Resources Defense Council, Friends of the Earth, and 130 other organizations have endorsed a statement calling for no financial incentives to be built into legislation for incinerators. These groups concur that policies qualifying mass-burn, gasification, pyrolysis, plasma, refuse-derived fuel, and other incinerator technologies for renewable energy credits, tax credits, subsidies, and other incentives present a renewed threat to environmental and economic justice in U.S. communities.[188] Indeed, incineration is a direct obstacle to reducing waste, which is far from renewable or inevitable; rather, <u>waste is a clear sign of inefficiency.</u>

The purported benefits of waste disposal rest heavily on the idea that waste is inevitable. For example, when incinerators and landfills generate electricity, we are told that this electricity is displacing power that would otherwise need to be generated from coal-burning power plants. This argument overlooks the significant and avoidable lifecycle global warming impacts of our one-way flow of materials from manufacturer to user to landfill/incinerator. (More on this fallacy is discussed under the Myths section.) This one-way linear system is clearly unsustainable over the long term on a planet with a finite supply of both space and natural resources. We must realize waste is a sign of a systemic failure and adopt solutions to address the entire lifecycle impacts of our wasting in order to reach sustainable resource management.

A further challenge to implementing sustainable solutions and policies is the inability of our current models to fairly and accurately assess greenhouse gas emissions from waste management options. See the sidebar on the U.S. EPA's WAste Reduction Model (WARM) for a further discussion of this topic. Municipalities looking to reduce their overall climate footprint often base their actions on inventories that only take into account greenhouse gas emissions directly released within their geographical territory. Ignored are the myriad ways that local activities contribute to global greenhouse gas emissions. In the case of waste, these inventories only conservatively account for some of the emissions released directly from landfills and incinerators within the municipality; ignored are the lifecycle emissions that are incurred prior to the disposal of these materials. These are directly linked to greenhouse gases from industrial energy use, land use, and transportation. As a result, cities can underestimate the positive impacts of reducing waste and increasing recycling and composting on the climate, while hiding the negative impact that waste disposal has on the climate. New models are needed for municipalities to more accurately account for lifecycle greenhouse gas emissions that relate to municipal activities. This would lead to better-informed actions to reduce overall greenhouse gas emissions on a global scale.

Deep flaws in both current modes of thinking and analytical tools are driving policymakers to publicly finance disposal projects to the detriment of resource conservation, energy efficiency, and successful renewable energy strategies. When examining strategies to combat greenhouse gas emissions from waste, it is imperative that we look beyond waste disposal for answers.

**We must realize waste is a sign of a systemic failure and adopt solutions to address the entire lifecycle impacts of our wasting in order to reach sustainable resource management.**

Fortunately, within reach are more cost-effective and environmentally-friendly zero waste solutions. These include: substituting durable for single-use products, redesigning products, reducing product toxicity, setting up material exchanges, expanding recycling and composting programs, banning unsustainable products, purchasing environmentally preferable products, instituting per-volume or per-weight trash fees, developing recycling-based markets, building resource recovery parks and industrial composting facilities, hiring and training a national zero waste workforce, implementing policies and programs promoting extended producer responsibility, and establishing innovative collection systems. Rather than continuing to pour taxpayer money into expensive and harmful disposal projects or into exporting our discards to other countries, lawmakers should enact responsible and forward-thinking public policies that provide incentives to create and sustain locally-based reuse, recycling, and composting jobs.

The success of many of these strategies is well documented across the U.S.; San Francisco provides an excellent example. This city declared a 75% landfill diversion goal by the year 2010, and a zero waste goal by 2020. This diverse metropolis of 800,000 residents reported a 69% recycling/composting level in 2006.

## EPA WAste Reduction Model (WARM) — Room for Improvement

Ten years ago, the U.S. EPA released the first version of a tool to help solid waste managers weigh the greenhouse gas and energy impacts of waste management practices — its WAste Reduction Model, or WARM. Since then, EPA has improved and updated WARM numerous times. WARM focuses exclusively on the waste sector and allows users to calculate and compare greenhouse gas emissions for 26 categories of materials landfilled, incinerated, composted or recycled. The model takes into account upstream benefits of recycling, the carbon sequestration benefits from composting, and the energy grid offsets from combusting landfill gases and municipal solid waste materials. The methodology used to estimate emissions is largely consistent with international and domestic accounting guidelines. The latest version, Version 8, was released in 2006, but may already be outdated based on new information learned in recent years. As a result, the model now falls short of its goal to allow for an adequate comparison among available solid waste management options. Serious shortcomings that could be addressed in future releases include the following:

- **Incorrect assumptions related to the capture rate of landfill gas recovery systems** that are installed to control methane emissions. The model relies on instantaneous landfill gas collection efficiency rates of 75% and uses a 44% capture rate as the national average for all landfills. However, capture rates over the lifetime of a landfill may be as low as 20%.[1]

- **Lack of credit for the ability of compost to displace synthetic fertilizers, fungicides, and pesticides**, which collectively have an enormous greenhouse gas profile. Composting also has additional benefits that are not considered, such as its ability to increase soil water retention that could lead to reduced energy use related to irrigation practices, or its ability to increase plant growth, which leads to improved carbon sequestration. (Recognized as a shortcoming in EPA's 2006 report, *Solid Waste Management and Greenhouse Gases*.)

- **A failure to consider the full range of soil conservation and management practices** that could be used in combination with compost application and the impacts of those practices on carbon storage. (Recognized as a shortcoming in EPA's 2006 report, *Solid Waste Management and Greenhouse Gases*.)

- **Lack of data on materials in the waste stream that are noncompostable or recycled at a paltry level** such as polystyrene and polyvinyl chloride.

- **Inability to calculate the benefits of product or material reuse.**

- **No reporting of biogenic emissions from incinerators** as recommended by the Intergovernmental Panel on Climate Change guidelines: "if incineration of waste is used for energy purposes, both fossil and biogenic should be estimated… biogenic $CO_2$ should be reported as an information item…"[2] For incinerators, biogenic materials represent three-quarters of all waste combusted and 72% of all $CO_2$ being emitted.[3]

- **A failure to adequately take into account the timing of $CO_2$ emissions and sinks.** Incinerators, for instance, release $CO_2$ instantaneously, while composting may store carbon for decades. Paper reuse and recycling also store carbon for many years. It is not appropriate to neglect such delays in the release of $CO_2$ into the atmosphere.[4] The EPA acknowledges that its model treats the timing of these releases the same: "Note that this approach does not distinguish between the timing of $CO_2$ emissions, provided that they occur in a reasonably short time scale relative to the speed of the processes that affect global climate change. In other words, as long as the biogenic carbon would eventually be released as $CO_2$, whether it is released virtually instantaneously (e.g., from combustion) or over a period of a few decades (e.g., decomposition on the forest floor), it is treated the same."[5] We now know that the timing of such releases is especially critical given the 10-15 year climate tipping point agreed upon by leading global scientists.[6] The U.K. Atropos© model is one example of a new modeling approach for evaluating solid waste management options that includes all biogenic emissions of carbon dioxide and also accounts for the timing of these emissions.[7]

1 Bogner, J., et al, *Waste Management, In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA), p. 600.

2 Intergovernmental Panel on Climate Change 2006, "Chapter 5: Incineration and Open Burning of Waste," *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, p. 5.5.

3 Based on U.S. EPA, 2006 MSW Characterization Data Tables, "Table 3, Materials Discarded in the Municipal Waste Stream, 1960 to 2006," and "Table 29, Generation, Materials Recovery, Composting, Combustion, and Discards of Municipal Solid Waste, 1960 to 2006." The 72% biogenic emission figure is based on data reported on the U.S. EPA Clean Energy web page, "How Does Electricity Affect the Environment," http://www.epa.gov/cleanenergy/energy-and-you/affect/air-emissions.html, browsed March 13, 2008; and in Jeremy K. O'Brien, P.E., SWANA, "Comparison of Air Emissions from Waste-to-Energy Facilities to Fossil Fuel Power Plants" (undated), available online at: http://www.wte.org/environment, browsed March 13, 2008.

4 Ari Rabl, Anthony Benoist, Dominque Dron, Bruno Peuportier, Joseph V. Spadaro and Assad Zoughaib, Ecole des Minesm Paris, France, "Editorials: How to Account for $CO_2$ Emissions from Biomass in an LCA," *The International Journal of LifeCycle Assessment* 12 (5) 281 (2007), p. 281.

5 U.S. EPA, *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sinks*, EPA 530-R-06-004, September 2006, p. 13.

6 Climate Change Research Centre, 2007. "2007 Bali Climate Declaration by Scientists." Available online at http://www.climate.unsw.edu.au/bali/ on December 19, 2007.

7 Dominic Hogg et al, Eunomia, *Greenhouse Gas Balances of Waste Management Scenarios, Report to the Greater London Authority*, Bristol, United Kingdom, January 2008, pp. i-ii.

Key elements of its zero waste program include the following: providing green bins for mixed food discards and yard trimmings and blue bins for mixed recyclables; instituting volume-based trash fees; targeting both the commercial and residential sectors; enacting bans on polystyrene take-out containers, plastic bags, and the use of water bottles at publicly-sponsored events; and working in partnership with a waste hauler that is committed to the city's zero waste goal. This city's example provides a practical blueprint for reducing its negative impact on the global climate and environment that others can and should follow.

Twenty years ago, many solid waste professionals believed that communities could recycle and compost no more than 15 to 20% of their waste. Today, the national recycling/composting level is 32.5% and hundreds of cities and businesses have reached 50% and higher diversion levels. These "record-setters" are demonstrating that waste reduction levels much higher than the national average can be achieved. Indeed, at least two dozen U.S. communities have embraced zero waste planning or goals. The experience of and lessons learned from these early adopters can readily be adapted to other communities throughout the country. (See the list of communities on page 44.)

There are numerous strategies for moving toward a zero waste economy, such as shifting back to the use of refillable containers or using compostable plastics made from crops and plants.[189] The guiding principles of these strategies are to conserve resources, reduce consumption, minimize pollution and greenhouse gas emissions, transform the byproducts of one process into the feedstocks for another, maximize employment opportunities, and provide the greatest degree of local economic self-reliance.

If we are to mitigate climate change, the following priority policies need serious and immediate consideration:

1. Establish and implement national, statewide, and municipal zero waste targets and plans: Taking immediate action to establish zero waste targets and plans is one of the most important strategies that can be adopted to address climate change. Any zero waste target or plan must be accompanied by a shift in funding from supporting waste disposal to supporting zero waste jobs, infrastructure, and local strategies. Zero waste programs should be developed with the full democratic participation of individuals and communities that are most adversely impacted by climate change and waste pollution.

2. Retire existing incinerators and halt construction of new incinerators or landfills: The use of incinerators and investments in new disposal facilities — including mass-burn, pyrolysis, plasma, gasification, other incineration technologies, and landfill "bioreactors" — obstruct efforts to reduce waste and increase materials recovery. Eliminating investments in incineration and landfilling is an important step to free up taxpayer money for resource conservation, efficiency, and renewable energy solutions.

3. Levy a per-ton surcharge on landfilled and incinerated materials: Many European nations have adopted significant fees on landfills of $20 to $40 per ton that are used to fund recycling programs and decrease greenhouse gases. Surcharges on both landfills and incinerators are an important counterbalance to the negative environmental and human health costs of disposal that are borne by the public. Instead of pouring money into incinerator and landfill disposal, public money should be used to strengthen resource conservation, efficiency, reuse, recycling, and composting strategies. Public funding should support the infrastructure, jobs, and research needed for effective resource recovery and clean production. It should also support initiatives to reduce waste generation and implement extended producer responsibility.

San Francisco collection vehicle for organics.

Based on 2006 disposal levels, a $20 to $40 per ton surcharge would generate $3.4 billion to $6.8 billion in the U.S. to advance these initiatives.

4. Stop organic materials from being sent to landfills and incinerators: Local, state, and national incentives, penalties or bans are needed to prevent organic materials, particularly food discards and yard trimmings, from being sent to landfills and incinerators. All organic materials should instead be source-reduced, followed by source-segregation for reuse, composting, or anaerobic digestion in controlled facilities. If the landfilling of biodegradable materials were ceased, the problem of methane generation from waste would be largely eliminated. Because methane is so potent over the short term — 72 times more potent than $CO_2$ — eliminating landfill methane should be an immediate priority. The European community has made progress toward achieving this goal since 1999 when its Landfill Directive required the phase-out of landfilling organics.[190] Several countries — Germany, Austria, Denmark, the Netherlands, and Sweden — have accelerated the EU schedule through more stringent national bans on landfilling organic materials.[191] Furthermore, composting, the preferred alternative treatment method for these materials, has the added benefit of protecting and revitalizing soils and agricultural farmland. As such, compost represents a value-added product while landfilling and incinerators represent long-term liabilities.

5. End state and federal "renewable energy" subsidies to landfills and incinerators: Incentives such as the federal Renewable Energy Production Tax Credit and state Renewable Portfolio Standards should only benefit truly renewable energy and resource conservation strategies, such as energy efficiency and the use of wind, solar, and ocean power. Resource conservation should be incentivized as a key strategy for reducing energy use and greenhouse gas emissions. In addition, the billions of dollars in subsidies to extractive industries such as mining, logging, and drilling should be eliminated. Instead, subsidies should support industries that conserve and safely reuse materials.

6. Provide policy incentives that create and sustain locally-based reuse, recycling, and composting jobs: Rather than continue to pour taxpayer money into expensive and harmful disposal projects or export our discards to other countries, public policies should revitalize local economies by supporting environmentally just, community-based, and green jobs and businesses in materials recovery. This investment would result in the creation of more local jobs, since incinerators and landfills sustain only 1 job for every 10 positions at a recycling facility.[192]

7. Expand adoption of per-volume or per-weight fees for the collection of trash: Pay-as-you-throw fees have been proven to increase recycling levels and reduce the amount of waste disposed.

8. Make manufacturers and brand owners responsible for the products and packaging they produce: Manufactured products and packaging represent 72.5% of all municipal solid waste disposed. When manufacturers accept responsibility for recycling their products, they have been shown to use less toxic materials, consume fewer materials, design their products to last longer, create better recycling systems, be motivated to minimize waste costs, and no longer pass the cost of disposal to the government and the taxpayer.[193] Effective extended producer responsibility (EPR) programs include robust regulations, individual responsibility, government-mandated participation, reuse and recycling requirements, and financing elements. With its German Packaging Ordinance passed in 1990, Germany has one of the longest track records for a broad-based EPR program for packaging. This ordinance has increased the use of reusable packaging, reduced the use of composite and plastic packaging, facilitated significant design changes in packaging, fostered the development of new technologies for recycling packaging materials, and reduced the burden of waste management on municipalities.[194]

9. Regulate single-use plastic products and packaging that have low or non-existent recycling levels: Plastic is the fastest-growing part of the waste stream and is among the most expensive discarded materials to manage. Its recycling rate of 6.9% is the lowest of all major material commodities. In less than one generation, the use and disposal of single-use plastic packaging, which is largely unrecyclable (despite the deceptive use of recycling arrow emblems), has grown from 120,000 tons in 1960 to 12,720,000 tons per year today.[195] Many communities are considering or

have already passed policies to reverse this trend. State beverage container deposit laws are effective tools for recovering beverage bottles. These deposit laws should be expanded to other states and to cover all beverage drinks. More than two dozen jurisdictions have passed some form of ban on nonrecyclable foamed polystyrene takeout food containers as well.[196] In addition, San Francisco and New York City have banned the use of single-use water bottles for publicly sponsored events; other cities may follow suit.[197] San Francisco also recently banned single-use plastic shopping bags that are not compostable. In 2002, Ireland enacted the most effective policy to address single-use shopping bags, whether plastic or paper. Its steep per-bag fee, the equivalent of 33¢, reduced the consumption of single-use bags by 94% within a matter of weeks.[198] These sorts of policies have proven to be successful and can be replicated elsewhere.

10. Regulate paper packaging and junk mail and pass policies to significantly increase paper recycling: Of the 170 million tons of municipal solid waste disposed each year in the U.S., 24.3% is paper and paperboard. The largest contributors include paper plates and cups (1.18 million tons), telephone directories (550,000 tons), and junk mail (3.61 million tons).[199] An estimated 20 billion catalogs are mailed each year, but only 6 out of 42 catalog makers use any significant recycled content.[200] Reducing and recycling paper decrease releases of numerous air and water pollutants to the environment and conserve energy and forest resources. When paper mills increase their use of recovered paper fiber, they lower their requirements for pulpwood, which extends the fiber base and conserves forest resources. Moreover, the reduced demand for virgin paper fiber will generally reduce the overall intensity of forest management required to meet the current level of demand for paper. This helps to foster environmentally beneficial changes in forest management practices. For example, pressure may be reduced to convert natural forests and sensitive ecological areas such as wetlands into intensively managed pine plantations, and more trees may be managed on longer rotations to meet the demand for solid wood products rather than paper fiber.[201]

San Francisco's organics are composted at the Jepson Prairie Organics facility near Vacaville, CA

11. Decision makers and environmental leaders should reject climate protection agreements and strategies that embrace landfill or incinerator disposal: Rather than embrace agreements and blueprints like the U.S. Conference of Mayors Climate Protection Agreement that call for supporting "waste to energy" as a strategy to combat climate change, decision makers and environmental organizations should adopt climate blueprints that support zero waste. One example of an agreement that will move cities in the right direction for zero waste is the Urban Environmental Accords. Signed by 103 major in cities around the world, the accords call for achieving zero waste to landfills and incinerators by 2040 and reducing per capita solid waste disposal by 20% within seven years.[202]

12. Better assess the true climate implications of the wasting sector: Measuring greenhouse gases over the 20-year time horizon is essential to reveal the impact of methane on the short-term climate tipping point. The IPCC publishes global warming potential figures for methane and other greenhouse gases over the 20-year time frame. Also needed are updates to the U.S. EPA's WAste Reduction Model (WARM), a tool for assessing the greenhouse gases emitted by solid waste management options. WARM should be updated to better account for lifetime landfill gas capture rates, and to report carbon emissions from both fossil-based and biogenic materials. In addition, municipalities need better tools to accurately account for lifecycle greenhouse gas emissions that relate to all municipal activities, including those that impact emissions outside of a municipality's geographical territory. New models that accurately take into account the myriad ways that local activities contribute to lifecycle greenhouse gas emissions globally would allow municipalities to take better-informed actions to reduce overall greenhouse gas emissions.

Products that could be source reduced include junk mail.

## Conclusions

Key findings of this report:

**1. A zero waste approach is one of the fastest, cheapest, and most effective strategies we can use to protect the climate and environment.** By reducing waste generation 1% each year and diverting 90% of our waste from landfills and incinerators by the year 2030, we could dramatically reduce greenhouse gas emissions within the United States and elsewhere. Achieving this waste reduction would conservatively reduce U.S. greenhouse gas emissions by 406 megatons $CO_2$ eq. per year by 2030. This is the equivalent of taking 21% of the existing 417 coal-fired power plants off the grid.[203] A zero waste approach has comparable (and sometimes complementary) benefits to leading proposals to protect the climate, such as significantly improving vehicle fuel efficiency and hybridizing vehicles, expanding and enhancing carbon sinks (such as forests), or retrofitting lighting and improving electronic equipment. It also has greater potential for reducing greenhouse gas emissions than environmentally harmful strategies proposed such as the expansion of nuclear energy. (See Table 11 on page 52.) Indeed, a zero waste approach is essential to put us on the path to climate stability by 2050.

**2. Wasting directly impacts climate change because it is directly linked to resource extraction, transportation, processing, and manufacturing.** Since 1970, we have used up one-third of global natural resources.[204] Virgin raw materials industries are among the world's largest consumers of energy and are thus significant contributors to climate change because energy use is directly correlated with greenhouse gas emissions. Our linear system of extraction, processing, transportation, consumption, and disposal is intimately tied to core contributors of global climate change, such as industrial energy use, transportation, and deforestation. When we minimize waste, we reduce greenhouse gas emissions in these and other sectors, which together represent 36.7% of all U.S. greenhouse gas emissions.[205] It is this number that more accurately reflects the impact of the whole system of extraction to disposal on climate change. (See Figure 2 on page 24.)

**3. A zero waste approach is essential.** Through the Urban Environmental Accords, 103 city mayors worldwide have committed to sending zero waste to landfills and incinerators by the year 2040 or earlier.[206] More than two dozen U.S. communities and the state of California have also now embraced zero waste as a goal. These zero waste programs are based on (1) reducing consumption and discards, (2) reusing materials, (3) extended producer responsibility and other measures to ensure that products can be safely recycled into the economy and environment,* (4) comprehensive recycling, (5) comprehensive composting of clean segregated organics, and (6) effective policies, regulations, incentives, and financing structures to support these systems. The existing 8,659 curbside collection programs in the U.S. can serve as the foundation for expanded materials recovery.

**4. Existing waste incinerators should be retired, and no new incinerators or landfills should be constructed.** Incinerators are significant sources of $CO_2$ and also emit nitrous oxide ($N_2O$), a potent greenhouse gas that is approximately 300 times more effective than carbon dioxide at trapping heat in the atmosphere.[207] By destroying resources rather than conserving them, all incinerators — including mass-burn, pyrolysis, plasma, and gasification[208] — cause significant and unnecessary lifecycle greenhouse gas emissions. Pyrolysis, plasma, and gasification incinerators may have an even larger climate footprint than conventional mass-burn incinerators because they can require inputs of additional fossil fuels or electricity to operate. Incineration is also pollution-ridden and cost prohibitive, and is a direct obstacle to reducing waste and increasing recycling. Further, sources of industrial pollution such as incineration also disproportionately impact people of color and low-income and indigenous communities.[209]

* Extended producer responsibility requires firms that manufacture, import or sell products and packaging, to be financially or physically responsible for such products over the entire lifecycle of the product, including after its useful life.

**5. Landfills are the largest source of anthropogenic methane emissions in the U.S., and the impact of landfill emissions in the short term is grossly underestimated — methane is 72 times more potent than $CO_2$ over a 20-year time frame.** National data on landfill greenhouse gas emissions are based on international accounting protocols that use a 100-year time frame for calculating methane's global warming potential.* Because methane only stays in the atmosphere for around 12 years, its impacts are far greater in the short term. Over a 100-year time frame, methane is 25 times more potent than $CO_2$. However, methane is 72 times more potent than $CO_2$ over 20 years.[210] The Intergovernmental Panel on Climate Change assesses greenhouse gas emissions over three time frames — 20, 100, and 500 years. The choice of which time frame to use is a policy-based decision, not one based on science.[211] On a 20-year time frame, landfill methane emissions alone represent 5.2% of all U.S. greenhouse gas emissions. Figures 8 and 9 illustrate the difference in the impact of landfill methane emissions on the national inventory when a 20-year time horizon is used. With the urgent need to reduce greenhouse gas emissions, the correct new policy is to measure greenhouse gases over the 20-year time horizon. This policy change will reveal the significant greenhouse gas reduction potential available from keeping organics out of the landfill and preventing methane generation. Furthermore, landfill gas capture systems are not an effective strategy for preventing methane emissions to the atmosphere. The portion of methane captured over a landfill's lifetime may be as low as 20% of total methane emitted.[212]

**6. The practice of landfilling and incinerating biodegradable materials such as food scraps, paper products, and yard trimmings should be phased out immediately.** Non-recyclable organic materials should be segregated at the source and composted or anaerobically digested under controlled conditions.‡ Composting avoids significant methane emissions from landfills, increases carbon storage in soils and improves plant growth, which in turn expands carbon sequestration. Composting is thus vital to restoring the climate and our soils. In addition, compost is a value-added product, while landfills and incinerators are long-term environmental liabilities. Consequently, composting should be front and center in a national strategy to protect the climate.

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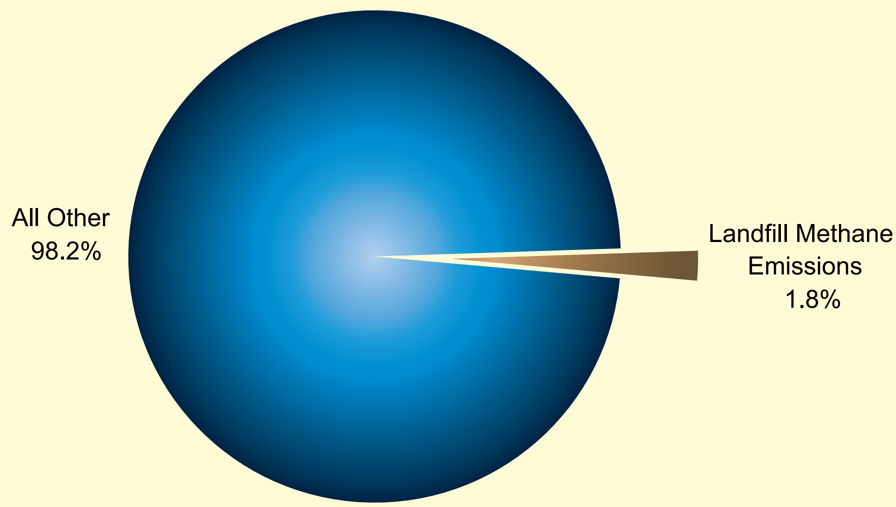
**7. Incinerators emit more $CO_2$ per megawatt-hour than coal-fired, natural-gas-fired, or oil-fired power plants. Incinerating materials such as wood, paper, yard debris, and food discards is far from "climate neutral"; rather, incinerating these and other materials is detrimental to the climate**. However, when comparing incineration with other energy options such as coal, natural gas, and oil power plants, the Solid Waste Association of North America (SWANA) and the Integrated Waste Services Association (an incinerator industry group), treat the incineration of "biomass" materials such as wood, paper, and food discards as "carbon neutral."

As a result, they ignore $CO_2$ emissions from these materials. This is inaccurate. Wood, paper, and agricultural materials are often produced from unsustainable forestry and land practices that are causing the amount of carbon stored in forests and soil to decrease over time. Incinerating these materials not only emits $CO_2$ in the process, but also destroys their potential for reuse as manufacturing and composting feedstocks. This ultimately leads to a net increase of $CO_2$ concentrations in the atmosphere and contributes to climate change. The bottom line is that tremendous opportunities for greenhouse gas reductions are lost when a material is incinerated. It is not appropriate to ignore the opportunities for $CO_2$ or other emissions to be avoided, sequestered or stored through non-combustion uses of a given material. More climate-friendly alternatives to incinerating materials include options such as waste avoidance, reuse, recycling, and composting.

* The Intergovernmental Panel on Climate Change (IPCC) developed the concept of global warming potential (GWP) as an index to help policymakers evaluate the impacts of greenhouse gases with different atmospheric lifetimes and infrared absorption properties, relative to the chosen baseline of carbon dioxide ($CO_2$).

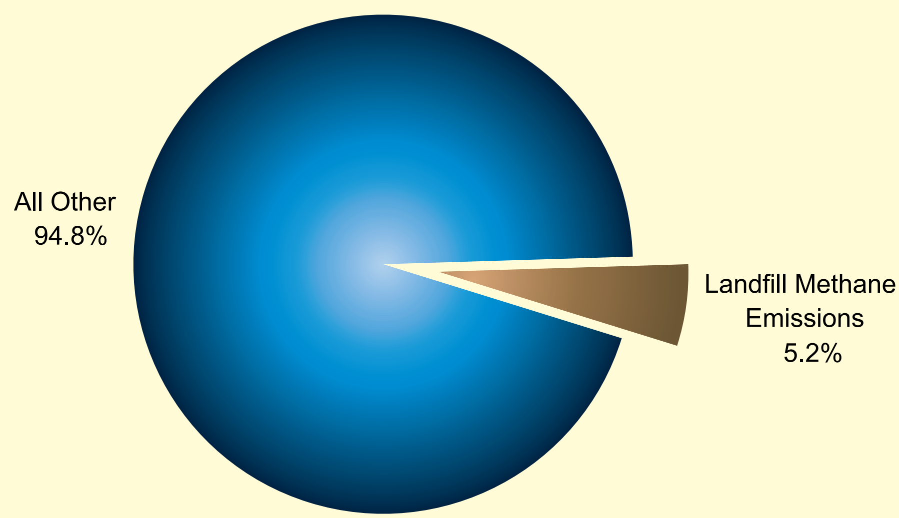
‡ Anaerobic digestion systems can complement composting. After energy extraction, nutrient rich materials from digesters make excellent compost feedstocks.

**Figure 8: 100-Year Time Frame, Landfill Methane Emissions (% of total U.S. emissions in 2005, $CO_2$ eq.)**




Source: Table 8-1: Emissions from Waste, *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2005*, U.S. EPA, Washington, DC, April 15, 2007, p. 8-1.

**Figure 9: 20-Year Time Frame, Landfill Methane Emissions (% of total U.S. emissions in 2005, $CO_2$ eq.)**




Source: Institute for Local Self-Reliance, June 2008. Based on converting U.S. EPA data on landfill methane emissions to a 20-year time frame.

Any climate model comparing the impact of energy generation or waste management options should take into account lifecycle emissions incurred (or not avoided) by not utilizing a material for its "highest and best" use. These emissions are the opportunity costs of incineration.

**8. Incinerators, landfill gas capture systems, and landfill "bioreactors" should not be subsidized under state and federal renewable energy and green power incentive programs or carbon trading schemes.** Far from benefiting the climate, subsidies to these systems reinforce a one-way flow of resources on a finite planet and make the task of conserving resources more difficult, not easier. Incineration technologies include mass-burn, pyrolysis, plasma, gasification, and other systems that generate electricity or fuels. All of these technologies contribute to, not protect against, climate change. Environment America, the Sierra Club, the Natural Resources Defense Council, Friends of the Earth, and 130 other organizations recognize the inappropriateness of public subsidization of these technologies and have signed onto a statement calling for no incentives for incinerators.[213] Incinerators are not the only problem though; planned landfill "bioreactors," which are being promoted to speed up methane generation, are likely to simply result in increased methane emissions in the short term and to directly compete with more effective climate protection systems such as composting and anaerobic digestion technologies. Preventing potent methane emissions altogether should be prioritized over strategies that offer only limited emissions mitigation. Indeed, all landfill operators should be ***required*** to collect landfill gases; they should not be subsidized to do this. In addition, subsidies to extractive industries such as mining, logging, and drilling should be eliminated. These subsidies encourage wasting and economically disadvantage resource conservation and reuse industries.

**9. New policies are needed to fund and expand climate change mitigation strategies such as waste reduction, reuse, recycling, composting, and extended producer responsibility. Policy incentives are also needed to create locally-based materials recovery jobs and industries.** Programs should be developed with the democratic participation of those individuals and communities most adversely impacted by climate change and waste pollution. Regulatory, permitting, financing, market development, and economic incentive policies (such as landfill, incinerator, and waste hauling surcharges) should be implemented to divert biodegradable organic materials from disposal. Policy mechanisms are also needed to ensure that products are built to last, constructed so that they can be readily repaired, and are safe and cost-effective to recycle back into the economy and environment. Taxpayer money should be redirected from supporting costly and polluting disposal technologies to funding zero waste strategies.

**10. Improved tools are needed to assess the true climate implications of the wasting sector.** With the urgent need to reduce greenhouse gas emissions, the correct new policy is to measure greenhouse gases over the 20-year time horizon. This policy change will reveal the significant greenhouse gas reduction potential available from preventing methane generation by keeping organics out of landfills. The U.S. EPA's WAste Reduction Model (WARM), a tool for assessing greenhouse gas emissions from solid waste management options, should be revised to more accurately account for the following: lifetime landfill gas capture rates; avoided synthetic fertilizer, pesticide, and fungicide impacts from compost use; reduced water irrigation energy needs from compost application; the benefits of product and material reuse; increased plant growth from compost use; and the timing of emissions and sinks. (For more detail, see the discussion of WARM, page 61.) New models are also needed to accurately take into account the myriad ways that the lifecycle impact of local activities contributes to global greenhouse gas emissions. This would lead to better-informed municipal actions to reduce overall greenhouse gas emissions. In addition, lifecycle models are needed to accurately compare the climate impact of different energy generation options. Models that compare incineration with other electricity generation options should be developed to account for lifecycle greenhouse gas emissions incurred (or not avoided) by not utilizing a material for its "highest and best" use.

Rapid action to reduce greenhouse gas emissions, with immediate attention to those gases that pose a more potent risk over the short term, is nothing short of essential. Methane is one of only a few gases with a powerful short-term impact, and methane and carbon dioxide emissions from landfills and incinerators are at the top of a short list of sources of greenhouse gas emissions that may be quickly and cost-effectively reduced or avoided altogether.

Today we need a paradigm shift in how we approach waste. We need to redesign products and packaging to minimize and more efficiently utilize materials. We need to begin using the least amount of packaging and materials to deliver a product or service. We need to significantly decrease the volume of resources that we consume and dispose in landfills and incinerators. We need to develop just and sustainable solutions with the democratic participation of individuals and communities most adversely impacted by climate change and waste pollution. In sum, we need to aim for a zero-waste economy. Now is the time to integrate the best features of the best programs, technologies, policies, and other practices that are currently in place around the country and around the world. It is time to remove antiquated incentives for wasting, such as government subsidies, untaxed and under-regulated pollution, and the system in which producers lack cradle-to-grave responsibility for their products and packaging. We need fundamental economic reforms that make products' prices reflect their true long-term costs, including production and end-of-life recovery, so that waste prevention, reuse, recycling, and composting can out-compete wasting every time.

*Stop Trashing the Climate* clearly establishes that in the face of climate change, waste disposal is neither inevitable nor sustainable. The playing field must be leveled to increase resource conservation, efficiency and sustainability. By adopting a zero waste approach to manage our resources, we would not only better protect the planet's climate — we would also double or triple the life of existing landfills, eliminate the need to build new incinerators and landfills, create jobs, build healthier and more equitable communities, restore the country's topsoil, conserve valuable resources, and reduce our reliance on imported goods and fuels. **The time to act is now.**

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## ENDNOTES:

1 Chris Hails et al., *Living Planet Report 2006* (Gland, Switzerland: World Wildlife Fund International, 2006), available online at http://assets.panda.org/downloads/living_planet_report.pdf; Energy Information Administration, *Emission of Greenhouse Gases in the United States 2006* (Washington, DC, November 2007), available online at http://www.eia.doe.gov/oiaf/1605/ggrpt/index.html; U.S. Census Bureau International Data Base, available online at http://www.census.gov/ipc/www/idb/; and John L. Seitz: *Global Issues: An Introduction*, (2001). "The U.S. produced approximately 33% of the world's waste with 4.6% of the world's population" (Miller 1998) quoted in Global Environmental Issues by Francis Harris (2004).

2 Jon Creyts, Anton Derkach, Scott Nyquist, Ken Ostrowski, Jack Stephenson, *Reducing U.S. Greenhouse Gas Emissions: How Much and at What Cost? U.S. Greenhouse Gas Abatement Mapping Initiative, Executive Report* (McKinsey & Company, December 2007). Available online at: http://www.mckinsey.com/clientservice/ccsi/greenhousegas.asp.

3 Dr. Rajendra Pachauri, Chair of the Intergovernmental Panel on Climate Change, quoted in "UN Climate Change Impact Report: Poor Will Suffer Most," *Environmental News Service*, April 6, 2007 (available online at: http://www.ens-newswire.com/ens/apr2007/2007-04-06-01.asp); Office of the Attorney General, State of California, "Global Warming's Unequal Impact" (available online at http://ag.ca.gov/globalwarming/unequal.php#notes_1); and *African Americans and Climate Change: An Unequal Burden*, July 1, 2004, Congressional Black Caucus Foundation and Redefining Progress, p. 2 (available online at www.rprogress.org/publications/2004/CBCF_REPORT_F.pdf).

4 The Urban Environmental Accords were drafted as part of the United Nations World Environment Day in 2005.

5 Each coal-fired power plant emits 4.644 megatons $CO_2$ equivalent. In 2005, there were 417 coal-fired power plants in the U.S. See U.S. EPA's web page on Climate Change at http://www.epa.gov/cleanenergy/energy-resources/refs.html#coalplant. Removing 87 plants from the grid in 2030, represents 21% of the coal-fired plants operating in 2005.

6 Scientific experts are now in general agreement that developed nations such as the U.S. need to reduce greenhouse gas emissions 80% below 1990 levels by 2050 in order to stabilize atmospheric greenhouse gas concentrations between 450 and 550 ppm of $CO_2$ eq. See for instance, Susan Joy Hassol, "Questions and Answers Emissions Reductions Needed to Stabilize Climate," for the Presidential Climate Action Project (2007). Available online at climatecommunication.org/PDFs/HassolPCAP.pdf.

7 In order to reduce the 1990 U.S. greenhouse gas emissions by 80% by 2050, greenhouse gas levels in 2030 should decrease to 3.9 gigatons $CO_2$ eq., which is approximately 37% of the 1990 level. This is based on a straight linear calculation. Emissions in 2005 were 7.2 gigatons $CO_2$ eq. Emissions in 2050 would need to drop to 1.24 gigatons $CO_2$ eq. to reflect an 80% reduction of the 1990 level of 6.2 gigatons. Between 2005 and 2050, this represents an annual reduction of 132.44 megatons $CO_2$ eq., resulting in a 3.9 gigaton $CO_2$ eq. emission level for 2030. U.S. greenhouse gas emissions are on a trajectory to increase to 9.7 gigatons $CO_2$ eq. by 2030. See Jon Creyts et al, *Reducing U.S. Greenhouse Gas Emissions: How Much and at What Cost?* p. 9. This means that annual greenhouse gas emissions by 2030 need to be reduced by 5.8 gigatons $CO_2$ eq. to put the U.S. on the path to help stabilize atmospheric greenhouse gas concentrations. A zero waste approach could achieve an estimated 406 megatons $CO_2$ eq., or 7% of the annual abatement needed in 2030.

8 It is important to note that emissions cuts by developed nations such as the U.S. may have to be even greater than the target of 80% below 1990 levels by 2050. Achieving this target may leave us vulnerable to a 17-36% chance of exceeding a 2°C increase in average global temperatures. See Paul Baer, et. al, *The Right to Development in a Climate Constrained World*, p. 20 (2007). In addition, there is ample evidence that climate change is already negatively impacting the lives of many individuals and communities throughout the world. To prevent climate-related disasters, the U.S. should and must take immediate and comprehensive action relative to its full contribution to climate change. As Al Gore has pointed out, countries (including the U.S.), will have to meet different requirements based on their historical share or contribution to the climate problem and their relative ability to carry the burden of change. He concludes that there is no other way. See Al Gore, "Moving Beyond Kyoto," *The New York Times* (July 1, 2007). Available online at http://www.nytimes.com/2007/07/01/opinion/01gore.html?pagewanted=all

9 Jon Creyts et al, *Reducing U.S. Greenhouse Gas Emissions: How Much and at What Cost?*, pp. xvii, 60-62, 71.

10 U.S. EPA, 2006 MSW Characterization Data Tables, "Table 29, Generation, Materials Recovery, Composting, Combustion, and Discards of Municipal Solid Waste, 1960 to 2006," Franklin Associates, A Division of ERG. Available online at: http://www.epa.gov/garbage/msw99.htm.

11 Gary Liss, Gary Liss & Associations, personal communication, March 2008; and Robert Haley, Zero Waste Manager, City and County of San Francisco, Department of the Environment, personal communication, May 1, 2008.

12 In 1960, for example, single-use plastic packaging was 0.14% of the waste stream (120,000 tons). In less than one generation, it has grown to 5.7% and 14.2 million tons per year. See U.S. EPA, 2006 MSW Characterization Data Tables, "Table 18, Products Generated in the Municipal Solid Waste Stream, 1960 to 2006 (with Detail on Containers and Packaging)."

13 Brenda Platt and Neil Seldman, Institute for Local Self-Reliance, *Wasting and Recycling in the U.S. 2000*, GrassRoots Recycling Network, 2000, p. 13. Based on data reported in Office of Technology Assessment, *Managing Industrial Solid Wastes from manufacturing, mining, oil, and gas production, and utility coal combustion* (OTA-BP-O-82), February 1992, pp. 7, 10.

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16 Each coal-fired power plant emits 4.644 megatons $CO_2$ equivalent. In 2005, there were 417 coal-fired power plants in the US. See U.S. EPA's web page on Climate Change at http://www.epa.gov/cleanenergy/energy-resources/refs.html#coalplant. Removing 87 plants from the grid in 2030, represents 21% of the coal-fired plants operating in 2005.

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20 On a 20-year time horizon, $N_2O$ has a 289 global warming potential. On a 100-year time horizon, its global warming potential is 310.

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