Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy

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1. Introduction

Heightened interest in renewable energy has prompted the Energy Information Administration (EIA) to examine some aspects of how it classifies energy sources as renewable. EIA employs the following definition of renewable energy sources: "Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action." Note that this definition defines renewable energy according to its primary source, which contrasts with other definitions that define any recurring waste stream as renewable.[1]

One concern in defining renewable energy fuels is how municipal solid waste (MSW) should be classified. Historically, because MSW has widely been viewed as principally composed of biomass, EIA has classified all consumption at MSW combustion plants as a renewable portion of "Waste Energy."[2] However, according to EIA's definition above, MSW clearly contains non-renewable components, raising a concern that EIA has been overstating the renewable content of MSW.

EIA recognizes that definitions of renewable energy used for State and federal energy policy purposes differ widely as to whether and to what extent MSW is included. For example, some States renewable portfolio standard (RPS) programs include all or part of MSW-fueled generation as an RPS-eligible generation source, while others do not. At the federal level, the treatment of MSW as a form of renewable energy varies across programs, laws, and even across sections of a given statute. For example, the definition of renewable energy in Section 203 of the Energy Policy Act of 2005 explicitly includes MSW-derived electricity as a "renewable energy" resource eligible to satisfy the federal renewable energy purchase requirement established in that section. Yet, many other sections of the same bill do not include MSW as an eligible renewable energy source for purposes of programs that aim to develop, assess, or support renewable energy.

To address this issue, EIA investigated whether sufficient information exists to reasonably divide MSW into its biogenic and non-biogenic portions. As a result, EIA has concluded that sufficient information does exist to reasonably estimate the split of energy produced from biogenic and non-biogenic components of MSW.

As a source of policy-neutral energy data, it is important for EIA to apply a consistent approach to defining renewable energy in its standard data reports. EIA will now include MSW in renewable energy only to the extent that the energy content of the MSW source stream is biogenic. This approach is more consistent with the definition of renewable energy used by EIA than alternatives that would either include or exclude all MSW from renewable energy. EIA's treatment of MSW's contribution to an aggregate

[1] Webster's Online Dictionary, for example, defines renewable as "Capable of being replaced by ecological cycles or sound management practices."

[2] Energy Information Administration, *Annual Energy Review*, Table 10.1, Renewable Energy Consumption by Source, http://www.eia.doe.gov/emeu/aer/pdf/pages/sec10_3.pdf).

measure of renewable energy is not intended to infringe on the prerogative of policymakers at the federal and/or State level to adopt one or more definitions of renewable energy that use a different approach to classifying MSW for their distinct policy purposes. Rather, our aim is to present energy data in a clear and consistent way, with enough detail that others can develop data consistent with whatever definition suits their objective.

MSW is primarily composed of residential solid waste but also includes some types of non-hazardous commercial, institutional and industrial wastes. MSW can be problematic to discard because of its large volume: one commonly adopted solution is to combust the MSW, which both decreases the volume of material and creates energy that can be recovered in the form of heat or steam. Because some materials have higher heat content than others, the amount of energy that can be produced by combusting MSW is a function of the composition of the waste stream.[3] For example, certain types of plastics have more than three times the heat content of yard trimmings or organic textiles. In general, combustible non-biogenic materials are characterized by higher heat contents per unit weight than combustible biogenic materials. Thus, the ratio of biogenic to non-biogenic material volumes can have a considerable effect on the heat content of the waste stream.

2. Summary of Activities

Using data from EIA, the Environmental Protection Agency (EPA), and fuel-specific Btu values, EIA determined two interrelated trends in the composition of the MSW stream. First, the heat content (per unit weight) of the waste stream has been steadily increasing over time. Second, the shares of energy contributed to the waste stream by biogenic and non-biogenic components have been changing over time. In 1989, biogenic materials contributed two-thirds of the heat content of the waste stream. By 2005, that number had dropped to 56 percent (see Table 1 and Figure 1). This change can likely be attributed to the changing composition of the MSW stream, as increasingly more plastics are being discarded at the same time that decreasing amounts of paper and paper products are entering the waste stream.

Based on this historical information, EIA has developed estimates of biogenic and non-biogenic MSW energy consumption (Table 2) to aid EIA in predicting the change in MSW composition over time. In keeping with the above trends, EIA estimates that non-biogenic MSW energy consumption grew slightly faster than total MSW energy consumption over the period from 1989-2005.

EIA is applying these results beginning with data for 2006, reporting only the biogenic portion of MSW as renewable energy for purposes of the National Energy Information System. The non-biogenic portion will be reported as a component of Other Non-Renewable Waste.[4] That is, MSW consumption data will be divided into renewable and non-renewable energy based on the estimated heat content of the biogenic and non-biogenic portions of MSW (Table 1). MSW data will be revised back to 2001 in the

[3] Heat content is measured in British thermal units (Btu) by weight

[4] This renewable component of MSW will also be reflected in restatements of prior data back to 2001.

Electric Power Monthly (*EPM*) (Table 2). EIA is publishing MSW generation and consumption split into its biogenic (renewable) and non-biogenic (non-renewable) portions in the March 2007 publications of the *Monthly Energy Review* and the *EPM*, which publish December 2006 preliminary data for the first time, and revises 2001 through November 2006 data.

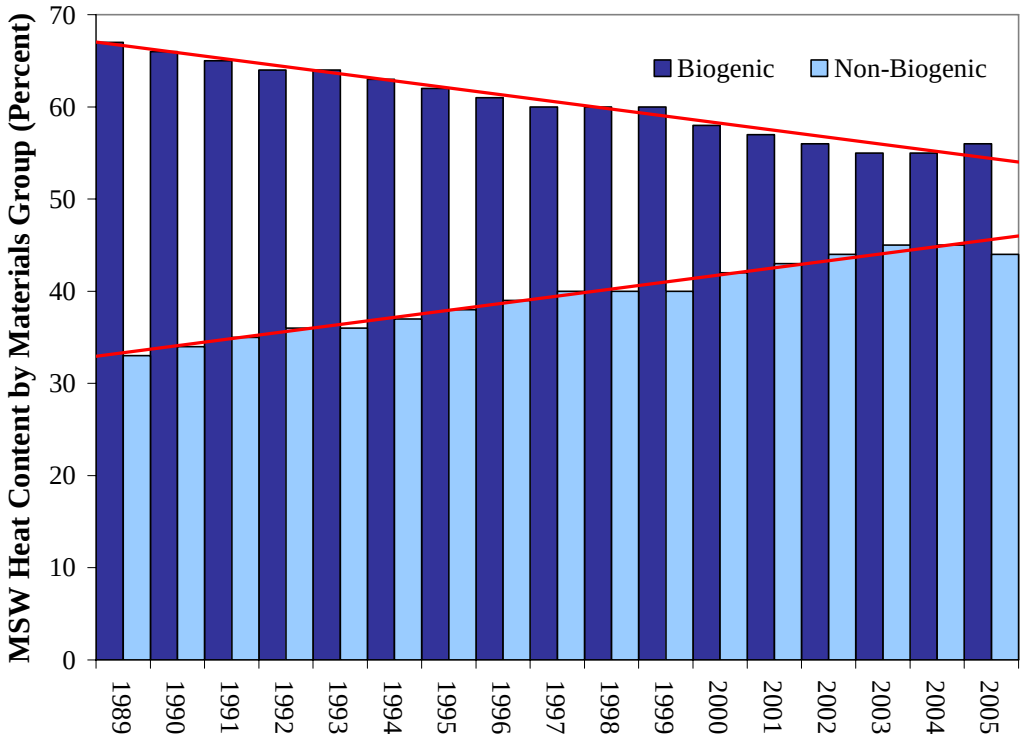
The remainder of this article describes the history of MSW and the methodology EIA will use to estimate the portions of energy derived from biogenic and non-biogenic MSW.

Table 1. Municipal Solid Waste (MSW) Heat Content and Biogenic/Non-Biogenic Shares, 1989-2005

Year	Heat Content (Million Btu/Ton)	Shares of Total MSW Energy	
		Biogenic	Non-Biogenic
1989	10.08	0.67	0.33
1990	10.21	0.66	0.34
1991	10.40	0.65	0.35
1992	10.61	0.64	0.36
1993	10.94	0.64	0.36
1994	11.15	0.63	0.37
1995	11.11	0.62	0.38
1996	10.94	0.61	0.39
1997	11.17	0.60	0.40
1998	11.06	0.60	0.40
1999	10.95	0.60	0.40
2000	11.33	0.58	0.42
2001	11.21	0.57	0.43
2002	11.19	0.56	0.44
2003	11.17	0.55	0.45
2004	11.45	0.55	0.45
2005	11.73	0.56	0.44

Note: Years in bold are EPA data collection years. Non-bolded years have been linearly interpolated at the materials group level between immediately surrounding bolded years.
Sources: Heat Content (Million Btu/ton) is derived from Environmental Protection Agency, *Municipal Solid Waste in the United States: 2005 Facts and Figures*, Table 4. http://www.epa.gov/msw/msw99.htm
Biogenic and non-biogenic percentages are EIA estimates.

Figure 1. Trends in Municipal Solid Waste (MSW) Composition



Source: Table 1 and Environmental Protection Agency, *Municipal Solid Waste in the United States: 2005 Facts and Figures*. http://www.epa.gov/msw/msw99.htm

Table 2. Municipal Solid Waste (MSW) Consumption: Biogenic (Renewable) and Non-Biogenic Energy (Non-Renewable)
(Trillion Btu)

	2001	2002	2003	2004	2005
Total	289	325	293	299	299
Biogenic (Renewable)	165	182	161	164	167
Non-Biogenic (Non-Renewable)	124	143	132	135	132

Sources: Total MSW consumption: Form EIA-906, "Power Plant Report" and Form EIA-920, "Combined Heat and Power Plant." Biogenic (Renewable) and non-biogenic (non-renewable) shares: EIA estimate.

3. History

Although the first facility that combusted MSW for energy came on line in New York City in 1898, the industry did not experience rapid growth until 1978 with the enactment of the Public Utility Regulatory Policy Act (PURPA).[5] This legislation made it mandatory for utilities to purchase electricity from qualifying facilities (QFs), which were defined as "cogeneration or small power production facilities that meet certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission pursuant to (PURPA)." This new law improved the economics

[5] Public Law 95-617, Public Utility Regulatory Policies Act of 1978.

of the many MSW waste-to-energy plants that qualified as QFs. PURPA mandated the price paid for electricity be equal to the utility's avoided cost of energy and capacity, and this resulted in MSW QFs receiving a higher price for their power than they might otherwise have received.[6] MSW plants also benefited from the increased cost of landfilling due to increases in "tipping fees" (the cost to dump waste at a landfill), making disposing of MSW at a waste-to-energy plant less expensive than at a landfill in many cases.

MSW waste-to-energy plants have high capital costs, and in order to make these plants financially viable, project financers required the plant to obtain a reliable stream of low-cost fuel. Usually, a plant would enter into a "flow contract" in which a municipality delivered its waste stream to a specific plant. Thus, certain facilities held a *de facto* monopoly over a certain locality's MSW. In some cases, these contracts were seen as restricting interstate commerce in municipal wastes, and in 1994 the U.S. Supreme Court upheld a challenge to flow control, finding that it violated the interstate commerce clause of the Constitution. This ruling partially or fully voided many flow supply contracts and created an added constraint on the waste-to-energy industry. Subsequent to this ruling, few plants have been able to come on line.

EIA tracks all electricity-generating plants with a capacity greater than 1 megawatt on survey forms EIA-906 "Power Plant Report" and EIA-920 "Combined Heat and Power Plant Report", including information on all MSW combustion facilities that meet this minimum capacity requirement. Historically, MSW and landfill gas (LFG) have been reported as the same fuel code on these surveys, but starting in 2001, MSW and LFG were reported as separate fuels. Therefore EIA has data that depict total MSW consumption from the year 2001 onward.

EPA maintains historical data on MSW (Table 3 below).

Table 3. Municipal Solid Waste (MSW) Disposal
(Percent by Weight)

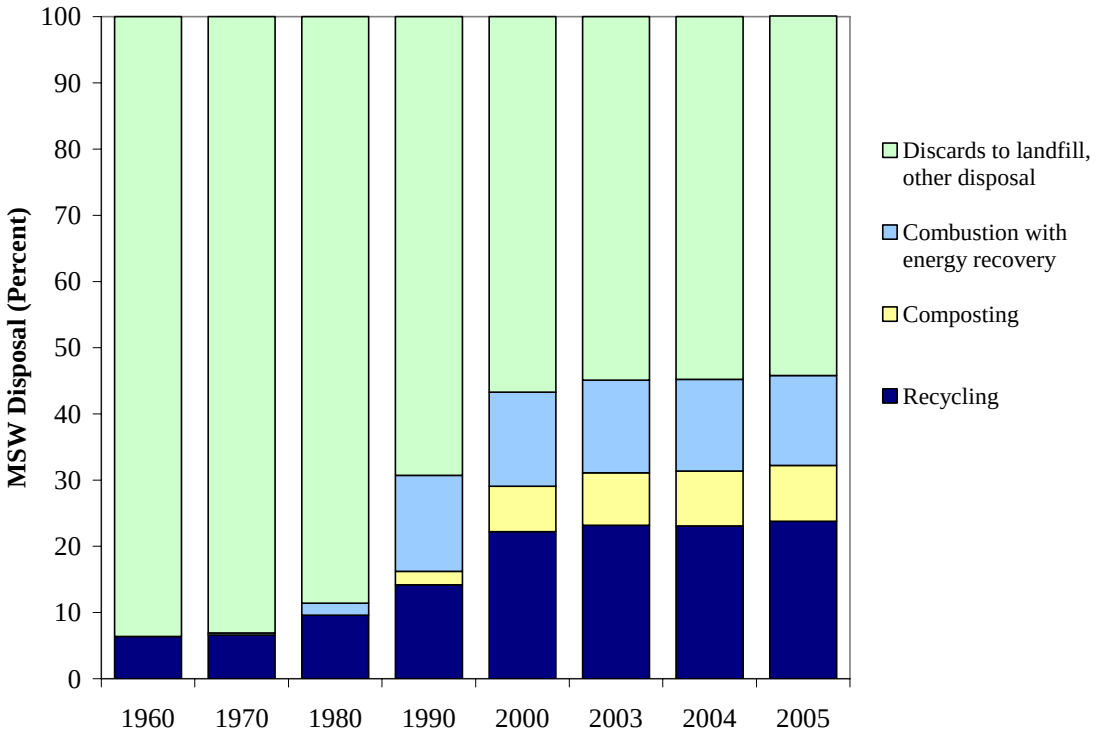
Year	1960	1970	1980	1990	2000	2003	2004	2005
Total materials recovery	6.4	6.6	9.6	16.2	29.1	31.1	31.4	32.1
Recycling	6.4	6.6	9.6	14.2	22.2	23.2	23.1	23.8
Composting [a]	s	s	s	2	6.9	7.9	8.3	8.4
Combustion with energy recovery [b]	0	0.3	1.8	14.5	14.2	14	13.8	13.6
Discards to landfill, other disposal [c]	93.6	93.1	88.6	69.3	56.7	54.9	54.8	54.3

[a] Composting of yard trimmings, food scraps, and other MSW organic material. Does not include backyard composting.
[b] Includes combustion of MSW in mass burn, modular, and refuse-derived fuel plants.
[c] Includes all other MSW that is not recovered for recycling, composting or combustion (with energy recovery). These discards are generally disposed of in landfills.
Note: Details may not add to totals due to rounding.

[6] The incremental cost to the electric utility of alternative electric energy which the utility would have generated or purchased from another source

Source: Environmental Protection Agency, Municipal *Solid Waste in the United States: 2005 Facts and Figures*. http://www.epa.gov/msw/msw99.htm
s=value less than 0.01 percent of total.

Figure 2. Municipal Solid Waste Disposal (MSW)



Source: Table 3 and Environmental Protection Agency, *Municipal Solid Waste in the United States: 2005 Facts and Figures*. http://www.epa.gov/msw/msw99.htm

4. Data Sources

Splitting MSW energy inputs into biogenic and non-biogenic components required three categories of data. First, the total amount of energy input to MSW combustion plants was obtained from EIA Forms EIA-906 and EIA-920 (Table 2). Second, data concerning the composition of the MSW stream were obtained from EPA's publication *Municipal Solid Waste in the United States*, which has been published yearly or bi-annually since 1995 (see Appendix, Table A1 for data from 1989-2005). Third, the energy content applicable to each of the combustible materials in the MSW plant input stream was obtained from the best sources EIA could identify. For most biomass fuels, EIA used Btu values published in Table B6 of the *Renewable Energy Annual* (Average Heat Content of Selected Biomass Fuels), http://www.eia.doe.gov/cneaf/solar.renewables/page/rea_data/tableb6.html. The heat content values for the remaining biomass fuels and all non-renewable fuels were obtained from various non-EIA sources. Table 4 lists the Btu content used for each component of the waste stream and the sources for that data. In some cases, the Btu value calculated was an average of several sources.

Table 4. Typical Heat Content of Materials in Municipal Solid Waste (MSW)
(Million Btu Per Ton)

Materials	Million Btu per ton
Plastics	
Polyethylene terephthalate [c, e] (PET)	20.5
High density polyethylene [e] (HDPE)	38.0
Polyvinyl chloride [c] (PVC)	16.5
Low density polyethylene/ Linear low density polyethylene [e] (LDPE/LLDPE)	24.1
Polypropylene [c] (PP)	38.0
Polystyrene [c] (PS)	35.6
Other [e]	20.5
Rubber [b]	26.9
Leather [d]	14.4
Textiles [c]	13.8
Wood [b]	10.0
Food [a, c]	5.2
Yard trimmings [b]	6.0
Newspaper [c]	16.0
Corrugated Cardboard [c, d]	16.5
Mixed paper [e]	6.7

a Includes recovery of other MSW organics for composting.
b Energy Information Administration, Renewable Energy Annual 2004, "Average Heat Content of Selected Biomass Fuels," (Washington, DC, 2005).
c Penn State Agricultural College Agricultural and Biological Engineering and Council for Solid Waste Solutions, Garth, J. and Kowal, P. Resource Recovery, Turning Waste into Energy, University Park, PA, 1993.
d Bahillo, A. et al. Journal of Energy Resources Technology, "NOx and N2O Emissions During Fluidized Bed Combustion of Leather Wastes," Volume 128, Issue 2, June 2006. pp. 99-103.
e Utah State University Recycling Center Frequently Asked Questions. http://www.usu.edu/recycle/faq.htm

5. Methodology Used to Estimate Biogenic and Non-Biogenic-Sourced MSW

Beginning in 1989 and for each year that EPA data exist, the potential quantities of combustible MSW discards (which include all MSW material available for combustion with energy recovery, discards to landfill, and other disposal) shown in Table A1 were multiplied by their respective Btu contents (Table 4). These EPA-based categories of MSW were then classified into biogenic and non-biogenic groupings (Table 5). From this, EIA was able to calculate how much of the energy potentially consumed from MSW should be attributed to renewables (biogenic) and how much should be put in the category of "other, non-renewable (non-biogenic) fuels."

Table 5. Municipal Solid Waste (MSW) Material Categories in Biogenic and Non-Biogenic Groups

Biogenic	Non-Biogenic
Newsprint	Plastics
Paper	PET
Containers & packaging	HDPE
Textiles	PVC
Yard trimmings	LDPE/LLDPE
Food wastes	PP
Wood	PS
Other biogenic	Other plastics
Leather	Rubber
	Other non-biogenic

Note: For explanation of plastics abbreviations, see Appendix C.

Specifically, the procedure to calculate the division is as follows:
(For calculations with 2005 as an example, see Appendix B)

1. Obtain the total weight of MSW discarded in a data year (Table A1).
2. For materials that are not combusted, set Btu values to zero, (e.g., glass and metals).[7]
3. Separate the remaining MSW weights into biogenic and non-biogenic fuel groups (Table 5). These two groups represent the weight of biogenic and non-biogenic materials that are theoretically available to MSW plants for combustion.
4. Multiply the Btu per ton factors from Table 4 by the total number of tons of each materials group estimated to be available for combustion. This provides both a weighted average estimate of the total Btu available to MSW plants for each EPA fuel group and a total weighted Btu per ton value for an average ton of MSW.
5. Calculate the biogenic and non-biogenic percentages of the estimated waste stream input to MSW combustion facilities.
6. Multiply these percentages by the MSW consumption data (in Btu) to estimate the total Btus available from biogenic versus non-biogenic sources (Table 2).
7. Repeat for all data years, and interpolate linearly between years to obtain the final estimates of shares of biogenic and non-biogenic MSW energy consumption (Table 1).

5.1. Caveats and Assumptions

1. The data provided by EPA are available only at the national level. Therefore, the assumed rates of recycling or MSW generation may not hold true for all States and regions.

[7] This does not mean that recycling such materials has no net effect on energy use. Rather, it reflects the fact that waste-to-energy facilities do not derive any energy from these sources.

2. The composite MSW HHV by year (Table 1) is not representative of the MSW HHV reported by EIA respondents. This is because respondent data did not include MSW composition information, which was necessary to divide MSW into biogenic and non-biogenic shares. For the purposes of determining a split, the small difference (between EIA respondent MSW HHV and calculated MSW HHV) most likely does not affect the results.
3. Discards available for combustion represent the average mixture of MSW available on a national level, which may or may not be representative of the mixture of MSW obtained by any particular MSW combustion facility.
4. Btu values were obtained from best available sources and may have been developed using different procedures.
5. All fuels have a range of Btu values from lower heating value (LHV) to higher heating value (HHV).[8] If the source did not specify which of these the value represented, it was assumed to represent HHV.
6. The EPA data divide categories of materials into sub-groups (for example, plastics are divided into seven sub-groups), each of which has a specific Btu content. However, in some cases, it is not clear what is included in the "other" category within a fuel group. Because of this, "other plastics" was assigned a heat content equal to the value of the average of all plastics groups not in the "other" category.
7. Unassigned "Other" is divided evenly between the renewable and non-renewable groups.
8. MSW input materials were classified as biogenic or non-biogenic according to their predominant composition.
    a. All rubber is assumed to be tires with the metals, fiber, and other material removed. Therefore, the rubber is assumed to be synthetic, and is treated as a non- biogenic material.[9]
    b. Textiles are all assumed to be composed of biogenic materials and are thus treated as biogenic.
9. Depending on plant design, some MSW plants may need to remove glass and metals prior to combustion. Because of their poor combustion characteristics, these materials do not produce significant heat when combusted, and may in fact reduce the net heat output of a plant. In order to allow for uniform analysis of waste stream heat contents, the Btu values of glass and metal were set at zero.
10. For the years EPA did not collect data, values for Btu content and the biogenic/non-biogenic split were interpolated linearly between the nearest prior and subsequent survey years.

[8] The heat content rates (i.e., thermal conversion factors) can either represent the gross (HHV) energy content of the fuels, or the net (LHV) energy content. HHV rates are applied in all Btu calculations for EIA's *Annual Energy Review* and are commonly used in energy calculations in the United States; LHV rates are typically used in European energy calculations. The difference between the two rates is the amount of energy that is consumed to vaporize water created during the combustion process. Generally, the difference rages from 2 percent to 10 percent, depending on the specific fuel and its hydrogen content. Some fuels, such as unseasoned wood, can be more than 40 percent different in their gross and net heat contents.

[9] Rubber Manufacturer's Association, Scrap Tire Characteristics, http://www.rma.org/scrap_tires/scrap_tire_markets/scrap_tire_characteristics/, accessed February 2007.

6. Results

As a result of this analysis, EIA has decided to split MSW into biogenic and non-biogenic components for its future data releases. This biogenic component of MSW will also be reflected in restatements of prior data back to 2001 when EIA began to collect MSW as a separate fuel.

In standard energy data reports, EIA will now include MSW in renewable energy only to the extent that the energy content of the MSW source stream is biogenic. This approach is more consistent with the definition of renewable energy used by EIA than alternatives that would either include or exclude all MSW from renewable energy. EIA's treatment of MSW's contribution to an aggregate measure of renewable energy is not intended to infringe on the prerogative of policymakers at the federal and/or State level to adopt one or more definitions of renewable energy that use a different approach to classifying MSW for their distinct policy purposes. Rather, our aim is to present energy data in a clear and consistent way, with enough detail that others can develop data consistent with whatever definition suits their objective.

As discussed above, the calculations performed revealed two trends.

1. The Btu content per ton of MSW is steadily increasing over time (Table 1).
2. The percentage of MSW's total energy content that comes from biogenic resources is decreasing, while the percentage of energy content from non-biogenic resources is increasing (Figure 1).

These trends are clearly interrelated and are most likely attributable to two factors. First, the percentage of paper and paperboard recycled has increased from 40 percent by weight in 1996 (the first year for which complete data are available) to 50 percent in 2005, while the amount combusted rose by only 3 percent (from 81.5 million tons to 84 million tons). Second, the amount of plastic combusted has increased dramatically, from 19 million tons in 1996 to 28.9 million tons in 2005, while the recycling rate grew only half of 1 percent (from 5.2 percent to 5.7 percent). These two factors have combined to decrease the amount of biogenic material in the waste stream while increasing the amount of non-biogenic material, mainly plastics, which have one of the highest Btu contents of any fuel group in MSW.

The historical trends observed in biogenic/non-biogenic MSW composition and energy content may change as a result of EPA's national policy designed to increase the recycling rates of all materials in MSW. However, it is difficult to predict if this policy will have differing effects on the biogenic and non-biogenic components of MSW and therefore EIA cannot forecast what effect this policy will have on the heat content of the waste stream. Until the effect of EPA's policy becomes clear, EIA expects that the energy content of MSW will continue to grow over time. EIA will continue to update its estimates of the biogenic and non-biogenic portions of MSW as revised EPA data become available. For purposes of standard EIA data reports, only the biogenic portion of MSW will be included in aggregate measures of renewable energy.

Appendix A. Data by Materials Category

Table A1. Municipal Solid Waste (MSW) Weights by Category, 1989-2005

(Million Tons)

Discards	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Textiles	4.87	5.15	5.30	5.48	5.64	5.80	6.50	6.70	7.10	7.50	7.90	8.10	8.40	8.74	9.08	9.24	9.40
Yard Trimmings	30.47	30.80	29.00	27.20	25.40	23.60	20.80	17.20	16.20	15.65	15.10	11.90	12.20	12.35	12.50	12.37	12.23
Food Wastes	20.02	20.80	19.00	17.20	15.40	13.60	13.40	21.40	21.30	22.95	24.60	25.20	25.50	26.18	26.85	27.68	28.50
Wood	11.57	12.08	12.36	12.64	12.92	13.20	13.50	10.30	11.00	11.30	11.60	12.20	11.90	12.11	12.32	12.46	12.59
Other	5.30	5.40	5.53	5.65	5.78	5.90	6.00	6.10	6.30	6.40	6.50	8.60	6.80	6.88	6.96	7.63	8.30
Glass	10.86	10.47	10.40	10.34	10.34	10.20	9.70	9.20	9.10	9.40	9.70	9.90	10.20	10.18	10.15	10.09	10.02
Rubber	4.13	4.24	4.34	4.43	4.53	4.63	4.73	4.90	5.01	5.09	5.17	4.77	4.49	4.66	4.83	4.85	4.88
Leather	1.15	1.18	1.21	1.24	1.26	1.29	0.77	0.80	0.80	0.82	0.83	0.83	0.88	0.89	0.90	0.88	0.86
Metals	12.75	12.58	11.91	11.24	11.24	9.90	9.60	9.70	9.90	10.70	11.50	11.66	11.80	11.88	11.96	11.85	11.74
Paper & Paperboard																	
Newsprint	7.27	7.40	7.40	7.41	7.41	7.41	6.17	5.64	6.12	6.03	5.94	6.28	4.85	3.54	2.23	4.13	6.03
Paper	23.99	24.41	24.42	24.42	24.43	24.44	24.58	23.78	24.49	25.11	25.72	23.78	23.00	23.48	23.96	20.20	16.44
Containers & Packaging	20.33	20.69	20.70	20.71	20.71	20.72	18.17	17.90	18.31	17.91	17.51	17.31	17.27	17.11	16.94	18.24	19.53
Plastics																	
PET	1.17	1.24	1.28	1.32	1.36	1.40	1.33	1.35	1.54	1.69	1.84	2.06	2.11	2.29	2.46	2.58	2.70
HDPE	2.76	2.93	3.03	3.12	3.22	3.31	3.15	3.17	4.21	4.37	4.52	4.41	4.49	4.58	4.67	5.11	5.55
PVC	1.31	1.40	1.44	1.49	1.53	1.58	1.50	1.23	1.32	1.35	1.37	1.39	1.42	1.45	1.47	1.51	1.55
LDPE/LLDPE	4.42	4.70	4.85	5.00	5.15	5.29	5.04	4.90	5.28	5.24	5.20	5.59	5.73	5.90	6.06	6.07	6.08
PP	2.44	2.59	2.67	2.76	2.84	2.92	2.78	2.45	2.67	2.67	2.67	3.34	3.45	3.53	3.60	3.69	3.77
PS	1.95	2.08	2.14	2.21	2.28	2.34	2.23	1.96	2.09	2.12	2.15	2.28	2.29	2.28	2.27	2.36	2.44
Other	1.72	1.83	1.88	1.94	2.00	2.06	1.96	3.10	3.24	3.33	3.41	4.30	4.50	4.62	4.73	4.95	5.17
Total	168.49	172	168.9	165.8	163.4	159.6	151.9	151.8	156	159.6	163.2	163.9	161.3	162.6	163.9	165.9	167.8

Notes: Totals may not equal the sum of all components due to independent rounding. Discards includes all MSW material available for combustion with energy recovery, discards to landfill, and other disposal. For explanation of plastics abbreviations, see Appendix C.

Source: Environmental Protection Agency, *Municipal Solid Waste in the United States*, 2005. http://www.epa.gov/msw/msw99.htm

Table A2. Paper and Paperboard Products Weights in Municipal Solid Waste (MSW) by Category, 2005
(Thousand Tons)

Material	Generation	Recovery	Discards
Newsprint	9,790	8,730	1,060
Groundwood Inserts	2,260	1,980	280
Books	1,120	260	860
Magazines	2,520	970	1,550
Office Papers [a]	6,580	4,120	2,460
Telephone Directories	660	120	540
Standard Mail [b]	5,830	2,090	3,740
Other Commercial Printing	7,340	760	6,580
Tissue Paper and Towels	3,430	s	3,430
Paper Plates and Cups	970	s	970
Other Non-Packaging Paper [c]	4,410	s	4,410
Corrugated Boxes	30,930	22,100	8,830
Milk Cartons	420	s	420
Folding Cartons	4,970	590	4,380
Other Paperboard Packaging	150	s	150
Bags and Sacks	1,190	250	940
Other Paper Packaging	1,370	s	1,370
Total Paper and Paperboard	83,940	41,970	41,970

[a] High-grade papers such as copy paper and printer paper.
[b] Formerly called Third Class Mail by the U.S. Postal Service.
[c] Includes tissue in disposable diapers, paper in games and novelties, cards, etc.
s=value less than 5,000 tons.
Notes: Details may not add to totals due to rounding. Discards includes all MSW material available for combustion with energy recovery, discards to landfill, and other disposal.
Source: Environmental Protection Agency, *Municipal Solid Waste in the United States*, 2005. http://www.epa.gov/msw/msw99.htm

Table A3. Plastic Products Weights in Municipal Solid Waste (MSW) by Category, 2005
(Thousand Tons)

Resin	Generation	Recovery	Discards
PET	2,860	540	2,320
HDPE	5,890	520	5,370
PVC	1,640	NA	1,640
LDPE/LLDPE	6,450	190	6,260
PP	4,000	10	3,990
PS	2,590	NA	2,590
Other resins	5,480	390	5,090
Total Plastics in MSW	28,910	1,650	27,260

Notes: Some detail of recovery by resin omitted due to lack of data. This table understates the recovery of plastics due to the dispersed nature of plastics recycling activities. Discards includes all MSW material available for combustion with energy recovery, discards to landfill, and other disposal. For explanation of

plastics abbreviations see Appendix C.
Source: Environmental Protection Agency, *Municipal Solid Waste in the United States*, 2005. http://www.epa.gov/msw/msw99.htm

Table A4. Rubber and Leather Products Weights in Municipal Solid Waste (MSW) by Category, 2005
(Thousand Tons)

Material	Generation	Recovery	Discards
Rubber in Tires [a]	2,760	960	1,800
Other Durables [b]	2,920	s	2,920
Clothing and Footwear	700	s	700
Other Non-durables	290	s	290
Containers and Packaging	30	s	30
Total Rubber & Leather	6,700	960	5,740

[a] Automobile and truck tires. Does not include other material in tires.
[b] Includes carpets, rugs, and other miscellaneous durables.
s=value less than 5,000 tons.
Notes: Details may not add to totals due to independent rounding. Discards include all MSW material available for combustion with energy recovery, discards to landfill, and other disposal.
Source: Environmental Protection Agency, *Municipal Solid Waste in the United States*, 2005. http://www.epa.gov/msw/msw99.htm

Appendix B. Calculations for 2005 as an Example

Table B1. Calculations to Obtain Average Million Btu Per Ton for Municipal Solid Waste (MSW)

Material Group	Discards (million tons)[a]	Heat Content (million Btu per ton) [b]	Heat Contributed (trillion Btu)
Newsprint	6.03	16.00	96.48
Paper	16.44	6.70	110.15
Containers & Packaging	19.53	16.50	322.25
Plastics			
PET	2.70	20.45	55.22
HDPE	5.55	19.00	105.45
PVC	1.55	16.50	25.58
LDPE/LLDPE	6.08	24.10	146.53
PP	3.77	38.00	143.26
PS	2.44	35.60	86.86
Other	5.17	20.50	105.99
Rubber	4.88	26.86	131.08
Leather	0.86	14.40	12.38
Textiles	9.40	13.80	129.72
Yard Trimmings	12.23	6.00	73.38

Food Wastes	28.50	5.20	148.20
Wood	12.59	9.96	125.40
Other	8.30	18.10	150.23
Glass	10.02	0.00	0.00
Metals	11.74	0.00	0.00
Total	167.78	11.73	1968.14

Total Btu/Total Tons → 1968.14 ÷ 167.78 = 11.73 Million Btu/Ton of MSW

[a] Table A1.
[b] Table 4.
Notes: Discards includes all MSW material available for combustion with energy recovery, discards to landfill, and other disposal. For explanation of plastics abbreviations, see Appendix C.
Source: Environmental Protection Agency, Municipal Solid Waste in the United States, 2005. http://www.epa.gov/msw/msw99.htm

Table B2. Biogenic and Non-Biogenic Contributions to Total Million Btu/Million Ton of Municipal Solid Waste (MSW)

Biogenic	Share	Non-Biogenic	Share
Newsprint	0.05	Plastics	
Paper	0.06	PET	0.03
Containers & Packaging	0.16	HDPE	0.05
Leather	0.01	PVC	0.01
Textiles	0.07	LDPE/LLDPE	0.07
Yard Trimmings	0.04	PP	0.07
Food Wastes	0.08	PS	0.04
Wood	0.06	Other plastics	0.05
Other Biogenic	0.04	Rubber	0.07
		Other Non-Biogenic	0.04
Total	0.56	Total	0.44

Note: For explanation of plastics abbreviations, see Appendix C.
Source: Biogenic and non-biogenic estimation methodology documented in this report.

Appendix C. Abbreviations

Btu – British Thermal Units
EIA – Energy Information Administration
EPA – Environmental Protection Agency
HDPE - High density polyethylene
HHV – Higher heating value
LDPE/LLDPE - Low density polyethylene/ Linear low density polyethylene
LFG – Landfill gas
LHV – Lower heating value
MSW – Municipal solid waste
PET - Polyethylene terephthalate
PVC - Polyvinyl chloride
PP - Polypropylene
PS - Polystyrene
RDF – Refuse derived fuel

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