

Survey of MSW Generation and Disposition in the US

The per capita generation of MSW in the US is substantially higher than in countries with nearly the same GDP per capita. BY NICKOLAS J. THEMELIS AND DOLLY SHIN

Summary

The Columbia 2013 Survey of Waste Generation and Disposition in the US is a continuation of Journal's State of Garbage in America (SOG) surveys, initiated by *BioCycle* in 1989. From 2002 to 2010, *BioCycle* conducted the State of Garbage in America survey and report with the Earth Engineering Center (EEC) of Columbia University. The Columbia 2013 Survey of Waste Generation and Disposition in the US compiled and analyzed 2011 data provided by the waste management agencies of the 50 States of the Union. The Survey questionnaire was first reviewed by EPA's Office of Resource Conservation and Recovery, and their comments were incorporated in the final edition submitted to the states. The Survey showed that in 2011 the US generated a total of 389 million short tons of municipal solid wastes (MSW), corresponding to a per capita generation of 1.3 short tons. Of the total MSW generated, 22.6% was recycled, 6.3% composted, 7.6% used as fuel in waste-to-energy (WTE) power plants, and 63.5% was landfilled.

An interesting finding was that, in comparison to 2008, landfilling decreased by about 20 million tons, while recycling increased by nearly the same amount. An estimated 247 million tons of solid wastes were landfilled in MSW landfills, i.e., 113 million higher than EPA estimate. This difference is believed to be due to several wastestreams that are deposited in MSW landfills but are not included in the EPA definition of MSW, such as packaging of imported goods, automobile shredder residue, ash residues, paper residues from wastewater treatment plants, and some construction and demolition debris. The Columbia Survey considers that all recyclable, compostable, or combustible materials that are discarded in MSW landfills represent a loss of valuable

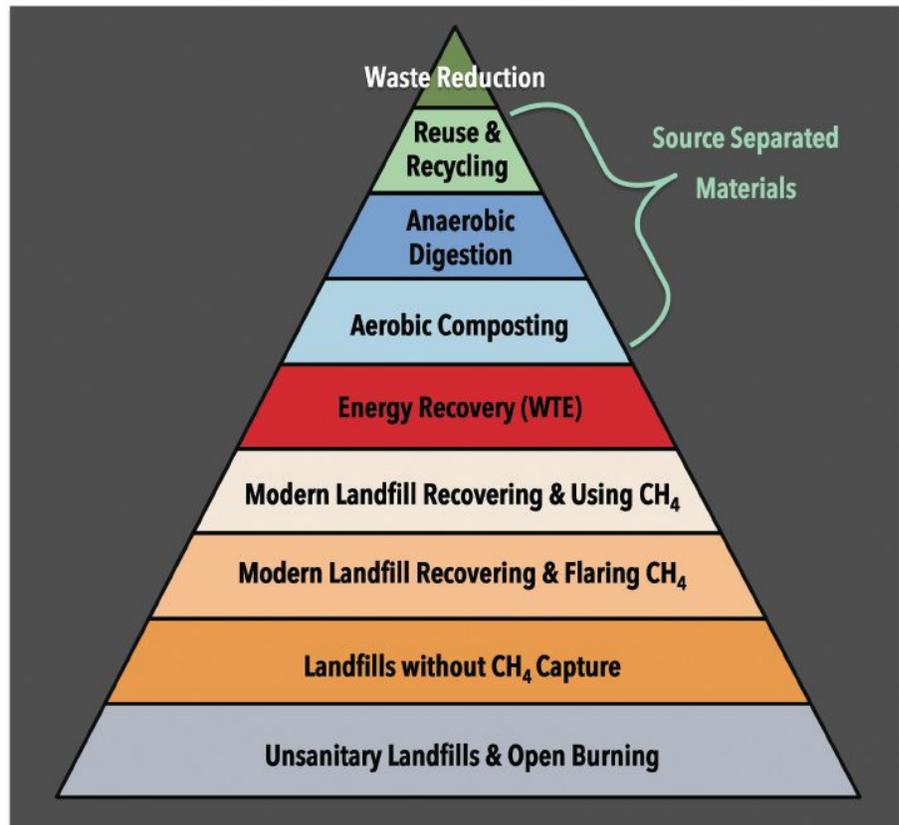


Figure 1. The hierarchy of waste management

resources and an unnecessary use of land; therefore, they should be included in the national account of waste management.

Introduction

All states and municipalities provide waste collection and disposal services to their citizens. However, an accurate account of how much of the MSW is directed to materials or energy recovery facilities is essential for planning and policy decisions. All tonnages in this paper are in short tons (1 metric ton = 1.1 short ton). In the hierarchy of waste management (Figure 1), the highest priority is to reduce the waste generation per person. However, this metric depends on economic development and culture, as witnessed by the fact that the per capita generation of

MSW in the US is substantially higher than in countries with nearly the same GDP per capita, such as Austria, Switzerland, and the Netherlands. Waste reduction is not within the control of MSW managers who have at their disposal four broad methods: Recycling, composting, thermal treatment with energy recovery, and landfilling. Landfills range from the preferred sanitary landfills to the non-regulated waste dumps that are still used in many parts of the developing world (Figure 1).

Several states have adopted various source reduction programs. For example, Minnesota has an exchange service that connects organizations with unwanted goods to others who may need them (iWasteNot Systems Inc.). Some cities in California,

Breakdown by EPA Regions

Recycling, composting, combusting, and landfilling rates by regions

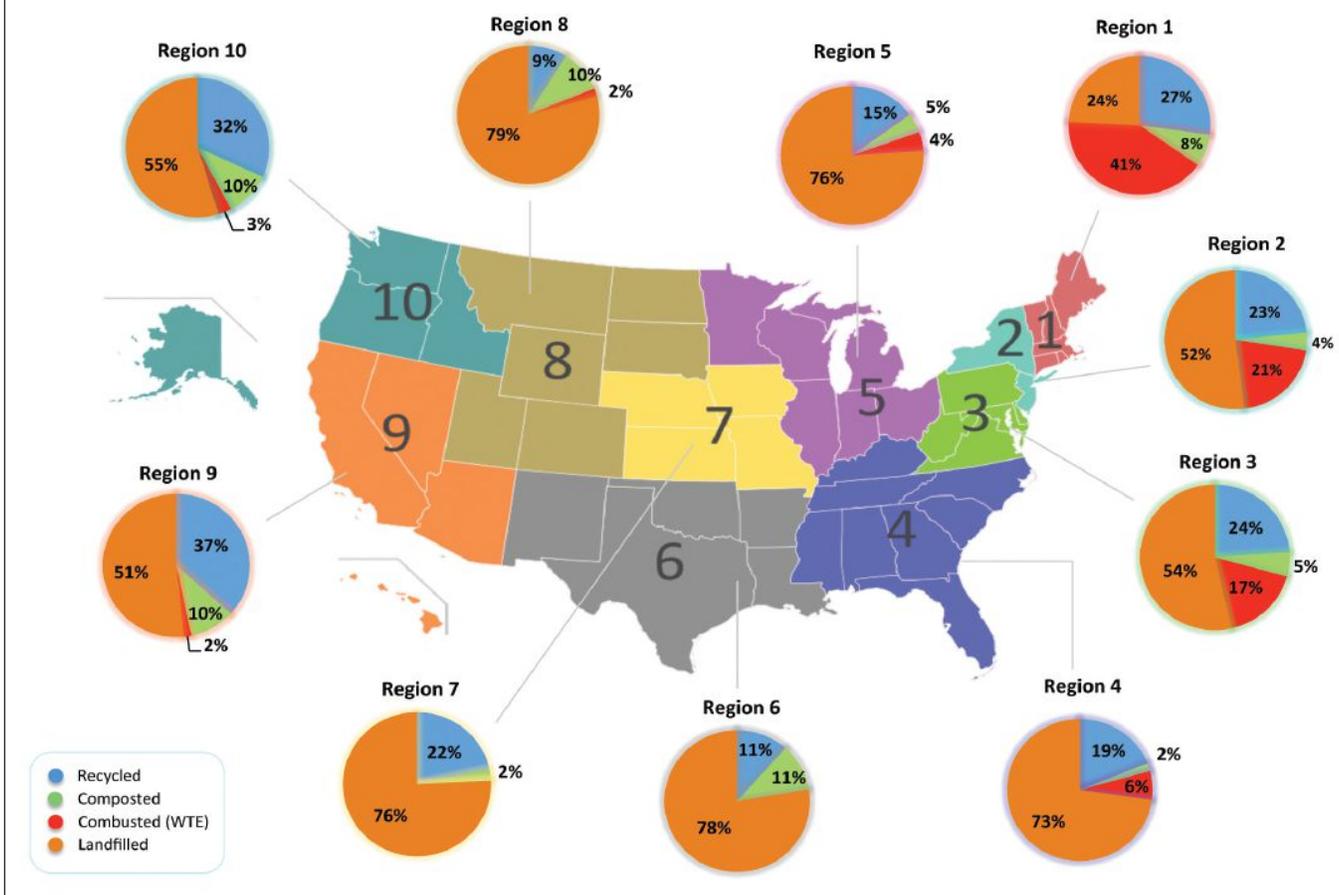


Figure 2. Methods of managing MSW in the 10 EPA Regions in 2011

Iowa, Massachusetts, New York, Washington, and Wisconsin have instituted pay-as-you-throw (PAYT; USEPA 2012). Some of these systems are also called Volume-Based-Waste-Fee (VBWF) programs. For example, the town of Sandwich, MA, has implemented a program whereby citizens have to purchase labeled trash bags at local stores at prices of 24 cents to \$1.20 for 8- to 30-gallon bags. This measure resulted in a 42% reduction of MSW to the WTE plant and a 74% increase in the collection of recyclable streams (Abrashkin 2015).

There are four methods of collecting recyclable materials in the US: Curbside collection, drop off, buy-back, and deposit/refund. The collected materials include paper fiber (office paper, newsprints, and cardboards), metals (aluminum cans, ferrous and non-ferrous metals), plastic containers, consumer electronics, and tires. In general, the collected recyclables are transported to material recovery facilities (MRF) or to transfer stations and then to MRF. At the MRF, the recyclables are sorted to marketable streams and a residue that is sent to a WTE, a cement plant, or is landfilled. Reporting of materials treated and marketed by MRF to the state agencies is not uniform. Also, some homogeneous streams—such as paper, cardboard, and aluminum cans—may go directly to recycling companies to be used as part of their feedstock.

Organic wastes can be broadly divided into two categories: Yard or green wastes (grass clippings, leaves, etc.) and food wastes. Source-separated yard wastes are usually processed in open-air windrows to

produce a soil conditioning compost. Food wastes are not usually composted in open-air windrows because they emit unpleasant odors. Therefore, the preferred method is “anaerobic digestion” in dedicated chemical plants or in biodigesters of wastewater treatment plants. A detailed analysis of the present state of composting in the US was published recently in *BioCycle* (Themelis and Arsova 2015); about 50% of the US yard/green wastes are processed, mostly in open air windrows, while collection and anaerobic digestion of food wastes is less than 10% of the US food wastes.

The 2014 Survey Questionnaire

From 2002 to 2010, the EEC of Columbia University conducted, in collaboration with *BioCycle* journal, *BioCycle*’s biannual survey of national waste statistics called “State of Garbage in America”. The 2014 EEC survey was based on 2011 data provided by the waste management agency of each state (Shin 2013). The excel-format survey included questions on all means of waste management in the state. The sum of reported MSW recycling, composting, combusting, and landfilling is equal to the total MSW generated.

The recycling section of the survey asked for tonnages of recyclables going to single-stream and dual-stream MRFs, as well as those sent directly to recycling plants. Estimated tonnages of individual recycled commodities were separate questions. Additional questions were on existing PAYT and VBWF programs. The

composting section asked for municipalities and populations provided with curbside collection of yard and food wastes and number of composting facilities in the state. In the energy recovery section, the survey requested the number of municipalities served by WTE facilities, MSW tonnage processed and gate fee paid, electricity and heat supplied, and tons of metals recovered. The landfill questions were on number of landfills, tons landfilled, gate fee, volume of landfill gas (LFG) generated, and tons of MSW exported to or imported from other states.

State Responses to Survey

Nine states, representing 13% of the US population, were not able to participate in the 2013 Columbia survey. For these states, their 2008 Survey data (Themelis and Musche 2014) were used, after adjusting for population growth between 2008 and 2011. The most accurate data reported in the Survey were for MSW disposed in landfills or combusted with energy recovery in WTE plants because trucks in and out of these facilities are weighed and the data are reported to the state. Since there is no reporting requirement for recycling facilities, 10 states could not provide recycling data (AL, GA, IA, ID, IL, IN, MS, NE, TX, and WI). Twenty-six states provided complete data on recycled tonnages of individual commodities. Eight states could not provide information on the number of municipalities providing curbside collection or the number of MRFs in the state. For the few states which did not provide recycling data, the 2008 Survey data were used, adjusted for population growth.

Composting facilities are also not required by states to report processed tonnages. Six states only provided combined total tonnages of yard and food wastes. Most of 21 states reporting composting tonnages provided tons of yard (“green”) waste composted. Eleven states provided tons of food waste composted while and eight states (AR, DE, KS, KY, NC, ND, RI, and WY), and Washington DC reported that they only compost yard waste. The composting results of the Survey are discussed in a recent *BioCycle* article (Themelis and Arsova 2015).

Only some states provided the average gate fee for landfills. Table 1 compares the landfill gate fees of 11 states (2011 data) with the WTE gate fees for the same states in the 2010 *BioCycle-Columbia* survey (2008 data). It can be seen that, on average, WTE

Table 1. Landfill and WTE Gate Fees at 11 States

States	Landfill Gate Fee	WTE Gate Fee
	US\$/Ton (2011)	US\$/Ton (2008)
Alabama	40	29
Connecticut	57	64
Florida	44	53
Iowa	38	64
Massachusetts	79	69
Minnesota	42	55
New Hampshire	78	68
New Jersey	75	85
New York	46	72
Washington	65	98
Wisconsin	54	51
Average of 11 states	56	64



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gate fees were a few dollars higher than landfill fees. Thirty-four states reported the number of biogas collecting landfills, and 17 of them provided the total amount of LFG collected.

Results of the Columbia 2014 Survey of 2011 Data National Overview

The Survey showed that in 2011, the United States generated a total of 389 million tons of MSW, and that the per capita generation of MSW was 1.3 tons (1.19 metric tons). Of the MSW generated, 22.7% was recycled, 6.3% composted, 7.6% was combusted with energy recovery at WTE facilities, and 63.5% was landfilled. The amounts of MSW recycled, composted, combusted, and landfilled in each state are shown in Tables 2 and 3. (Tables 2–4 are available online at <http://foresternetwork.com/msw-management-magazine/ms-waste/administration>.)

Figure 2 shows the percent disposition of MSW generated with the states divided into the 10 EPA regions. Combustion with energy recovery (WTE) is most prevalent in the East Coast (Regions 1–4), with Region 1 having the highest fraction of MSW disposed by WTE (41%). In the other regions, less than 4%, or none, of the MSW is disposed at WTE facilities. The mid-western regions (Regions 5–8) are still very reliant on landfilling and have the lowest recycling rates. The West Coast states (Regions 9 and 10), lead in recycling with over 30% rates. Composting activity is highest in Region 6, with Regions 8–10 following closely.

Figure 3 shows how the 50 states compare with regard to fraction of their MSW landfilled.

Recycling of Commodities

Twenty-one states and the District of Columbia (total population: 123 million) provided data on the various commodities recycled within the state. Prorating the tonnage of each commodity recycled from MSW in these states (e.g., 13.4 million tons of paper fiber) to the entire US 2011 population resulted

in the following estimates:

- All paper fiber: 34 million tons
- All metals: 36.2 million tons
- All plastics: 2.3 million tons
- Glass: 3.8 million tons

The quantity of recycled plastics (2.3 million tons) is a relatively small fraction of the nearly

34 million tons of waste plastics generated in the US annually (EPA 2011). This number is very close to the American Chemistry Council report of 1.82 million tons of recycled non-durable plastics plus the EPA report of 0.39 million tons of recycled durable plastics (EPA 2011, American Chemistry Council 2011).

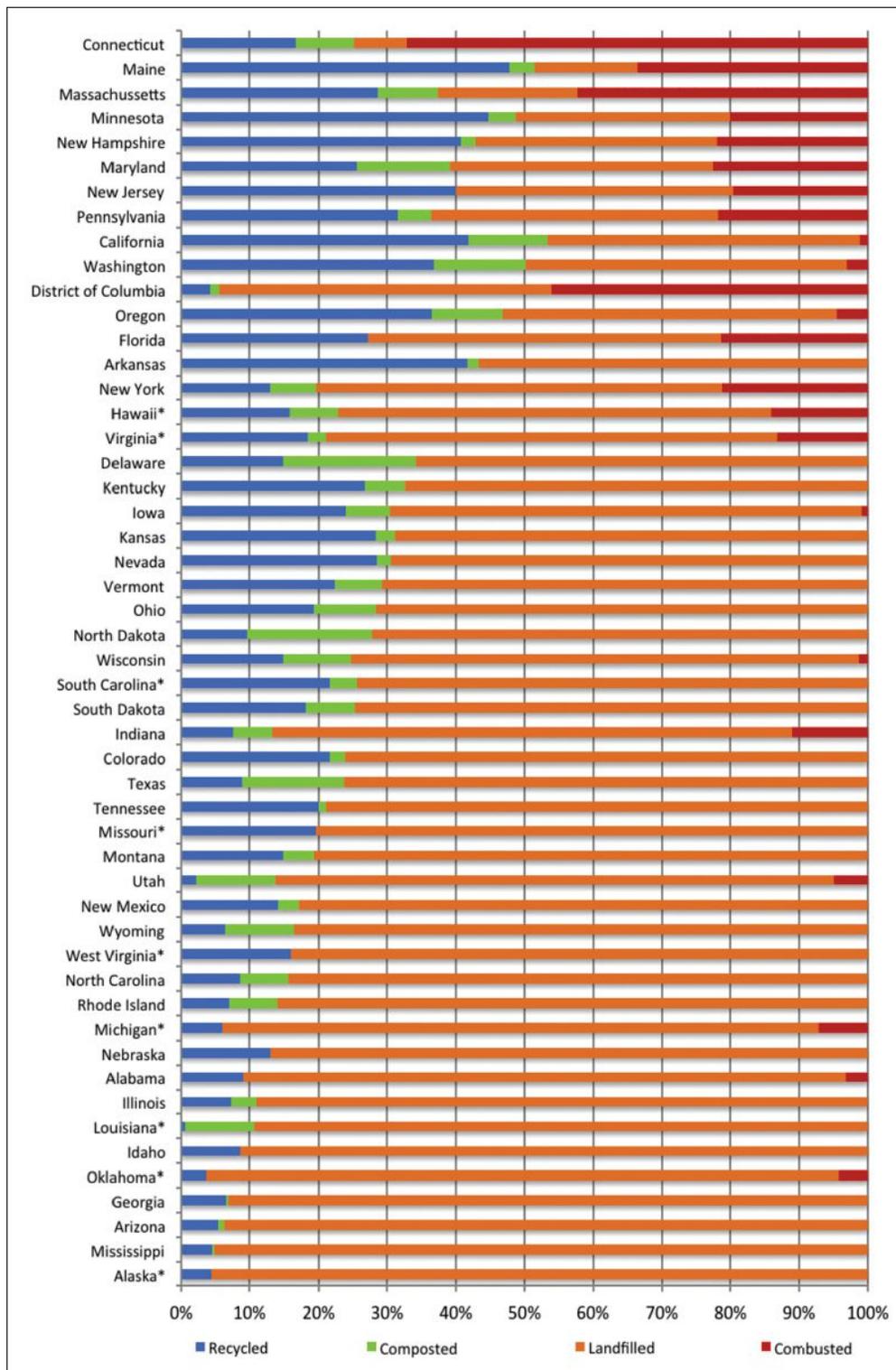


Figure 3. Percent disposition of MSW in the 50 States

MSW Management Trend in Period 2002–11

The BioCycle-Columbia Surveys of MSW generation over the past decade (Figure 4) show that from 2002 to 2006, the MSW generation increased at about 5-6%; in 2008, there was a 5% decrease and in 2009, to 2011 when there was a slight increase of 0.3%. This pattern roughly follows the US GDP trend over the same period.

When policy makers and businesses are looking for national MSW data and trends, the most cited works are EPA's "MSW in the US: Fact and Figures" and the past BioCycle-Columbia Surveys. The two reports use different estimating methods and the landfilling numbers vary considerably. (See Table 4 online.) This section discusses the reasons for this difference.

Since 1960, EPA has been using a materials balance method to estimate the amount of different commodities discarded and how they are managed. The generation numbers are derived from data gathered from sources such as industrial associations, major companies, and government (i.e., Department of Commerce). Adjustments are made to reflect imports and exports of goods. In order to determine the amount of MSW generation, EPA assigns lifetimes to various commodities and products. Since food and yard waste data cannot be estimated from materials flow methods, EPA uses data from various sampling and weighing studies.

However, most of the US landfills are not perfectly categorized as MSW-only or as non-MSW landfills. While there are separate C&D, or industrial landfills with permits specifically for non-MSW wastes, many sanitary landfills accept what is called "subtitle D" wastes, which may include wastes of non-municipal origin. Therefore, many wastes that are not included in the EPA definition of MSW, e.g. road kill, automobile shredder residue, residues from MRFs, residues from paper-recycling plants, and residential home renovation projects end up in MSW landfills.

The EPA Facts and Figures have been published since 1960 and provide a consistent picture of the trends in MSW management in the US. However, EPA reports consistently underestimate the tonnage landfilled by over 100 million tons.

The difference in landfilling numbers is due to the fact that Columbia Survey considers that all recyclable, compostable, or combustible materials that are discarded in MSW landfills represent a loss of materials or energy, and also unnecessary use of land;

therefore, they should be included in the national accounting of waste management. The Columbia Survey method is a bottom-up approach, where the MSW generation information is provided by state agencies and is added up to generate the national picture. Instead of focusing on how much of the waste generated is MSW or non-MSW, the method relies on how much waste enters in what are supposed to be MSW landfills. These actual numbers are a more reliable measure, for example, in planning for future allocation of land for landfilling.

The weakness of the Columbia Survey is that, in contrast to WTE and landfilling facilities, there is no national policy, and in many cases no state regulation, for reporting recycling and composting tonnages. Even when tons of recyclables to MRFs are tracked by the state, they do not include the tonnage of recyclables collected by private haulers and sent directly to plants using recyclable feedstock. However, even with incomplete recycling and composting data, the Columbia Survey provides the only consolidated report of state-by-state waste



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management data. Some of the reasons for the 112-million-ton difference between this Survey and EPA estimates of landfilling are:

- Construction and demolition debris that is not acceptable at C&D landfills and non-recycled industrial waste residues end up in MSW landfills. Similarly, wastes produced from residential remodeling projects (e.g., wood, PVC pipes, paint containers, roof tiles) enter the MSW stream.
- Recycling of used cars involves removal of useful and hazardous materials and shredding of the car body. Ferrous and non-ferrous metals are removed by magnetic or eddy current separation. The remaining “fluff” is called automotive shredder residue (ASR) and is mostly landfilled in MSW landfills. EPA estimates that annually about 5 million tons of ASR are generated in the US.
- Moisture in MSW: Tchobanoglous et al. (1993) reported the moisture content of various materials in MSW. Excluding the obvious carriers of moisture (food, yard, and wood wastes) the moisture content of other materials in the MSW stream can represent as much as 30 million tons.
- Statistically “invisible” wastes: These include packaging material coming to the US with imported products, illegal goods, etc.

It is interesting to note that, as of 2009, the EPA department that has to estimate the greenhouse gas (GHG) impacts of managing wastes, uses the *BioCycle*-Columbia data on landfilling.

Conclusions

This Survey was based on 2011 data and showed that the principal changes from 2008 were that landfilling decreased by about 20 million tons while recycling increased by nearly the same amount. In contrast to the most advanced nations in Europe and Asia, the US continues to landfill about 63% of its MSW while recycling and composting about 30%. The state of Connecticut is at the top of the waste management “ladder” by landfilling only 7.7% of its MSW.

The survey showed that it has become increasingly difficult for the states to collect and compile reliable recycling and composting data, especially since the economic downturn of 2008 has reduced state budgets and resources. For states to sustainably manage waste and plan ahead to accommodate for increasing waste generation,

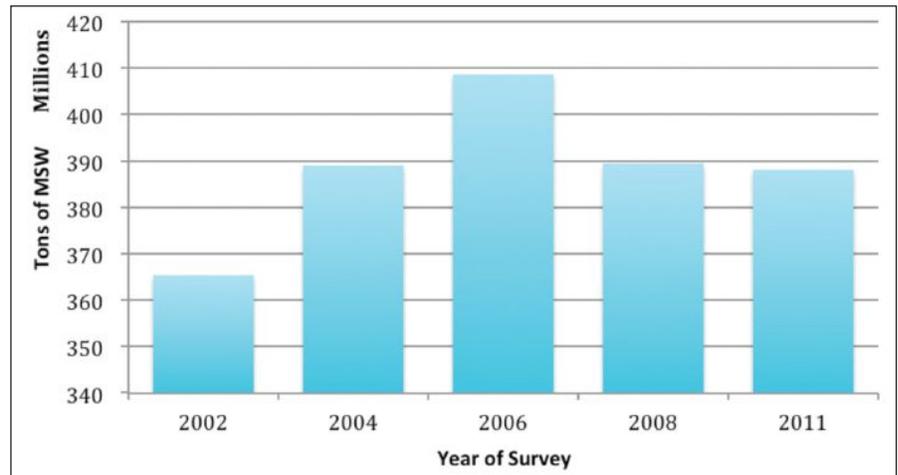


Figure 4. US MSW generation, 2002–2011; Discussion of the difference between the survey and EPA estimates of MSW generation

timely collection and accurate analysis of recycling and composting data are essential. The environmental agencies of some states need to develop a systematic data reporting process for all types of waste managing facilities.

This study identified, semi-quantitatively, several types of wastes that, according to the EPA definition, are not considered to be MSW and yet, for lack of other alternatives, are disposed in MSW landfills. Further study is required to quantify the annual generation of these wastes and use this information to devise strategies for reducing landfilling and increasing the recovery of materials and energy from MSW.

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References

- Abrashkin, J. 2015. “Increasing recycling by means of Volume Based Waste Fee.” M.S. thesis for Columbia University.
- American Chemistry Council: 2011 United States National Post-Consumer Plastics Bottle Recycling Report, 2011.
- iWasteNot Systems Inc. (n.d.). About Minnesota Material Exchange. Retrieved January 15, 2013, from www.mnexchange.org.

Jody, B. and E. Daniels. 2006. *End-of-Life Vehicle Recycling: The State of the Art of Resource Recovery from Shredder Residue*. Argonne National Laboratory, Energy Systems Division.

Kaufman, S. M., and N. J. Themelis. 2009. “Using a Direct Method to Characterize and Measure Flows of Municipal Solid Waste in the United States.” *Journal of the Air & Waste Management Association*. December 2009. pp. 1386–90.

Shin D., MS thesis, Columbia University 2013. www.seas.columbia.edu/earth/wtert/sofos/Dolly_Shin_Thesis.pdf.

Tchobanoglous, G., H. Theisen, and S. Virgil, “Integrated Solid Waste Management,” McGraw Hill (1993).

Themelis, N. J. and L. Arsova, “Calculating Tons to US Composting.” *BioCycle*. Feb. 2015, No. 2, Vol. 56, No. 2, p. 27.

Themelis, N. and C. Musche. 2014. “Energy and economic value of MSW and non-recycled plastics.” American Chemistry Council, July 2014.

USEPA. 2012. 2006 PAYT Program. November 15, 2012. www.epa.gov/epawaste/conservation/tools/payt/states/06comm.htm.

USEPA, Facts and Figures, Plastics 2011. www.epa.gov/osw/nonhaz/municipal/pubs/MSWcharacterization_508_053113_fs.pdf.

Van Haaren, R., N. J. Themelis, N. J., and N. Goldstein. 2010. 17th Nationwide Survey of MSW Management in the US: The State of Garbage in America. *BioCycle* Journal. October 2010, pp. 16–23. **MSW**



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