



Recycling, Composting and Greenhouse Gas Reductions in Minnesota

1. Introduction: What is Waste?

In 2006 in Minnesota, 3.6 million tons of municipal solid waste (the trash we generate every day) were buried in landfills or burned in incinerators, while 2.5 million tons of our discards were captured for recycling. That means Minnesota has achieved a 41% recycling rate, an impressive rate that is matched by only a handful of states and just 20 years ago was thought impossible. Our recycling efforts prevent nearly half of the products and packaging we use from being wasted. However, most of what is still being wasted every day in Minnesota can be recycled and composted with just a little improvement to our current systems.

Over 50% of what we still throw in the garbage can be recycled through curbside and other types of collection. An additional 25% of our trash is comprised of food wastes and other materials that could be composted. A typical household in the Twin Cities area throws away over 10 pounds of household compostable material every week. The little bit of garbage that remains after we recycle and compost can be thoughtfully addressed through a zero-waste approach (which includes extended producer responsibility) to prevent waste altogether. In other words, there really is no waste.

Waste, and our choice to reduce waste, has a significant impact on the environment. The U.S. Environmental Protection Agency (EPA) reports that the greenhouse gas emissions emitted directly from our waste being burned in an incinerator or buried in a landfill account for about 3% of the total greenhouse gas emitted in the U.S. each year. (2005 report) (Platt et al., 2008. pg 24). While 3% alone is a significant number, the impact of trashing these materials instead of recycling or composting them is actually much greater. *Citation for Image – (Coordinating Board (SWMCB). 2000).*

When you take into account the full lifecycle of the products we use every day and the increased energy needed to make replacement products from virgin, raw materials, the



actual impact of all this waste grows significantly. Accounting for the connections between waste in many sectors, including mining, deforestation, industrial agriculture, manufacturing, transportation, and electricity, our wasting actually represents 36.7% of all U.S. greenhouse gas emissions (Platt et al., 2008. pg 24).

Recycling, composting, and producer responsibility are powerful tools to reduce waste and therefore, our greenhouse gas emissions. Specifically in Minnesota, reducing our waste has a greenhouse gas reduction impact equivalent to shutting down 20% of our state's coal power plants, or reducing every car usage in the state by two-thirds, or using 75% less electricity in our own homes. Through a zero-waste approach across our whole country, we could achieve reductions in greenhouse gas emissions equivalent to closing 21% of all U.S. coal-fired power plants (Platt et al., 2008. pg 50).

2. Climate Change Impacts of Waste



Waste in incinerators and landfills create greenhouse gas emissions.

When trash is burned, incinerators emit carbon dioxide (CO_2) and nitrous oxide (N_2O), a greenhouse gas 310 times more powerful in atmospheric warming than carbon dioxide. On average in the U.S., incinerators emit more carbon dioxide per megawatt-hour than coal-fired, natural-gas fired, or oil-fired power plants (Hartwell, 2007).

Many people believe that throwing food scraps and paper products into a landfill is harmless because they biodegrade. However, most people are surprised to learn that when these materials break down in a landfill, they become powerful contributors to greenhouse gas emissions. Compostable materials such as food waste and

paper decompose anaerobically (without oxygen) in a landfill, producing methane (CH_4) which has 23-71 times greater heat trapping capabilities than carbon dioxide. Landfills are the single largest direct human source of methane (Platt et al., 2008. pg 7).

Creating energy from waste

Methane from landfills and the BTUs generated from incinerators are sometimes captured and converted into energy. However, energy from waste is inefficient and does not eliminate the pollution created by landfills and incinerators, including the emissions of greenhouse gases. Even when a landfill is capturing some methane gas for energy production, many studies have shown that most of the methane gas is released before landfills even begin to capture it. This fact results in landfill capture rates being overstated, in some models dramatically (Anderson, 2006).

Calculating Methane Recovery from Landfills

For landfills capturing methane for energy, the EPA assumes a 75% methane instantaneous capture rate for the year in which the calculation is made. The conversion of methane's impact to carbon's impact (calculated by the EPA to be 21 times the impact of carbon) is based on a 100 year time frame (U.S. EPA Warm Model, November 2008) For our calculations, we reluctantly used the WARM model's default landfill capture rates based on the proportions of landfills with landfill gas control in 2004, because they are widely accepted. Using this national average, the result is a 44% capture rate as a national average based on EPA calculations.

However, several people have pointed out significant problems with these calculations. First, the landfill gas capture rate should be calculated over a period of time, not an instantaneous rate. Over a realistic time frame based on the life of a landfill, the methane captured may be as low as 20%, not the 75% as stated in the assumptions used by WARM (U.S. EPA, 2008) (Anderson, 2006). This means that more methane gas is released from landfills, which are already the largest source of methane from humans even by



conservative calculations, than is reported in WARM. Secondly, there is an urgency to reduce our greenhouse gas emissions that is not reflected in the EPA's choice to use a 100-year time frame. Over a 20-year time frame, methane is 71 times as potent as carbon as a green house gas, not 21 times as stated in WARM assumptions.

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 CO₂. However, methane is 72 times more potent than CO₂ over 20 years. The Intergovernmental Panel on Climate Change assesses greenhouse gas emission 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 (Platt et al., 2008. pg 7).

Calculating methane emissions over 20-years instead of 100-years

There is a general consensus among scientists that if we do not reduce the amount of carbon dioxide in our atmosphere to below 350 parts per million by 2012, we may never be able to reverse the impacts of global warming (350.org, About Us/Science Page). In other words, there is an urgency of action required to fight the effects of global warming. A 20-year time frame for measuring the impact of methane illustrates the short-term effect of methane on the environment, which, when acknowledged highlights the urgent need—and the potential—to reduce methane emission.

Dr. Ed J. Dlugokencky, a global methane expert at the NOAA Earth System Research Laboratory, emphasizes the benefits of reducing emissions.

Added benefits of reducing methane emission 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 (Platt et al., 2008. pg7).

Regardless of how much methane is captured from a landfill or how many BTUs are generated from an incinerator, waste does not generate nearly as much energy as recycling conserves. Overall, recycling produces a net reduction in energy 3.6 times larger than the amount of energy generated by incineration and 11 times larger than the energy generated by methane recovery at a landfill (Choate, 2005). You simply cannot capture enough energy from landfills or incinerators to offset the energy required to make new products from natural resources to replace those we waste.

3. A Better Choice: Climate Change Benefits of Recycling & Composting

Recycling is an effective way to reduce greenhouse gases.

When we recycle, we avoid the greenhouse gas emissions from landfills and incinerators. We also reduce the need to extract new resources from the earth and replace logging, drilling, and mining of virgin materials with recycled materials that we no longer want. This greatly reduces the energy it takes to process and manufacture new goods.



About 94% of the materials extracted for use in manufacturing durable products become waste before the product is manufactured...80% of what we make is thrown away within six months of production. For every rubbish bag placed at the curb, the equivalent of 71 rubbish bags worth of waste is created in mining, logging, agriculture, oil and gas exploration, and the industrial processes used to convert raw materials into finished products and packaging. This doesn't even include the extra energy usage and climate change impacts resulting from resource extraction and processing (Hawken, A. Lovins, L.H. Lovins, 1999).



Every product we use has embedded energy, which is the energy it took to extract, transport, and transform the materials needed to produce the product. Every single item we recycle results in significant energy savings because recycling takes advantage of this embedded energy. For some items, like an aluminum can, the energy savings are tremendous. Making a new aluminum can from old cans results in 90-97% energy savings compared to making a new can from bauxite and other raw materials, according to (Choate, 2005). Similarly, it takes 30% less energy to make a glass bottle from recycled glass than from silica, sand, soda ash, limestone, and feldspar. Recycling paper results in a 44% energy savings (Choate, 2005). Virtually every recycled material uses less energy than its virgin component.

Composting is an effective way to reduce greenhouse gases.

A compost process is either aerobic or anaerobic. Anaerobic composting is when organic materials—or compostables—break down by bacteria without the presence of oxygen. This process, which happens in landfills, produces methane, carbon dioxide, and trace amounts of other gases. Aerobic composting is when organic material breaks down by bacteria in the presence of oxygen. The end byproducts in aerobic composting are mainly carbon dioxide and water, and nutrient-packed soil of finished compost. By composting these materials, the generation of greenhouse gases, particularly methane, is avoided. Backyard composting and well-run industrial compost operations will produce negligible greenhouse gas emissions (mostly from the operation of tractors and other equipment).

Composting also has “upstream” benefits, which further conserve our resources and reduce greenhouse gas emissions.

When this compost is used on fields it displaces synthetic chemical fertilizers. Fertilizer production requires intensive fossil fuel energy and seriously impacts human and environmental health (Pimental, et al., 2005). By using compost:

- The greenhouse gas emissions related to fertilizer production are avoided
- There is significant reduction in the use of pesticides (avoiding emissions associated with their production)
- Improves health and workability of soils, resulting in less fuel consumption to till the soil
- Helps soils hold or sequester carbon dioxide



In addition to these emission reductions, compost replenishes and revitalizes exhausted farm soils by replacing trace minerals and organic material, reduces soil erosion and helps prevent storm water runoff.

In fact, a single 40-pound bag of fertilizer contains the equivalent of 2.5 gallons of gasoline. In addition to their oil base, synthetic fertilizers are spiked with concentrated forms of nitrogen and phosphorus, which are harder for plants to absorb than their naturally occurring counterparts. The excess phosphorus and nitrogen, not absorbed by plants, runs off into storm drains that feed into rivers and streams, contributing to algae blooms that deprive waterways of oxygen and kill off aquatic life (National Geographic Society, 2008).

What about the environmental costs to collect and process recycling and composting?



Recycling and composting do require transportation and processing. The environmental costs from trucks and equipment to process the materials are real; however they are small compared to the energy savings and environmental benefits from recycling and composting materials. For instance,

in Saint Paul, the greenhouse gas reductions achieved from recycling are over 100 times greater than the greenhouse gas emission caused by collection. Managing trash has similar transportation and processing requirements; however, trash provides little benefit and wastes the embedded energy in materials, contributes to greenhouse gas emissions, and pollutes the environment.

4. Measuring our impact in Minnesota

To quantify our climate impact from wasting in Minnesota, we need to have an in-depth understanding of what we currently discard and what we do with those discards. Using two studies, outlined below, we are able to compile an accurate picture of Minnesota’s total waste stream. Dividing the total waste stream by our population, we can understand our individual impact.

What do Minnesotans Currently Waste and Recycle?

Since 1990, the State of Minnesota has produced a *SCORE Report*, an annual report on recycling and waste management programs in Minnesota. The report is currently compiled by the Minnesota Pollution Control Agency (MPCA):

SCORE is an annual examination of Minnesota programs and data. The figures are gathered through a formal survey of county solid waste officers. Analysis and evaluation of this data helps the MPCA report on:

- ★ Statewide recycling rates.
- ★ Waste reduction efforts.
- ★ Waste generation figures.
- ★ Waste processing and disposal.
- ★ SCORE finance and administration (MPCA, 2008).

Table 1 shows the total amount of reported municipal solid waste (MSW) for the year 2006 (most recent available data) and the amount of reported recycling. Currently, Minnesota reports about a 41% diversion rate. MSW estimates how much waste residents generate throughout their daily routines. It includes waste generated in their homes as well as waste generated at work places and commercial locations, such as restaurants, retail stores, and other businesses. It does not include industrial, hazardous, or construction waste.

Table 1: Municipal Solid Waste (SCORE Reports 2006)		
	Tons	% of MSW
Disposal		
Total Incinerated	1,200,000	19.7%
Total Landfilled	2,200,000	36.1%
Other (onsite disposal, etc.)	200,000	3.3%
Total Disposed	3,600,000	59%
Total Recycled	2,500,000	41%
Total MSW	6,100,000	

Using US Census data, Table 2 shows us our individual impact.

Table 2: Per Capita Calculations of Waste (US Census 2006 and SCORE 2006)	
Population for Minnesota	5,200,000 people
Total amount of discards recycled or disposed of annually	6,100,000 tons
Discard generation/person/year	2346.15 pounds
Discards/person/day	6.43 pounds

Table 3 shows a further breakdown of recycling by type, as reported in the SCORE data. Eureka Recycling created six main diversion categories (described in the Calculating Diversion section) which are used in to calculate the state-wide potential for recycling and composting (in Table 5).

Table 3: Recycling by Type (2006 SCORE)	% of Total	Tons	Diversion Category
Banned			
Antifreeze	0.06%	1,406	avoided
Electronics	0.41%	10,386	computers
Fluorescent & HID lamps	0.02%	510	avoided
HHW	0.03%	812	avoided
Latex paint	0.08%	2,011	avoided
Major appliances	1.59%	40,193	scrap metal
Used oil	0.40%	10,125	avoided
Used oil filters	0.11%	2,688	avoided
Vehicle batteries	1.34%	33,792	avoided
Waste tires	0.74%	18,646	tires
Glass			
Food & beverage	3.16%	79,772	glass
Other glass	1.68%	42,502	avoided
Metal			
Aluminum	1.33%	33,564	aluminum
Co-mingled alum/steel/tin			
<i>Estimated aluminum</i>	0.58%	14,968	aluminum
<i>Estimated tin/steel</i>	1.00%	25,659	tin
Other ferrous & non-ferrous	14.50%	365,977	scrap metal
Steel/tin cans	0.98%	24,778	tin
Organic			
Food to livestock	6.62%	166,966	compost food
Food to people	0.18%	4,427	compost food
Source-separated organics	0.30%	7,650	compost food
Other			
Mattresses & box springs	0.01%	267	wood
	0.01%	267	scrap metal
Pallets	4.11%	103,837	wood
Unspecified or Other	21.22%	535,626	avoided
Paper			
Computer paper	0.06%	1,600	mix
Corrugated	14.32%	361,375	cardboard
Magazine/catalog	1.44%	36,375	news
Mixed paper	10.03%	253,186	mix
Newsprint	7.08%	178,625	news
Office paper	2.83%	71,399	mix
Other paper	1.13%	28,480	mix
Phone book	0.06%	1,462	mix

Plastic			
Film plastic	0.17%	4,227	ldpe
HDPE	0.13%	3,311	hdpe
Mixed plastic	1.37%		
<i>Estimated HDPE</i>	<i>43.48%</i>	15067	hdpe
<i>Estimated PET</i>	<i>56.52%</i>	19586	pet
Other plastic	0.07%	1,688	other plastic
PET	0.14%	3,605	pet
Polystyrene	0.01%	361	avoided
Textiles			
Carpet	0.01%	216	carpet
Textiles	0.64%	16,244	textiles
Minnesota Total	100%	2,523,636	

What is in our waste?

The 2006 SCORE data shows that after recycling, there are still 3,600,000 tons of discards being disposed of annually. To understand what is in this waste, we can look to a study by the State of Minnesota in 2000 on the composition of our waste.

The Statewide MSW Composition Study (March 2000) is a detailed examination of what Minnesotans throw away as garbage. By sorting waste samples at eight locations around the state, the study offers a comprehensive look at the materials that are going to landfills, MSW composting operations, and incinerators. The study has also worked to differentiate between waste from residential and commercial/industrial sources (Solid Waste Management Coordinating Board, 2000).

Table 4 shows the percentage results from the 2000 composition study applied to the 2006 SCORE numbers to estimate what is being disposed off in detail by material. These discards are currently either buried in landfills or incinerated. To determine how much can be diverted from the trash, we applied the composition study numbers to the most current trash weights from 2006. Again, Eureka Recycling created six main diversion categories (described in the Calculating Diversion section) which are used in to calculate the state-wide potential for recycling and composting (in Table 5).

Table 4: Composition of Minnesota's MSW (MPCA 2000)		% Composition	Tons Disposed 2006	Diversion Category
Recyclable PAPER				
	news (ONP)	4.10%	147600	news
	high grade office	3.10%	111600	mix
	mag/cat	2.50%	90000	news
	OCC recyclable	6.20%	223200	cardboard
	coated OCC	0.20%	7200	cardboard
	boxboard	2.50%	90000	cardboard
	mix paper recyclable	6.00%	216000	news
Compostable Paper				
	OCC nonrecyclable	0.50%	18000	compost paper
	mix paper nonrecyclable	9.20%	331200	compost paper
PLASTICS				
	PET Bottles	0.60%	21600	pet
	Other PET	0.10%	3600	pet
	HDPE Nat	0.30%	10800	hdpe
	HDPE col	0.20%	7200	hdpe

	PVC	0.10%	3600	trash
	Ploystyrene	0.80%	28800	trash
	Film-transport packaging	0.30%	10800	ldpe
	other film	3.50%	126000	ldpe
	other containers	0.50%	18000	other plastics
	other non-containers	4.90%	176400	trash
METALS				
	aluminum cans	0.70%	25200	aluminum
	other aluminum	0.50%	18000	aluminum
	ferrous containers	0.90%	32400	tin
	other ferrous	2.90%	104400	tin
	other non-ferous	0.10%	3600	scrap metal
GLASS				
	Clear Containers	1.30%	46800	glass
	Green Containers	0.30%	10800	glass
	Brown Containers	0.40%	14400	glass
	Other Glass	0.70%	25200	avoided
ORGANIC MATERIALS				
	Yard Waste- grass/leaves	2.10%	75600	compost yard
	yard waste	0.20%	7200	compost yard
	food waste	12.40%	446400	compost food
	wood pallets	2.60%	93600	wood
	treated wood	3.00%	108000	avoided
	untreated wood	1.90%	68400	wood
	daipers	2.10%	75600	trash
	other organic material	1.40%	50400	compost food
PROBLEM MATERIAL				
	computer equipment/perihperals	0.20%	7200	computers
	electric and electronic products	1.60%	57600	computers
	batteries	0.10%	3600	avoided
	hhw/HW	0.60%	21600	avoided
other waste				
	Textiles	2.70%	97200	textiles
	Carpet	2.40%	86400	carpet
	Sharps and Infectious Waste	0.10%	3600	trash
	Rubber	0.80%	28800	tires
	Construction and Demo	2.80%	100800	trash
	Bulky Items	3.40%	122400	trash
	Empty HHW/HW containers	0.40%	14400	trash
	Misc	5.80%	208800	trash
	total MSW (disposed)	100%	3,600,000	

Calculating Diversion

To calculate the maximum state-wide diversion potential, we can use the amount of materials that are currently recycled (Table 3) combined with the amount of materials in the trash that we can divert (Table 4). By combining SCORE report and MPCA's composition study categories into six main categories we created to simplify this report, we can calculate the state-wide potential for recycling and composting. The six categories are:

1. **Curbside recyclables.** This category includes the typical papers, bottles, and cans that most people in the state can recycle at the curb.
2. **Drop off recyclables.** This category includes recyclables that currently have drop-off options in Minnesota such as carpet, textiles, and plastic bags.
3. **Compostables.** This category includes food scraps, yard waste that is currently in the MSW stream, and non-recyclable paper. These numbers do not include the yard waste currently being handled as compost as these numbers are not currently tracked by these state reports.
4. **Wood/Tires/Electronics.** This includes any wood waste currently in the MSW. Electronics includes computers, peripherals and other items labeled "electronics." Tires include used tires and items labeled "rubber."

5. ***Avoided Disposal.*** This category includes items that are currently diverted from the waste stream, but do not currently have quantified upstream benefits. There certainly is an environmental benefit to handling these materials properly, but many of these benefits are associated with toxics reductions and less directly related to climate change. These items include batteries, household hazardous waste and other “banned” items such as oils and paint. This category also includes “other glass” since glass not going back into glass bottles does not result in the same upstream benefits.
6. ***Extended Producer Responsibility.*** This category includes the remaining waste that is not currently recyclable or compostable in Minnesota and could be addressed through Extended Producer Responsibility (EPR) and other prevention design and management strategies. For instance, in the European Union, producers are required to either use packaging that fits into a current recovery option (recycling or composting) or provide a mechanism to take the product packaging back at their cost.

Table 5: By combining SCORE report and composition study categories into six main categories, Eureka Recycling calculated the state-wide potential for recycling and composting.

Table 5: Maximum Diversion Potential	Currently Recycled & Composted	Recyclables & Compost in Trash	Total Potential	% of Total
1. Curbside Recycling				
news	215,000	453,600	668,600	10.9%
mixed paper	356,127	111,600	467,727	7.6%
cardboard	361,375	320,400	681,775	11.1%
PET containers	23,191	25,200	48,391	0.8%
HDPE containers	18,378	18,000	36,378	0.6%
other plastic containers	1,688	18,000	19,688	0.3%
Aluminum	48532	43,200	91,732	1.5%
Tin	50437	136,800	187,237	3.1%
Other Scrap Metal	406437	3,600	410,037	6.7%
Glass	79772	72,000	151,772	2.5%
Subtotal:	1,560,937	1,202,400	2,763,337	45.1%
2. Drop Off Recycling				
Plastic Film/Bags	4,227	136,800	141,027	2.3%
textiles	16,244	97,200	113,444	1.9%
carpet	216	86,400	86,616	1.4%
Subtotal:	20,687	320,400	341,087	5.6%
3. Compost				
Food scraps	179,043	496,800	675,843	11.0%
yard waste	0	82,800	82,800	1.4%
non recyclable paper	0	349,200	349,200	5.7%
Subtotal:	179,043	928800	110,7843	18.1%
4. Wood/Tires/Electronics				
Wood	104,104	162,000	266,104	4.3%
Tires	18,646	28,800	47,446	0.8%
Electronics	10,386	64,800	75,186	1.2%
Subtotal:	133,136	255,600	388,736	6.3%
5. Avoided Disposal	629,833	158,400	788,233	12.9%
6. Extended Producer Responsibility	3,600,000	734,400	734,400	12.0%
TOTAL	6,123,636	3,600,000	6,123,636	100.0%
% of waste diversion	41%	80%	88%	

Calculating scenarios for diversion

For ease of comparison and understanding, we have chosen to evaluate the impacts of three scenarios over the same baseline.

Baseline: The baseline reflects no recycling or composting. We used the state's average of 35% waste-to-energy incineration and 65% landfill as the potential energy generation from waste. We used the national averages for distance to landfill and national average landfill gas capture rates of 44%, which are increasingly questioned as the rate is predicted to be much too high.

Current Average Scenario (using 2006 data): The current average scenario uses the charts and reports from SCORE to give a snap shot of the greenhouse gas reductions achieved by participating in recycling and composting at the average Minnesota level:

- 41% recycling and 3% composting

MCCAG 2012 Goal Scenario (future): For a mid-range scenario we used the State of Minnesota goals for recovery efforts. The Minnesota Climate Change Advisory Group (MCCAG), a governor appointed body of public, private, and nonprofit groups, convened in 2007 with the purpose of presenting a climate change mitigation plan to the legislature. They looked at issues across all sectors including waste. The goals they set for waste reduction are:

- 50% recycling and 10% composting by 2012
- 60% recycling and 15% composting by 2025.

The middle scenario uses the 2012 goals of achieving a 50% recycling rate and 10% composting rate. To calculate the additional diversion needed to reach these goals, start with the average scenario (what is currently being done, 41% recycling and 3% composting) and add tonnage based upon what is left in the garbage. It will require capturing 40% of the additional recyclables in the garbage to meet the 50% overall recycling goal and 50% of the compostables in the garbage to meet the 10% composting goal.

Zero-Waste Scenario (maximum): The zero-waste scenario measures the impact of capturing virtually everything currently recyclable or compostable. Using the current diversion numbers and adding in all the potential recycling and composting identified through the 2000 waste composition study:

- 100% recycling and 100% composting

This result is approximately an overall 88% diversion rate (see Total Potential column in Table 5). The remaining 12% of the waste stream is currently not recyclable or compostable. In a true zero-waste model, this 12% would be source reduced or redesigned to be recyclable or compostable.

5. Calculating the greenhouse gas impact of waste reduction efforts in Minnesota

Carbon Equivalents

The final step in quantifying Minnesota's climate impact of waste is to convert the tons of waste diversion into a measurement that shows its impact on global warming. The most common way to do this is to state the impact in carbon equivalents. Since waste reduction results in the reduction of several types of greenhouse gases, the conversion to a standard carbon equivalent (CO₂ E) measurement allows for a total quantification of the impact. It also provides a standard language for people to compare these actions to other's such as transportation and energy conservation efforts. A carbon equivalent (CO₂ E) is simply the amount of CO₂ that would have the same global warming potential as the waste reduction impacts, when measured over a specified timescale. The international reporting standard for CO₂ emissions is in metric tons, so you will often see carbon dioxide amounts reported as MTCO₂ E, which stands for metric tons of carbon equivalent.

Conversion Models

While there are many models emerging to calculate greenhouse gas reductions, the most recognized and standard model is the EPA's WARM model. Produced by the EPA, the Waste Reduction Model (WARM) was designed to help solid waste planners and organizations track and voluntarily report greenhouse gas emissions reductions from several different waste management practices. The WARM model was last updated in August of 2008 and recognizes 34 material types (U.S. EPA, 2008).

Credibility of WARM

WARM has been in development for over 10 years and relies on information from leading scientists and technical experts. The methodology and data has been peer reviewed at several stages; including a lengthy review process that included public comments and responses (U.S. EPA, 2008).

The field of life-cycle analysis has expanded dramatically since WARM was originally developed and interest in life cycle studies and supply chain impacts is at an all-time high. For that reason, EPA is in the process of updating many of the emission factors and assumptions embedded in WARM. As new updates and improvements become available, EPA will post new versions of the model and explanations of revisions. To learn more about the data sources and methodology employed in WARM, consult the latest edition of EPA's research report: *Solid Waste Management and Greenhouse Gases: A Life-Cycle Assessment of Emissions and Sink*, online at <http://www.epa.gov/climatechange/wycd/waste/SWMSGHGreport.html>.

Although WARM is the most widely peer-reviewed and accepted model, it is considered to have several flaws. Because of these flaws, the results from WARM are conservative, meaning the environmental benefit of recycling and composting are in fact understated. That said, the good news is that we know now that we can achieve reductions in greenhouse gas emissions that are equivalent to closing many more than 21% of all U.S. coal-fired power plants in the U.S. by recycling and composting.

- WARM overstates the landfill capture rate at 44%, but it actually may be closer to 20% (Anderson, 2006).
- It does not include the upside of composting (replacing petroleum based fertilizers and pesticides). Other models consider these impacts, but are not as widely-used or accepted as the WARM model.
- It does not include all the materials we would like to see in the calculations.
- There have been questions raised, about the politically-based decision to measure methane emissions over a 100-year life span. If you measure the emissions over a 20-year life span instead of a 100-year life span (which is scientifically valid), methane has 70 times the impact of carbon dioxide, not 23 times as is calculated in WARM (Platt, et al., 2008. pg 7).

We believe the use of this calculator is conservative and understates the real impact of waste reduction efforts. However, despite these flaws, the WARM model is a well-recognized, published calculator. Until a better calculator is peer reviewed and accepted, WARM gives us a conservative starting place to measure these impacts and work towards our goals. Even with WARM, as you will see, the impacts are quite significant.

Protocols for climate change calculations

Many cities around the country, including Minneapolis and Saint Paul, work with the International Council for Local Environmental Initiatives (ICLEI) to quantify the climate change impacts of their city. ICLEI has developed protocols for calculating the carbon footprint consistent with the Climate Registry. To ensure our protocol matches with the work currently being done, we researched how our quantification fits in with current protocols.

A new set of protocols for measuring greenhouse gases for cities was recently released in a report by ICLEI.

Many local governments have actively engaged in a variety of programs and activities to reduce waste going to landfills, mainly through recycling and composting activities. While it is outside of the scope of this Protocol to provide quantification methodologies to estimate the GHG reductions or benefits associated with these waste-reducing activities, we do plan to explore developing such methodologies as part of the community-level protocol process. Information about your local recycling and composting activities can be reported optionally (ICLEI, 2008, pg 85).

While the community-level protocol process has not happened yet, California Air and Resources recently conducted a white paper on quantifying greenhouse reductions from recycling and composting. This white paper states that WARM is the best practice to use right now and that it is a conservative approach. It states that it does not quantify the full upstream benefits of composting. It stated that they were working on an update to this, but had limited resources (Moore and Edgar, 2008). We were unable to locate anything more recent.

Results

Table 6 is a summary of the total MTCO₂E achieved for each scenario over our baseline (35% incineration/65% landfill) by item and category.

Table 6: WARM greenhouse gas reductions in MTCO₂E (gain compared to disposal)			
Category Break Down	Current Average Scenario	MCCAG 2012 Goal Scenario	Zero-Waste Scenario (Maximum)
1. Curbside Recycling:			
news	-420,503	-775,369	-1,307,668
mixed paper	-1,239,984	-1,395,414	-1,628,559
cardboard	-1,119,062	-1,515,933	-2,111,239
PET containers	-4,5234	-64,895	-94,387
HDPE containers	-3,2080	-44,648	-63,501
other plastic containers	-3,189	-16,790	-37,192
Aluminum	-665,727	-902,761	-1,258,313
Tin	-64,748	-134,994	-240,364
Other Scrap Metal	-1,994,738	-2,001,806	-2,012,407
Glass	-25,665	-34,931	-48,829
Subtotal:	-5,610,930	-6,887,542	-8,802,459
2. Drop Off Recyclables			
Plastic Film/Bags	-8,666	-120,856	-289,141
carpet and textiles	-121,613	-664,219	-1,478,128
Subtotal:	-130,279	-785,075	-1,767,269
3. Compost			
Food scraps	-103,388	-105,851	-109,545
yard waste	0	538	1,345
non recyclable paper	0	-31,446	-78,615
Subtotal:	-103,388	-136,759	-186,815
4. Wood/tires/computers			
Wood	-191,567	-310,809	-489,671
computers	-41,523	-62,995	-95,204
tires	-19,358	-77,079	-163,660
Subtotal:	-252,448	-450,883	-748,535
5. Avoided Disposal	-122,082	-134,363	-152,785
6. Extended Producer Responsibility	N/A	N/A	N/A
TOTAL greenhouse gas reductions from waste diversion Efforts (in MTCO₂E)	(6,219,127)	(8,394,621)	(11,657,863)

Tables 7 and 8 summarize these numbers by category and calculate the per capita impact. Table 7 calculates recycling efforts. Table 8 calculates composting efforts. The per capita impact is per person, so if there are three people in a household, the family's impact is three times greater. Also, note that a negative number means a reduction in carbon emissions.

Table 7: Scenario Comparison of GHG Reductions from RECYCLING efforts	Current Average Scenario	MCCAG 2012 Goal Scenario	Zero-Waste Scenario (Maximum)
1. Curbside Recycling (tons)	1,560,937	2,041,897	2,763,337
2. Drop off Recycling (tons)	20,687	148,847	341,087
3. Compost (tons)	N/A	N/A	N/A
4. Wood/computers/tires (tons)	133,136	235,376	388,736
5. Avoided Disposal (tons)	629,833	693,193	788,233
6. Extended Producer Responsibility	N/A	N/A	N/A
Total Recycling (tons)	2,344,593	3,119,313	4,281,393
% Diversion from Recycling (of total waste)	38%	51%	70%
Total GHG reductions from RECYCLING efforts (tons CO₂E)	(6,115,739.00)	(8,257,862.60)	(11,471,048.00)
GHG Reductions per person per year from RECYCLING efforts (pounds CO₂E)	(2,352.21)	(3,176.10)	(4,411.94)

Table 8: Scenario Comparison of GHG Reductions from COMPOSTING efforts	Current Average Scenario	MCCAG 2012 Goal Scenario	Zero-Waste Scenario (Maximum)
3. Composting (tons)	179,043	643,443	1,107,843
% Diversion from Composting (of total waste)	3%	11%	18%
Total GHG reductions from COMPOSTING efforts (tons CO₂E)	(103,388.00)	(161,786.90)	(186,815.00)
GHG reductions per person per year from COMPOSTING efforts (pounds CO₂E)	(39.76)	(62.23)	(71.85)

6. Why measure waste reduction in terms of climate change?

Efforts are needed across all the sectors of our lives to reduce greenhouse gas emission. Leading scientists have indicated that 350 parts per million (ppm) of carbon dioxide is the upper limit for us to continue life on this planet as we know it (350.org. About Us/Science page. December 2008). We're currently at 385 ppm (and just 200 years ago we were at 275 ppm). As we work to lower to 350 ppm as soon as possible, we need to employ every strategy we can—including waste reduction strategies—to reduce our emissions. While many strategies require large purchases (i.e. new heaters, coolers, cars, etc.) recycling and composting require little or no investment and in most cases some systems are already in place. What are needed are requirements and incentives for manufacturers to use recycled content and to design for recycling and composting.

Measuring the climate change impact of waste reduction actions allows us to speak in a common language, understand the impact of our choices, and help us prioritize the personal and policy actions that we take. Consider these facts:

- Recycling and composting all our municipal solid waste in Minnesota would have the same impact as shutting down 19.2% of all the coal-fired power plants in Minnesota (American Coal Foundation, 2007).
- Recycling and composting all are municipal solid waste would have the same impact as removing 2,135,140 passenger vehicles from the road. That is equal to over two-thirds of all the cars on the road today in Minnesota (Vennewitz, 1998).
- Recycling and composting all of our municipal solid waste would reduce carbon emissions enough to equal the carbon emissions from 1,544,088 households every year. That's almost 75% of the total in Minnesota (Minnesota Population Estimates December (website) 11/2008).

While actions such as shutting down 20% of our coal power plants, or reducing our car usage by two-thirds, or using 75% less electricity in our own homes may seem daunting, recycling and composting are accessible and easy actions we can do right now, every day, to make a difference. Translating recycling and composting into climate change impact reminds us that these actions are not trivial or passé. They are a powerful and significant part of the solution:

Indeed, a zero waste approach would achieve 7% of the cuts in U.S. emission needed to put us on the path to climate stability by 2050 (Platt, et al., 2008. pg 6).

It is also important to calculate the carbon impact of waste reduction as the global effort continues to enact a carbon "cap and trade" system. This system would create financial incentives to reduce green gas emissions, incentives that could benefit new recycling and composting efforts to expand our current infrastructure. We must weigh this against any further subsidies for landfilling and incineration as supposed "renewable" technologies.

7. Can we really recycle and compost this much?

For over 150 years, our worldwide manufacturing, distribution, and disposal systems have developed under the illusion that our natural resources are manageable and expendable and that any amount of pollution can be absorbed or diluted by the land and water. Today, we know this is not true: the cost of maintaining and expanding landfills continues to rise, incinerators have been proven to decrease our air quality and impact our health, and our once “endless” natural resources are showing obvious signs of depletion. Our waste is in fact very valuable, despite the current paradigm that tells us that it is no so.

We have the technology, and we can have the foresight to cost-effectively adapt this old system of using and disposing to a new system of conserving, reusing, recycling, and composting our resources. This will allow us to reinvest more of the “output” of our waste stream, rather than burying it in a landfill or burning it in an incinerator. Not only will our environment and our health improve, but so will our economy.

On a per-ton basis, sorting and processing recyclables alone sustains ten times more jobs than landfilling or incineration. [...] Each recycling step a community takes locally means more jobs, more business expenditures on supplies and services, and more money circulating in the local economy through spending and tax payments (Platt and Seldman, 2000).

By adopting zero waste as our goal right now, we shift job creation to reuse, recycling, and composting industries that transform discarded materials into resources. Many people left out of the current economy will be able to find interesting and fulfilling work in these efficient and inventive businesses. We can change our economic measurements to support an abundant economy that rewards creativity, efficiency, community, healthy families and environmental protection.

Communities and businesses currently in the process of adopting zero-waste goals look to examples of ecological systems, where the output of one system becomes the input for another system, the way decomposition and decay form the basis of nourishment for new organisms. In nature, there is no waste, and we can mimic this as we interact with nature. Zero-waste initiatives are being adopted and implemented all over the globe, in big and small ways, including in Seattle, Washington; San Francisco and Del Norte, California; New Zealand; Canberra, Australia; Denmark; Edmonton, Alberta; Ottawa, Ontario; and Nova Scotia. Businesses like Hewlett Packard, the EPA green building program, and Mad River Brewing have achieved 95% and higher diversion rates. Zero Waste is being incorporated into the business functions of many organizations including Xerox, Sony, Mitsubishi, Interface Flooring Systems, The Beer Store, IBM, DuPont, Honda and Toyota, 3M, Anderson Windows, Aveda, and Pillsbury.

The Stop Trashing the Climate reports makes a case for a zero waste approach as one of the “fastest, cheapest, and most effective strategies for mitigating climate change in the short and long-term” and reports on several communities that are putting these zero waste strategies in place:

Zero waste goals or plans have now been adopted by dozens of communities and businesses in the U.S. and thereby the entire state of California. 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 disposal in landfills and incinerators by 20% within seven years (Platt, et al., 2008. pg 15).

In 2005, Eureka Recycling convened the Saint Paul Environmental Roundtable. The work of the Roundtable, made up of residents from throughout Saint Paul, culminated in the passage of a resolution to set Saint Paul's policy direction on six environmental issues: zero waste, food systems, cleaner energy, green building, open space and water stewardship. In 2006, as a result of the roundtable recommendations, the City of Saint Paul adopted the goal of being a zero waste city by 2020 (<http://www.eurekarecycling.org/environmentalroundtable/index.cfm>).

In 2008, the City of Burnsville (<http://www.ci.burnsville.mn.us>) began working with a consortium of nonprofits and businesses to create the first ever full municipal sustainability plan in Minnesota. Recognizing the need to provide all communities clear and concise examples for crafting zero-waste policies and strategic plans to achieve zero waste, Eureka Recycling compiled a Zero Waste Ordinance Resource Guide with nearly 70 examples from communities that are leading the way. This Resource Guide was first presented at the Alliance For Sustainability's "Local Government Sustainability Workshop – Using Model Sustainability Ordinances to Implement your City's Sustainability Goals" in Saint Paul, MN, in April 2008 (<http://www.stpaul.gov>).

In order to reach these goals, it will take an investment in our current recycling and composting infrastructure. If we continue to invest in wasting by putting the significant capital investments required to build incinerators and landfills, our zero-waste efforts will be bankrupt. Currently wasting competes for the dollars that could be used to preserve and expand recycling and composting efforts such as these:

- Invest in a composting infrastructure.
- Provide more drop-off opportunities for hard-to-recycle items.
- Maximize our curbside work by investing in education, adding new materials, and ensuring that the materials collected actually get recycled.
- Find solutions to deal with mixed plastics and additional metals, since they have a large carbon footprint and are under-recycled.
- Focus on eliminating a small percent of waste that is left using extended producer responsibility, reuse, and reduction strategies.

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10. Background on Organizations and Resources

Eureka Recycling

www.eurekarecycling.org

Composting website: www.makedirtnotwaste.org

A nonprofit that demonstrates that waste is preventable, not inevitable.

350.org

www.350.org

A nonprofit of youth from throughout the world, working with renowned author and environmentalist Bill McKibben, to build a movement to stop global warming.

Climate Registry

www.climateregistry.org

A nonprofit organization working that establishes consistent, transparent standards throughout North America for businesses and governments to calculate, verify and publicly report their carbon footprints in a single, unified registry

ICLEI - Local Governments for Sustainability

www.iclei.org

An international association of local governments as well as national and regional local government organizations that have made a commitment to sustainable development.

Minnesota Climate Change Advisory Group (MCCAG)

www.mnclimatechange.us

A advisory group convened in 2007 with the purpose of presenting a climate change mitigation plan to the legislature, including issues across all sectors including waste.

SCORE Report

<http://proteus.pca.state.mn.us/oea/lc/score.cfm>

An annual report on recycling and waste management programs in Minnesota. The report is currently compiled by the Minnesota Pollution Control Agency (MPCA).

Stop Trashing the Climate

www.stoptrashingthecclimate.org

A report by issued in June 2008 by the Institute for Local Self-Reliance, the Global Anti-Incineration Alliance and Eco-Cycle.