Analyzing the costs of composting strategies
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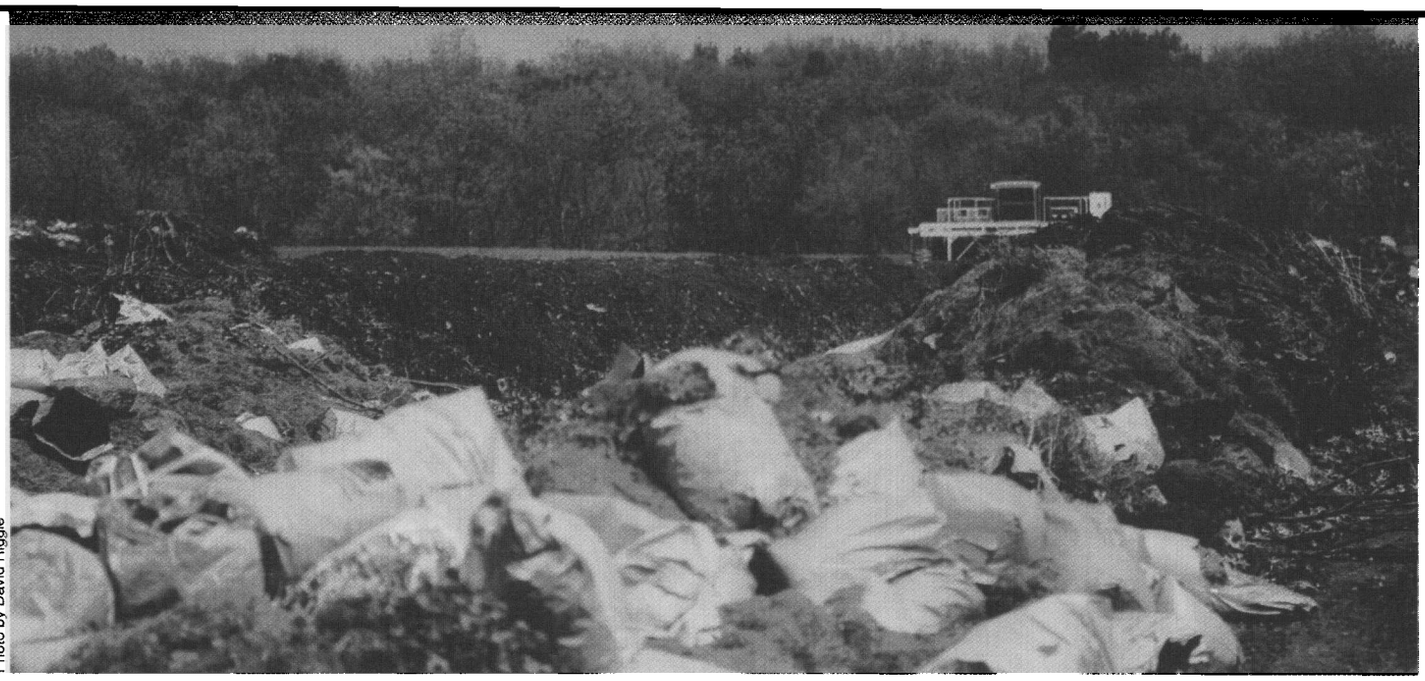

Photo by David Riggle

MAXIMIZING ORGANICS DIVERSION

ANALYZING THE COSTS OF COMPOSTING STRATEGIES

A recent EPA report first estimates quantities of compostables in the MSW stream, then runs through various composting strategies to determine a cost/ton basis for diversion through each method.

Paul J. Ligon and George Garland

THE U.S. Environmental Protection Agency's Office of Solid Waste released a report, *Organic Materials Management Strategies* (OMMS), in May, 1998. The OMMS explores the national potential for widespread implementation of composting strategies that have been used successfully throughout the United States. These include grasscycling, backyard home composting, on-site institutional composting, municipal yard trimmings composting, commercial composting, mixed waste composting, and residential source separated composting. For each strategy, the report uses information from EPA's *Characterization of Municipal Solid Waste in the United States: 1996 Update* to estimate national quantities of organic materials available for composting. Estimates in this article use information from the recently released *'97 Update*.

The estimated mid-range cost of yard trimmings composting is $66.02/ton diverted — $44.37/ton for collection and $21.65/ton for composting.

The OMMS report addresses organic materials in the municipal solid waste stream that are recovered by existing composting operations. This focus was chosen for consistency with the EPA's characterization studies, which only addresses a select set of nonhazardous materials generated by municipal, commercial and institutional sources. Because of this focus, some organic residuals that may have important implications for composting — such as biosolids and industrial food processing and agricultural residuals — were not considered in the report. Information from existing composting programs was used to identify the types of organic MSW materials typically targeted by the compost strategies analyzed. The *'97 Update* indicates that over one-third of the U.S. waste stream consists of organic materials — 28 million tons of yard trimmings, 21.9 million tons of food residuals, and 24.8 million tons of soiled or unrecyclable paper (see Table 1). Although about 11 million tons of these materials (primarily yard trimmings) were recovered for composting in 1996, most of the remaining 63 million tons were discarded in disposal facilities.

ASSESSING POTENTIAL FOR DIVERSION

For each of the seven strategies analyzed, a review of six to ten existing operations was conducted to develop the following information:

1) Strategy description providing general design features along with illustrative examples from existing operations throughout the U.S.; 2) Technical problems — the diffi-

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Table 1. Materials in U.S. MSW available for composting (1996)

Materials Targeted By Strategies Analyzed	Generation (thousands of tons)
Yard trimmings	28,000
Food wastes	21,900
Folding cartons	5,390
Other nonpackaging paper	4,120
Tissue paper/towels	2,980
Bags and sacks	1,980
Other paper packaging	1,350
Corrugated boxes	7,300
Paper plates, cups	950
Milk cartons	460
Other paperboard packaging	230
Wrapping papers	50
Total organic materials	74,710
Total MSW	209,660
% MSW available for composting	36%

Source: Organic Materials Management Strategies and Characterization of Municipal Solid Waste in the United States: 1997 Update

culties and limitations of each strategy; 3) Applicable portion of the national waste stream that could be targeted by the strategy; and 4) Cost per ton diverted — calculated by taking the capital and operating costs from existing programs to determine a high, low and mid-range cost per ton diverted for each strategy.

Table 2 provides a summary of the seven strategies analyzed. One cannot get a sum of the tonnage values shown in the "available tons" column because more than one strategy may target the same materials. For example, grasscycling, home composting and municipal yard trimmings programs all target grass clippings and, thus, grass quantities are included in the applicable tons for each strategy. The Compost Strategy Savings Curve discussed in the final section of this article illustrates the most cost-effective combination of strategies that could be used to capture the nation's compostable waste stream.

GRASSCYCLING PROGRAMS

Of the 28 million tons of yard trimmings generated annually, approximately 50 percent are grass clippings. Therefore, the available portion of yard trimmings that potentially could be targeted by grasscycling programs is 14 million tons.

Staff time required for public education often represents the only cost associated with grasscycling. Some programs also offer rebates for mulching equipment. Cost per ton diverted through grasscycling programs can be calculated based on the program cost in the first year. However, once residents have been educated about grasscycling (the start-up program cost), they probably will not need to be educated again each year. Therefore, Table 3 assumes that the cost of educating a given generator to grasscycle is incurred only one time, and that the program's impact (i.e., the quantity of waste di-

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Table 2. Summary of individual organic materials management strategies

Strategy	Strategy Description	Materials Targeted	Available Tons (Millions/Yr)	Range ($/Ton)	Mid-Range ($/Ton)
Grasscycling	Primarily education and promotion	Residential and commercial grass	14.0	.26-7.04	1.00
Home composting	Education, promotion, and possibly bin distribution	Residential yard trimmings and food waste	30.6	5.00-15.68	12.90
On-site institutional composting	Institutions, such as universities, correctional facilities, and military bases, collect and compost organic materials on-site	Institutional food, select paper grades, and yard waste	2.4	29.00-98.00	49.00
Municipal yard trimmings collection and processing	Dedicated collection and processing of leaves, grass, and brush	Residential and commercial yard trimmings	28.0	21.65-88.21	55.00
Commercial composting	Dedicated collection of targeted materials; processing off site	Food and select paper grades	24.6	50.00-144.00	72.00
Mixed waste composting	Standard garbage collection; separation of compostable waste at a single facility; composting of organic materials	All commercial and residential organic waste	74.7	102.00-126.00	113.00
Residential source separated organics	Dedicated collection of targeted materials; processing at a central facility	Select paper grades, food, and yard trimmings	47.3	N/A	N/A

Source: Organic Materials Management Strategies

verted) lasts for five years before additional education or outreach is needed. This is a conservative estimate since most generators are likely to continue grasscycling after an initial training period. The first year average cost per ton diverted was amortized over five years to arrive at an estimated average cost of $1.03. Of the seven programs analyzed, costs per ton ranged from a low of $0.26/ton in Montgomery County, Ohio to a high of $7.04/ton in Dubuque, Iowa. The higher cost in Dubuque is likely due to the city's residential rebate program for mulching blade attachments.

HOME COMPOSTING

Of the 21.9 million tons of food scraps generated by the residential and commercial sectors, approximately 72 percent are compostable in backyard bins. This includes all food scraps except meat, fish, cheese, milk, and fats and oils. According to the *'97 Update*, about half of all food scraps are generated by the residential sector. Thus, the portion of food residuals generated by the residential sector that are available for backyard composting is about 7.9 million tons (21.9 million tons of food times 50 percent generated by residents times 72 percent available for backyard composting). Franklin Associates' *1994 Update of the Characterization of Municipal Solid Waste in the U.S.* (the only update that attempted to split residential and commercial data) indicated that about 90 percent of yard trimmings come from the residential sector. Making an allowance of 10 percent for large items (e.g. tree trunks and large limbs) that are not easily compostable, about 22.7 million tons of yard trimmings are available for backyard composting (28 million tons (total) times 90 percent generated by residents times 90 percent available). Thus, a total of 30.6 million tons of organic materials could be targeted by backyard compost programs. This estimate probably is conservative since some areas also encourage home composting of select paper and other organic residuals.

Costs for municipally sponsored home composting can vary greatly. Some programs include significant start-up costs associated with bin subsidization and initial education and outreach. In these cases, the costs for initiating the program are high compared to the amount diverted in the first year. But since bins typically last for seven years (and some now have warranties for up to 25 years) and only minimal additional funding may be needed to sustain the program, costs decrease over time. Although bin prices vary depending on the type and quantity purchased, they generally range from $25 to $50.

Backyard compost program costs are provided in Table 4. Tonnage impacts and costs per ton diverted assume seven years of program impact based on the assumed life of the bin. The programs are organized in Table 4 based on whether bin subsidies are provided. Subsidy programs tend to cost an average of $15.68/ton diverted over a bin's useful life, while programs emphasizing education cost an average of $5/ton diverted. The average cost of all backyard compost programs is about $12.90/ton diverted.

ON-SITE INSTITUTIONAL COMPOSTING

Institutions such as universities, schools, hospitals, correctional facilities and military installations are uniquely suited to composting because they typically generate large quantities of organic materials and have land available for composting. Institutional composting can reduce disposal costs or, as is the case at many universities, provide opportunities for research and development of new compost technologies. Data

Table 3. Grasscycling costs for select programs

Location	Grass Diverted (tons)	Program Cost($)	First Year ($/ton)	Five Year ($/ton)
Huntington Woods, Michigan	450	10,500	23.33	4.67
Montgomery County, Ohio	25,000	32,000	1.28	.26
Pinellas County, Florida	48,889	80,000	1.64	.33
Dubuque, Iowa	284	10,000	35.21	7.04
Islip, New York	20,000	300,000	15.00	3.00
SE Oakland Resource Recovery Authority, Michigan	9,000	55,000	6.11	1.22
Milwaukee, Wisconsin	29,677	200,000	6.74	1.35
Average		98,214	5.16	1.03

Source: Organic Materials Management Strategies

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Table 4. Home composting program costs

	Tons Diverted	Total ($)	Per Ton ($)
Bin Subsidy Programs			
Palm Beach County, Florida	9,737	135,500	13.92
Alameda County, California	28,000	537,600	19.20
Glendale, California	7,077	43,150	6.10
Amherst, Massachusetts	1,750	13,803	7.89
Subtotal	46,564	730,053	15.68
Education Programs			
Olympia, Washington	1,500	11,530	7.68
Ann Arbor, Michigan	13,000	25,000	1.92
East Chicago, Indiana	1,400	24,400	17.42
Austin, Texas	379	20,000	52.77
Subtotal	16,279	80,930	4.97
Total/average per ton	62,843	810,983	12.90

Source: Composting Council. Cost Benefit Analysis of Home Composting Programs, 1996

Table 5. Weighted average costs of select low and high tech on-site institutional composting operations

Facility	Composted (tons/year)	Capital Costs ($)	Operating Costs($)	Total Costs($)	Costs ($/Ton)
Low Technology					
NYDOC	7,800	n/a	n/a	n/a	22
GDCC	1,040	11,429	28,000	39,429	38
Kelley AFB	800	47,143	20,000	67,143	84
Weighted avg.					29
High Technology					
Rikers	4,000	152,070	230,000	382,070	96
NRCan	94	5,853	11,274	17,127	182
Weighted avg.					98
Overall weighted avg.					49

Source: Organic Materials Management Strategies

from existing institutional composting operations suggests that up to 2.4 million tons of food, paper and yard trimmings generated by this sector could be captured by compost programs.

Costs for five on-site institutional programs are shown in Table 5. Low-tech options include open windrow systems that often rely on low-cost inmate labor. High-tech options include aerated, in-vessel systems that can be effective for institutions with space constraints. Weighted average costs of low technology and high technology operations are $49/ton diverted.

YARD TRIMMINGS COMPOSTING PROGRAMS

Municipal yard trimmings composting programs represent the most widespread and well-established composting strategy. Municipalities collect yard trimmings in many ways, ranging from curbside operations to drop-off programs. These typically target leaves, grass and brush. As noted earlier, approximately 28 million tons of these materials are generated annually.

A variety of factors can influence the cost of yard trimmings programs, including the collection method used (e.g., drop-off, curbside), types of materials targeted (e.g., leaves, grass, brush, some combination, etc.), collection frequency, quantity of yard materials generated, technology used for turning compost windrows or grinding brush (e.g., dedicated equipment versus existing or shared resources), and numerous other factors.

To develop a mid-range national cost estimate for leaf and yard trimmings collection, it was necessary to consider the relative quantities and costs of drop-off versus curbside pick up. A study of 500 U.S. municipalities conducted by Skumatz Economic Research Associates indicates that curbside yard trimmings collection diverted approximately two times as much material as drop-off collection programs. Therefore, for the purposes of estimating a mid-range national yard trimmings collection cost, a 2:1 curbside to drop-off diversion ratio is used in conjunction with cost per ton collected by curbside versus drop-off programs. For drop-off, the cost of collection for the compost service provider is assumed to be zero since those that drop their yard trimmings off at the compost facility bear the cost of collection. For curbside collection, a cost of $66.56/ton collected is estimated — based on a study by Barbara Stevens of Ecodata Inc. — of 60 randomly selected cities that divert 10 to 19.9 percent of the waste stream through curbside yard trimmings programs. This estimate is conservative since the same study indicated that programs that divert larger quantities of the waste stream cost less per ton collected. Combining the curbside and drop-off costs at a 2:1 ratio to reflect the relative quantities of materials collected by each method yields a mid-range national cost estimate of $44.37/ton collected in yard trimmings programs.

With both curbside and drop-off programs, further costs will be incurred at the facility as the material is turned into finished product. A *BioCycle* article ("How Much Does It Cost To Compost Yard Trimmings," September, 1996) presented the results of a survey of seven public composting facilities that process from 2,000 to 23,500

Table 6. Select (yard trimmings) windrow composting facility throughput and costs

Facility	Throughput (tons/year)	Total ($/year)	Operating Costs ($/ton)	Capital Costs ($/ton)	Total ($/ton)
Atlantic County, New Jersey	22,000	484,000	11.80	10.20	22.00
Bozeman, Montana	2,000	16,000	6.50	1.50	8.00
Cedar Rapids, Iowa	70,000	784,000	7.00	4.20	11.20
Des Moines, Iowa	23,500	528,750	N/A	N/A	22.50
Lehigh County, Pennsylvania	17,000	314,500	8.10	10.40	18.50
St. Petersburg, Florida	16,600	424,960	N/A	N/A	25.60
Three Rivers, Michigan	2,700	46,440	N/A	N/A	17.20
Weighted average		1,814,650			21.65

Source: Robert Steuteville, How Much Does it Cost to Compost Yard Trimmings?, BioCycle, September. 1996, p. 40.

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tons/year of feedstock. This survey revealed an average total cost (capital plus operating) of $21.65/ton, as shown in Table 6.

Among the municipal yard trimmings programs analyzed, costs ranged from a low of $21.65/ton diverted (for programs that rely on drop-off collection) to a high of $88.21/ton — $66.56 for collection plus $21.65/ton for composting — diverted (for programs that use more extensive curbside collection and processing operations). The estimated national mid-range cost of yard trimmings composting is $66.02/ton diverted ($44.37/ton for collection and $21.65/ton for composting).

COMMERCIAL COMPOSTING

Commercial generators of organic materials, such as supermarkets, food processing companies and restaurants, have the potential for diverting large amounts of food, soiled and waxed cardboard, and paper. In a supermarket, for example, organic residuals may represent 75 to 90 percent of the total waste stream. Data from existing commercial composting operations suggests that up to 24.6 million tons of food and soiled or unrecyclable paper generated by commercial establishments could be captured for composting.

The city of Seattle, the King County Solid Waste Division and the Washington Department of Ecology funded development of detailed cost models for collection and processing of commercial organics as part of the Seattle/King County Commercial Food Waste Demonstration Project. The collection models were based on several factors, including food residuals generation rates per employee for different types of generators, participation rates based on survey information, efficiency of organics separation by participating firms, collection frequency and container weight limits. The model indicated that the quantity of food generated at each commercial site and the distance between generators had the greatest impact on commercial organics collection costs. Collection and transport and processing cost ranges were calculated for several service areas. Model cost estimates are shown in Table 7 along with price estimates provided by other commercial establishments and haulers. Average collection and processing costs are estimated at about $72/ton diverted. Cost per ton collected and composted (based on averages) range from a low of about $50 as reported by Shop-Rite, to a high of around $96 estimated by the Seattle cost model.

Table 7. Estimated commercial organics costs per ton diverted

	Low ($/ton)	High ($/ton)	Average ($/ton)
Reported Collection Costs			
Seattle Cost Model			
Downtown service area	34.00	45.00	39.50
Urban neighborhood	46.00	89.00	67.50
Suburban city	63.00	102.00	82.50
Seattle Cost Model Average	47.67	78.67	63.17
Shop-Rite	n/a	n/a	14.00
Hannaford Brothers	n/a	n/a	43.00
Average Cost of Collection			40.06
Reported Processing Costs			
Seattle Cost Model	23.00	42.00	32.50
Shop-Rite	n/a	n/a	36.00
Hannaford Brothers	n/a	n/a	18.00
Intervale compost facility	n/a	n/a	40.00
Earthgro compost	n/a	n/a	33.00
Average cost of processing			31.90
Average collection and processing			71.96

Source: Organic Materials Management Strategies

Table 8. Mixed waste composting facility costs

Facility	Tons/Day	Tons/Year	Capital Cost ($/Ton)	Operating Costs ($/Ton)	Total ($/Ton)
Pinetop-Lakeside, Arizona	15	3,900	N/A	32.05	N/A
Sumter County, Florida	42.5	11,050	24.25	39.19	63.44
Truman, Minnesota (Prairieland Solid Waste Board)	70	18,200	41.81	13.13	54.95
Wright County, Minnesota	190	49,400	26.32	33.40	59.72
Sevierville, Tennessee (Sevier Solid Waste)	220	57,200	23.60	15.73	39.34
Columbia County, Wisconsin	72	18,720	14.96	28.31	43.27
Weighted average					$49.89

Source: Solid Waste Association of North America. 1995. Cost Information Based on Municipal Solid Waste Composting — A Status Report. Prepared by Gershman, Brickner & Bratton, Inc. Table VI-4

MIXED WASTE COMPOSTING

Mixed waste composting refers to a centralized processing system that accepts mixed MSW and separates materials into component parts for composting, recycling and final disposal. In theory, this strategy could divert all organic materials currently available for composting — approximately 74.7 million tons/year. To date, mixed waste composting operations have had an uneven track record in the United States.

Mixed waste composting facilities use much higher levels of technology than other organic material diversion strategies to sort recyclables and compostables from disposed waste. Facilities have dramatically different capital costs, depending on the level of technology employed and the extent of reliance upon low-skilled labor for sorting. Odor control technologies also incur associated design, construction and operating costs that vary widely from project to project. Operating costs include labor, operation and maintenance, utilities and residual disposal. The technology used determines labor requirements. Residual disposal can be a very significant cost item, depending on the compost quality and the corresponding degree of contaminant removal needed, as well as the cost of disposal. One study reports estimated costs for capital debt service and operation (see Table 8) at a number of mixed waste

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Table 9. Maximum savings to local governments from composting strategies

Compost Strategies That Produce Net Savings	Mid-Range Cost ($/Ton)	Avoided Disposal ($/Ton)	Revenue/ Input ($/Ton)	Savings ($/Ton)
Grasscycling	1.03	38	0	36.97
On-site institutional	49.00	61	20	31.58
Home composting	12.90	38	0	25.10
Yard trimmings	66.02	61	16	10.86
Commercial organics	72.00	61	20	8.58
Mixed waste	113.00	102	2	(9.28)

composting facilities around the country. The estimates do not generally include the costs for land or siting, as the facilities are all publicly owned and land was already available. (For consistency, no land costs were included for any of the strategies.) The resulting average cost per ton is $49.89.

In addition to facility costs, mixed waste composting involves collection costs. However, unlike other organics management strategies, it does not necessarily require a separate collection system. Therefore, the cost of collection for this strategy is equivalent to the cost of garbage collection. Using information from a study conducted by Franklin Associates and Keep America Beautiful, average garbage collection costs are estimated at $63/ton. Combined with the operating costs in Table 8, the range is $102 to $126/ton diverted. The weighted average cost of diversion for this strategy is $113/ton diverted.

RESIDENTIAL SOURCE SEPARATION

Increasing sensitivity about the poor quality of mixed waste compost in Europe started a wave of residential collection programs targeting the organic fraction of the solid waste stream. Several pilot programs in the Netherlands and Germany in the late 1980s demonstrated that compost produced from residentially source separated feedstock contained substantially lower levels of toxic heavy metals and physical contaminants, such as glass and plastic, than mixed waste compost. Like mixed waste composting, source separated organics composting has the potential to target a large portion of the residential organics stream, which is comprised of about 47.3 million tons of compostable MSW.

Costs for collection of source separated residential organics are not readily available because such programs have not been widely implemented in the United States. Average collection costs for a wet/dry pilot operation in DeKalb, Illinois ranged from $48 to $62/ton diverted, according to a report prepared by Waste Management Inc. and E&A Environmental Consultants. Wet and dry organic materials were collected weekly by a dual collection vehicle. Residents were supplied with cellulose lined bags, eight-gallon containers to hold the bags, and 20-gallon containers to hold full wet waste bags for curbside collection. On one of the two pilot routes, recyclables were cocollected with wet and dry organic materials in blue bags.

There also is a general lack of complete cost information specific to source separation processing technologies. Swift County, Minnesota built a composting facility designed to receive bagged, source separated MSW as feedstock. The cost for source separated collection and processing at this facility was compared to the cost of mixed waste composting in neighboring counties. The source separated costs ranged between $63 to $86/ton whereas mixed waste composting ranged from $102 to $126/ton.

THE COMPOST STRATEGY SAVINGS CURVE

The previous discussion focused on national average costs and potential for seven individual compost strategies. Clearly, some combination of the strategies analyzed would be needed to address the entire U.S. organics stream. The question is, which combination of strategies would be most cost-effective? To address this question, a Compost Strategies Savings Curve (Figure 1) was developed. The curve identifies the most cost-effective combination of options available for composting the 74.7 million ton compostable waste stream shown in Table 1.

The average cost per ton diverted for individual compost strategies is used as a starting point for constructing the curve. This information is combined with average avoided garbage collection and disposal costs, as well as average revenue for finished compost, to estimate a net cost or savings for each compost strategy as shown in Table 9. (Source separated composting was excluded from this analysis because complete cost information was not readily available.) Avoided disposal costs are calculated using national average tip fees ($38/ton based on adjusted *BioCycle's* "State of Garbage in America" survey data from 1995-1996). Average avoided garbage collection costs ($23/ton using Franklin Associates 1994 data) were applied to on-site institutional, municipal yard trimmings and commercial organics because these composting programs are assumed to result in an incremental reduction in garbage

Table 10. Maximum savings to local governments from composting strategies[1]

Compost Strategies That Produce Net Savings	Tons Targeted (millions)	Avg. Savings To Local Gov't. Per Ton Diverted ($)	Total Potential Savings (Millions $)
Grasscycling	14	37	518
On-site institutional	2.5	32	77
Home composting	21.9	25	549
Commercial organics	24.6	9	212
Total	63		1,356

[1] *Municipal yard trimmings composting is not included in this table because even though it results in savings, it is more expensive then source reduction approaches.*

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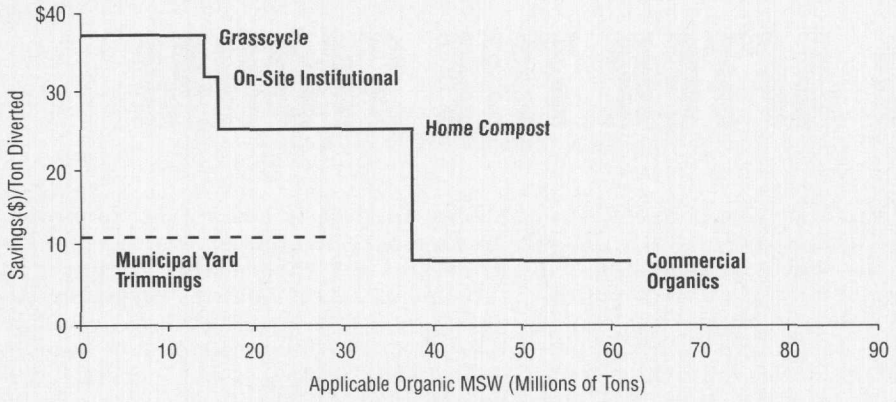
Figure 1. Compost strategies savings curve



collection service. For mixed waste composting, the average cost of garbage collection ($64/ton) was used because there isn't any avoided cost (assuming mixed waste composting collection replaces garbage collection). Average revenue per input ton is based on the reported market value for various kinds of finished compost. (See the OMMS report for further explanation of avoided disposal costs and compost revenue assumptions.)

To develop the Compost Strategies Savings Curve, savings from column four of Table 9 were plotted on the graph with applicable tonnage information shown in Table 2. The curve shows the strategies analyzed from highest to lowest savings per ton, such that strategies resulting in the greatest savings per ton diverted appear first and are applied to the total quantity of organic material available for diversion through that strategy. Any overlap of targeted materials between options is simply removed from the contribution of each subsequent (i.e., more costly) segment of the curve. Thus, for example, the tonnage attributed to home composting is net of the tonnage attributed to grasscycling and on-site institutional composting; the three combined are equal to the diversion available through only doing municipal yard trimmings composting. Mixed waste composting is not on the curve because it results in a net cost of $9/ton. (This strategy, however, could encompass the total quantity of organic materials in the MSW stream available for composting.)

The curve indicates that 83 percent of the available compostable stream (about 62 million tons) could be composted at a net savings through a combination of grasscycling, home composting, on-site institutional composting, leaf and yard trimmings composting, and commercial organics composting. Composting the remaining 17 percent of the organic waste stream could be accomplished through more costly mixed waste composting programs or perhaps through source separation strategies once they become better established in the United States.

Table 10 illustrates the maximum savings to local governments from composting strategies. Grasscycling, on-site institutional and home composting programs — three source reduction strategies — could target 50 percent of the organic waste stream at a net savings to local governments of over $1 billion annually. Alternatively, yard trimmings composting programs could be employed to target many of the same materials at a savings of about $240 million annually. The curve illustrates how source reduction strategies divert more of the organics stream (because they also include food residuals) at a savings of anywhere from about $25 to $37/ton versus municipal yard trimmings composting, which diverts less organics at a savings of roughly $11/ton. Commercial compost strategies could capture another third of the organic waste stream at net savings of about $211.5 million annually. The compost strategy curve underscores the major impact that a few proven strategies could have in achieving substantial and cost-effective incremental reduction in the U.S. waste stream. ■

Paul Ligon is a senior scientist at the Tellus Institute in Boston. George Garland is a policy analyst at EPA's Office of Solid Waste. They are principal authors of the Organic Materials Management Strategies report, available from the EPA Office of Solid Waste (EPA530-R-97-003) or its website (www.epa.gov\compost).

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