The Role of Recycling in Integrated Solid Waste Management to the Year 2000

SUMMARY

Prepared for
Keep America Beautiful, Inc.
by Franklin Associates, Ltd.

THE ROLE OF RECYCLING IN INTEGRATED SOLID WASTE MANAGEMENT TO THE YEAR 2000

Prepared for

KEEP AMERICA BEAUTIFUL, INC.
by
FRANKLIN ASSOCIATES, LTD.

September 1994

Keep America Beautiful, Inc.
9 West Broad Street
Stamford, Connecticut 06902
(203) 323-8987

Printed on recycled paper.

PREFACE

Keep America Beautiful, Inc. (KAB) is the sponsoring organization for this comprehensive study of the role of recycling and composting of municipal solid waste (MSW) to the year 2000. The oversight committee was KAB's Solid Waste Committee with an Industry Advisory Group of sponsoring organization providing input and information to build up the database throughout the twelve-month study period.

Ultimately, the findings, observations, conclusions, and content of this report are those of Franklin Associates, Ltd. (FAL) staff, the independent research group responsible for producing this 500-page report.

The overall management and responsibility for this project was the joint effort of William E. Franklin and Marjorie A. Franklin. A number of our key staff members made significant contributions to the report and appendices to the report. They are:

Nicholas S. Artz
Jacob E. Beachey
Mark A. Kinkelaar
Beverly J. Sauer
Shelly H. Schneider
John P. Wood
Betty R. Wyckoff

Beverly Sauer provided the internal technical editing; other staff members provided detailed technical input to the study.

William E. Franklin
Chairman and Principal
Franklin Associates, Ltd.

Marjorie A. Franklin
President and CEO
Franklin Associates, Ltd.

September 1994

ACKNOWLEDGMENTS

No report of this magnitude is possible without the cooperation, support, and participation of a large number of persons representing a diverse group of organizations. One of the strengths of this effort is the balance between public sector agencies and private sector organizations. In particular, we acknowledge the leadership of Frank Miller, who chairs the Solid Waste Committee of Keep America Beautiful, and of Roger W. Powers and Susanne M. Woods, who championed the study from its inception to its completion.

Participation of any person or organization does not imply an endorsement of the report on behalf of that organization or person. Rather, each person's participation added substantively to the final document, which remains the independent work and responsibility of Franklin Associates, Ltd.

The participants and their organizations are listed below.

For Keep America Beautiful, Inc.:

Roger W. Powers, President

Susanne M. Woods, Vice President

For the Solid Waste Committee of Keep America Beautiful:

Frank H. Miller, Jr., Chairman
American Public Works Association

Dr. Harvey Alter
Chamber of Commerce of the United States

Jerald Bannister
Owens-Illinois

Bill Child
Illinois Environmental Protection Agency

Gregory L. Crawford
Steel Recycling Institute

Truett DeGeare
U.S. Environmental Protection Agency

Jeff Fletcher
National League of Cities

Naomi Friedman
National Association of Counties

Brian Hogan
American Society of Civil Engineers

Mosi Kitwana
The U.S. Conference of Mayors

Michael Mathews
The Coca-Cola Company

Pat Nolan
General Federation of Women's Clubs

Janet Oakley
National Association of Regional Councils

Thomas Rattray
The Procter & Gamble Company

Barbara Schwartz
International City Management Association

Richard Storat
American Forest & Paper Association

Dennis C. Turk
Mobil Chemical Company

Jane Witheridge
WMX Technologies, Inc.

EXECUTIVE OVERVIEW

In a period of seven years (1985 to 1992), recycling and yard trimmings composting became an important part of integrated municipal solid waste management. Municipal solid waste (MSW) recovered for recycling and composting in the United States increased two and one-half times in tonnage in this period, while doubling the rate of recovery from 10 percent to 21 percent of total MSW. In spite of this rapid growth, the path to the year 2000 is one of great challenges because recycling and composting as currently practiced have limits that will be reached in this decade.

As recycling and composting mature as solid waste management techniques, community leaders are challenged to be visionary in a time when technology, costs, and environmental concerns are constantly changing the shape of solid waste management. This study is designed to focus attention on understanding the options while making decisions that reflect community values and goals. The remaining years of the 1990s will be an era of recycling realities, with recovery for recycling and composting moving from 21 percent of total MSW generated in 1992 to a potential national average range of 25 to 35 percent in 2000. There are several important factors to be considered:

- **There are practical limits to increasing recycling from residential sources.** Successful communities achieving recovery levels greater than 35 percent of generation have very comprehensive programs in place, combining curbside collection, composting, multi-family programs, drop-offs, buy-back centers, existing private scrap infrastructure, and often unit-based pricing on solid waste to be managed by conventional landfill disposal.

To reach national average recovery scenario levels of 25 to 35 percent, curbside collection will need to double by 2000. Expanding curbside programs to double the 1992 coverage of about 78 million people will be a formidable task, leading to more costly programs. In addition, multi-family dwellings, drop-off centers, the conventional scrap infrastructure, and programs in non-urban areas will be even more important in the years ahead *if* the scenario range is an important goal.

- **Materials recovered from commercial, institutional, and government sources will be a vital part of total recovery for recycling.** While a majority of municipal solid waste generation is from residential sources, recovery of recyclable materials from commercial, institutional, and governmental sources of MSW is absolutely essential, because these sources will account for over half of the materials projected to be recovered for recycling and composting in 2000.

- **There are costs to increasing recovery.** Program costs will have growing influence over the decision-making process at the local level. The reality is that recycling at the community level is not free and usually does not reduce the costs of total solid waste management. In fact, it increases costs in most communities. Since collection costs dominate total costs, emphasis on reducing collection costs is

important to pursue. This will require innovative collection techniques, which are just beginning to emerge. Revenues from recovered materials help to offset costs, but will fluctuate with scrap markets.

- **Composting of yard trimmings is a key component of achieving recovery levels of 25 to 35 percent of total MSW.** New yard trimmings policies such as restricted disposal at landfills are projected to result in a significant decrease in yard trimmings entering MSW in 2000. More community composting programs will increase recovery.

- **The quantity and composition of municipal solid waste are continually changing; source reduction measures may accelerate changes in the last half of the 1990s.** There is a growing awareness of the need for source reduction as a preventative strategy; as a result, community educators, businesses and manufacturers, government, and institutions are focusing attention on this important measure. Their combined efforts are playing a vital role in reducing the growth of MSW generation.

- **Overall, recovery for recycling saves energy and reduces solid wastes landfilled.** The obvious benefit to recycling is the reduced dependence on landfills for disposal. The most significant potential energy and environmental effects are realized when the recovered materials are utilized in place of virgin materials in manufacturing processes.

- **The optimum solid waste management system for each community will be determined by its individual situation with respect to quantity and composition of MSW, infrastructure, cost structure, and community goals.** The decision-making process should begin with identifying problems and determining the level of effort and expenditure the community is willing to support. Adding community-based infrastructure for recycling and composting (at increased cost) can achieve up to 35 percent recovery nationally using commonly practiced techniques.

- **For communities to achieve higher overall recovery (or diversion) goals, other municipal solid waste management technologies must come into use.** Consequently, several components of integrated solid waste management beyond source reduction, recycling, and composting of yard trimmings will have to be utilized where diversion goals are above 25 to 35 percent.

- **A 30 percent national average recovery scenario for recycling and composting in the year 2000 would only offset the total projected growth in MSW generated (driven by increases in population and economic growth), leaving the remaining solid waste to be managed through other integrated solid waste management approaches and emerging technologies.**

For a copy of the full report, please contact Keep America Beautiful, Inc., 9 West Broad Street, Stamford, CT 06902 (203) 323-8987.

SUMMARY

Keep America Beautiful, Inc. (KAB) is the sponsoring organization for this comprehensive study of the role of recycling and composting of municipal solid waste (MSW) to the year 2000. The advisory group consisted of KAB's Solid Waste Committee and an industry group of sponsoring organizations. Because of the diverse nature of representatives on Keep America Beautiful's Solid Waste Committee and the industry advisory group, this is probably the most thoroughly peer reviewed report on MSW and recycling ever to reach the public domain. Ultimately the findings, observations, conclusions, and content are those of Franklin Associates, Ltd., which is the independent research group responsible for this report.

THE PURPOSES OF THIS REPORT

The primary purposes of this report are:

1. To provide information about municipal solid waste (MSW) generated from residences and commercial activities. In this report, commercial MSW includes wastes from retail and service establishments, institutions such as schools and government agencies, and packaging from industrial sources.

2. To define the potential for recycling and other means of recovery and diversion from landfill as solid waste management options.

3. To provide information for local, state, and federal officials and for the private sector to use in carrying out effective planning for the role of recycling and composting in the context of integrated municipal solid waste management.

4. To project where recycling/composting and solid waste management could be in 2000, considering current and emerging technological developments.

5. To determine the energy required, solid waste generated, and environmental emissions to collect and process recyclables compared to the energy used in the manufacturing process by using recycled material versus virgin material.

TARGET AUDIENCES AND INTENDED USES

The principal audience for this report is local community officials responsible for managing and for planning municipal solid waste programs in their communities. Many other persons in the public and private sectors may find the report useful also. While this report provides basic information that can be used in municipal solid waste planning, it is not a planning document that

will answer every question for every community. In using this report, certain facts should be kept in mind:

- The data in this report are restricted to municipal solid waste (primarily residential and commercial, institutional, and government wastes). Construction and demolition wastes, industrial process wastes, wastewater treatment sludges, etc. may also be managed by communities, *but they are not addressed in this study.*

- Most of the data on waste characterization and management are national averages. Circumstances in any particular community are likely to be different. The local "mix" of residential and commercial activities, variations in the management of yard trimmings, and the urban or rural nature of the community are some of the factors contributing to local variations.

- Regional data are presented in some of the chapters, e.g., economics and markets for recovered materials. Within any particular region, however, there will be wide variations in local conditions due to some of the factors named above.

SCOPE OF THIS REPORT

This report provides information on the total municipal solid waste stream and integrated solid waste management of MSW. Emphasis is placed on residential MSW and recovery for recycling of residential MSW as a management tool. In most areas, local officials have the most direct responsibility for residential MSW. Consequently, most of the report emphasizes solid waste from single-family homes, with less emphasis given to multi-family homes and commercially collected solid waste, i.e., MSW from businesses, institutions, governments, public facilities, and other non-residential sources.

Notwithstanding the emphasis on residential waste management, the role of commercial waste management and recycling is vital because commercial waste constitutes about 45 percent of all MSW generated Even more important, commercial sources accounted for about 55 percent of materials recovery for recycling (excluding yard trimmings composting) in 1992.

The scope of the report also includes information on infrastructure, the economics of MSW management, markets for recovered materials, and the comparative energy and environmental consequences of the various waste management options. It examines the average range of what can be accomplished with recycling along with the associated estimated costs to the year 2000, and includes some regional analyses, especially for solid waste management costs and markets for recyclable materials.

CHARACTERIZATION AND MANAGEMENT OF MSW

MSW Characterization

Potential recovery for recycling and composting can best be estimated from a knowledge of MSW quantity and composition plus where it is generated. Twenty separate products or product categories plus yard trimmings were analyzed in this study; they were selected because they were already recovered in measurable quantities in 1992. Collectively these are referred to as "the selected recyclable products and materials." These commonly recycled products and materials constituted about three-fourths of total MSW in 1992. (While these products/materials constitute three-fourths of MSW, this does not mean all of these materials are in fact separated or recoverable, as will become evident in later discussions.)

The recovery of these products and materials was already significant in 1992, as shown in Table 1. Recovery for recycling and composting as a percentage of total MSW was 21 percent overall in 1992, with recovery of residential MSW at 17 percent of residential generation and recovery of commercial MSW at 27 percent of generation (Table 1). The sources of recovered products and materials are illustrated graphically in Figure 1.

A projected national average scenario of 30 percent overall recovery for recycling and composting from residential and commercial sources is shown in Table 2. In order to increase recovery for recycling and composting from the 1992 level of 21 percent to an assumed 30 percent in 2000, the current recovery of 32 percent of these products and materials would have to increase to 42 percent, including almost 23 million tons from residential sources and 32 million tons from commercial sources (Tables 1 and 2). Recovery of recyclables from commercial MSW is absolutely essential, because this source would account

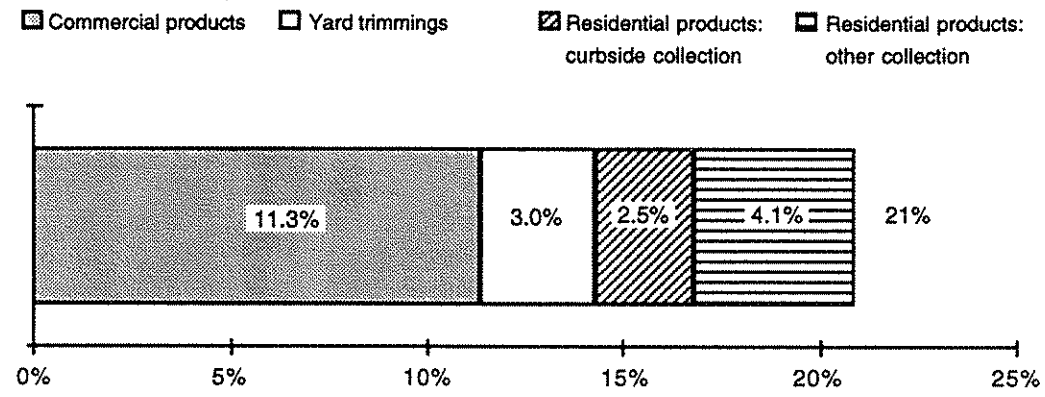
Table 1

SUMMARY OF MSW GENERATION AND RECOVERY FOR RECYCLING/COMPOSTING FROM RESIDENTIAL AND COMMERCIAL SOURCES, 1992
(In million tons and percent)

	Total	Total	Percent	Residential MSW			Commercial MSW		
	Generation	Recovery	Recovery	Generation	Recovery	Percent	Generation	Recovery	Percent
Selected Recyclable Products	112.3	36.4	32%	50.8	13.4	26%	61.6	23.0	37%
Yard Trimmings	35.0	6.0	17%	31.5	5.7	18%	3.5	0.3	9%
Subtotal	147.3	42.4	29%	82.3	19.1	23%	65.1	23.3	36%
Other Materials	55.7	–		33.4	–		22.3	–	
Total MSW	203.0	42.4	21%	115.7	19.1	17%	87.3	23.3	27%

Source: Franklin Associates, Ltd. (Table 2-4, Chapter 2).

Figure 1. Sources of recovered products and materials for recycling/composting, 1992 (in percent of total MSW generation)



for 58 percent of the recyclable products recovered for recycling in the year 2000 scenario (Table 2).

Furthermore, reaching the level of 30 percent recovery of total MSW for recycling and composting in the year 2000 would require a doubling of the number of single family households served, from 27 million in 1992 to 54 million households, nearly two-thirds of all single family households.

Table 2 shows that the quantity of yard trimmings in MSW is projected to decline significantly by the year 2000, representing only 10 percent of total MSW

Table 2

SUMMARY OF MSW GENERATION AND RECOVERY FOR RECYCLING/COMPOSTING FROM RESIDENTIAL AND COMMERCIAL SOURCES, 2000 (AT 30 PERCENT OVERALL RECOVERY)

(In million tons and percent)

				Residential MSW			Commercial MSW		
	Total Generation	Total Recovery	Percent Recovery	Generation	Recovery	Percent Recovery	Generation	Recovery	Percent Recovery
Selected recyclable products	131.3	55.0	42%	58.5	22.9	39%	72.8	32.1	44%
Yard trimmings	22.2	8.6	39%	20.0	8.4	42%	2.2	0.2	10%
Subtotal	153.5	63.6	41%	78.5	31.3	40%	75.0	32.3	43%
Other materials	62.0			37.2			24.8		
Total MSW	215.5	63.6	30%	115.7	31.3	27%	99.8	32.3	32%

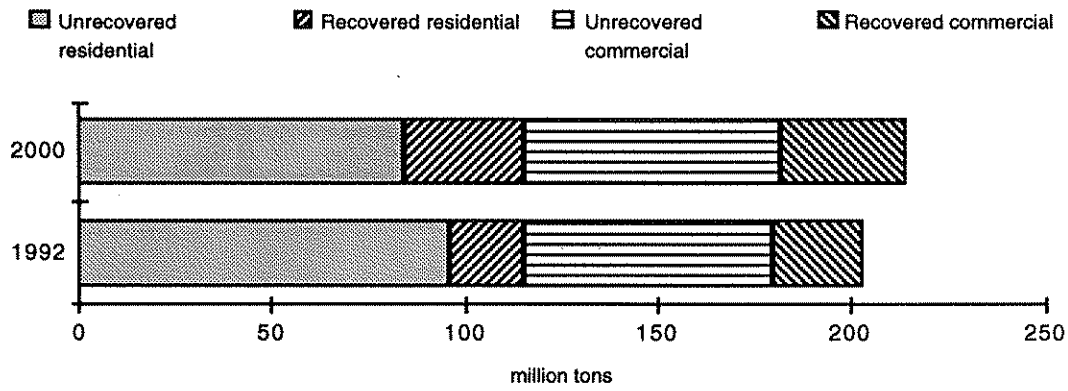
Source: Franklin Associates, Ltd. (Table 7-5).

versus 18 percent in 1992. This projected decline is due primarily to local and state bans of yard trimmings at landfills.

Table 2 also shows that composting of yard trimmings is a key component of achieving national average recovery levels of 25 to 35 percent of total MSW. Most yard trimmings are from residential sources. The 8.4 million tons of residential yard trimmings projected for composting in 2000 constitutes 27 percent of the projected total recovery of products plus yard trimmings from residential MSW.

The discards (unrecovered quantities) of residential and commercial MSW based on MSW generation and recovery for recycling and composting from residential and commercial sources in 1992 and projections for 2000 are illustrated in Figure 2. (These discards could be subjected to other types of recovery techniques such as food waste composting and prepared fuels.)

Figure 2. Recovery and discards of residential and commercial MSW, 1992 and 2000. (Based on 30 percent overall recovery in 2000)



MSW Management

A profile of solid waste management from a national perspective for 1985, 1992, and 2000 shows how solid waste management has changed overall and is likely to change in the future (Table 3).

The alternatives for managing material categories are shown in Table 4. Most materials can be recycled in part, but composting, energy recovery, prepared

Table 3

MUNICIPAL SOLID WASTE MANAGEMENT, 1985 TO 2000
(In million tons and percent of MSW generation)

	1985	1992	30% Recovery Scenario for 2000
MSW generated (million tons)	164	203	215
Management technique (% of generation)			
Recovered for recycling	10%	18%	26%
Yard trimmings composted	–	3%	4%
Total recovered for recycling and composting	10%	21%	30% *
Energy recovery	5%	16%	15% **
Incineration without energy recovery	2%	1%	–
Landfilled	83%	62%	55%
Total	100%	100%	100%

* Estimated range for 2000 is 25% to 35%; landfill by difference would range from 50% to 60%.

** The tonnage of waste combusted with energy recovery is estimated to be the same as in 1992; however, as a percentage of MSW it decreases, because the generation of MSW increases.

Source: Franklin Associates, Ltd. estimates.

Table 4
HOW CAN MATERIALS IN MSW BE MANAGED?

Material	Recycling	Composting	Energy Recovery	Prepared Fuel	Landfill
Paper and paperboard	✔	✔	✔	✔	✔
Plastics	✔		✔	✔	✔
Glass	✔				✔
Metals	✔				✔
Textiles	✔		✔	✔	✔
Rubber	✔		✔	✔	✔
Wood	✔	✔	✔	✔	✔
Yard trimmings, food wastes		✔	✔		✔

fuel, and landfill will continue to play important roles once the practical limits of recovery for recycling are reached.

The relative actual generation and recovery of materials in 1992 is summarized in Table 5 and Figure 3. Paper products and yard trimmings dominate recovery, as they also dominate in generation of MSW.

Table 3

MUNICIPAL SOLID WASTE MANAGEMENT, 1985 TO 2000
(In million tons and percent of MSW generation)

	1985	1992	30% Recovery Scenario for 2000
MSW generated (million tons)	164	203	215
Management technique (% of generation)			
Recovered for recycling	10%	18%	26%
Yard trimmings composted	–	3%	4%
Total recovered for recycling and composting	10%	21%	30% *
Energy recovery	5%	16%	15% **
Incineration without energy recovery	2%	1%	–
Landfilled	83%	62%	55%
Total	100%	100%	100%

* Estimated range for 2000 is 25% to 35%; landfill by difference would range from 50% to 60%.

** The tonnage of waste combusted with energy recovery is estimated to be the same as in 1992; however, as a percentage of MSW it decreases, because the generation of MSW increases.

Source: Franklin Associates, Ltd. estimates.

Table 4
HOW CAN MATERIALS IN MSW BE MANAGED?

Material	Recycling	Composting	Energy Recovery	Prepared Fuel	Landfill
Paper and paperboard	✔	✔	✔	✔	✔
Plastics	✔		✔	✔	✔
Glass	✔				✔
Metals	✔				✔
Textiles	✔		✔	✔	✔
Rubber	✔		✔	✔	✔
Wood	✔	✔	✔	✔	✔
Yard trimmings, food wastes		✔	✔		✔

fuel, and landfill will continue to play important roles once the practical limits of recovery for recycling are reached.

The relative actual generation and recovery of materials in 1992 is summarized in Table 5 and Figure 3. Paper products and yard trimmings dominate recovery, as they also dominate in generation of MSW.

Table 5

GENERATION AND RECOVERY FOR RECYCLING AND COMPOSTING OF SELECTED* MATERIALS IN MUNICIPAL SOLID WASTE, 1992
(In millions of tons and percent)

Material Category	Generation	Recovery	Percent of Generation	Percent of Total Recovery
Paper and paperboard	67.4	24.5	36%	58%
Yard trimmings	35.0	6.0	17%	14%
Glass	11.9	3.9	33%	9%
Steel	5.5	2.6	47%	6%
Wood	8.9	2.2	25%	5%
Aluminum	1.9	1.1	57%	3%
Plastics	8.0	0.6	8%	1%
All others**	8.7	1.5	17%	4%
Subtotal	147.3	42.4	29%	100%
Other MSW	55.7		0%	
Total MSW	203.0	42.4	21%	

* Based on products and yard trimmings recovered in measurable quantities in 1992.

** Textiles, rubber in tires, lead in automotive batteries.

Source: Franklin Associates, Ltd.

Figure 3. Generation and recovery for recycling and composting of selected materials in MSW, 1992
(In million tons)

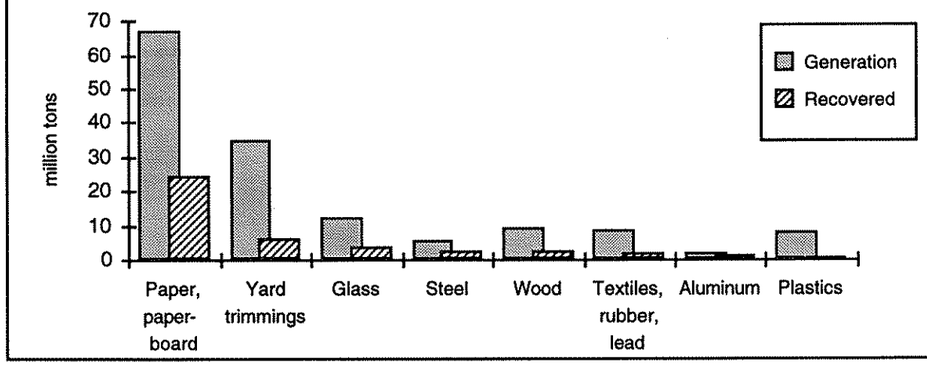


Table 5

GENERATION AND RECOVERY FOR RECYCLING AND COMPOSTING OF SELECTED* MATERIALS IN MUNICIPAL SOLID WASTE, 1992
(In millions of tons and percent)

Material Category	Generation	Recovery	Percent of Generation	Percent of Total Recovery
Paper and paperboard	67.4	24.5	36%	58%
Yard trimmings	35.0	6.0	17%	14%
Glass	11.9	3.9	33%	9%
Steel	5.5	2.6	47%	6%
Wood	8.9	2.2	25%	5%
Aluminum	1.9	1.1	57%	3%
Plastics	8.0	0.6	8%	1%
All others**	8.7	1.5	17%	4%
Subtotal	147.3	42.4	29%	100%
Other MSW	55.7		0%	
Total MSW	203.0	42.4	21%	

* Based on products and yard trimmings recovered in measurable quantities in 1992.

** Textiles, rubber in tires, lead in automotive batteries.

Source: Franklin Associates, Ltd.

Figure 3. Generation and recovery for recycling and composting of selected materials in MSW, 1992 (In million tons)

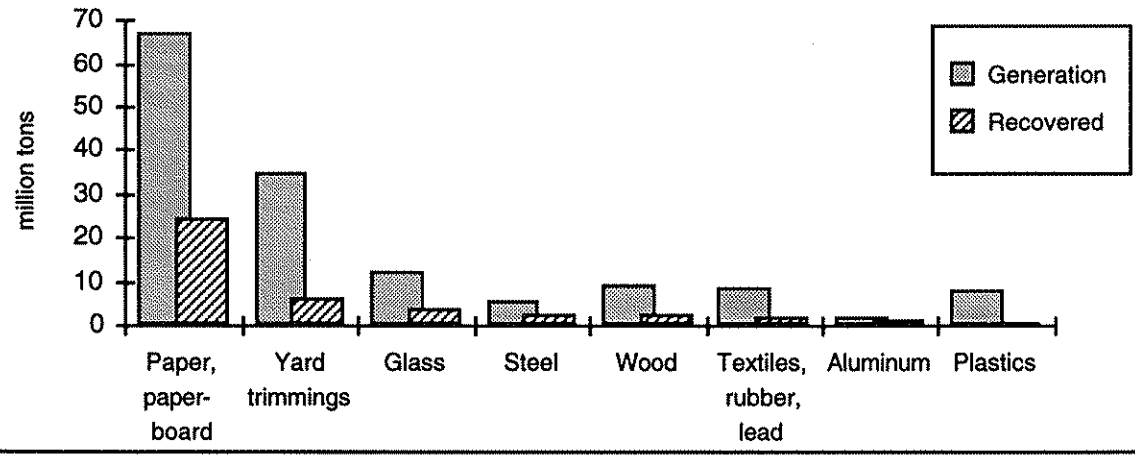


Table 3

MUNICIPAL SOLID WASTE MANAGEMENT, 1985 TO 2000
(In million tons and percent of MSW generation)

	1985	1992	30% Recovery Scenario for 2000
MSW generated (million tons)	164	203	215
Management technique (% of generation)			
Recovered for recycling	10%	18%	26%
Yard trimmings composted	–	3%	4%
Total recovered for recycling and composting	10%	21%	30% *
Energy recovery	5%	16%	15% **
Incineration without energy recovery	2%	1%	–
Landfilled	83%	62%	55%
Total	100%	100%	100%

* Estimated range for 2000 is 25% to 35%; landfill by difference would range from 50% to 60%.

** The tonnage of waste combusted with energy recovery is estimated to be the same as in 1992; however, as a percentage of MSW it decreases, because the generation of MSW increases.

Source: Franklin Associates, Ltd. estimates.

Table 4
HOW CAN MATERIALS IN MSW BE MANAGED?

Material	Recycling	Composting	Energy Recovery	Prepared Fuel	Landfill
Paper and paperboard	✔	✔	✔	✔	✔
Plastics	✔		✔	✔	✔
Glass	✔				✔
Metals	✔				✔
Textiles	✔		✔	✔	✔
Rubber	✔		✔	✔	✔
Wood	✔	✔	✔	✔	✔
Yard trimmings, food wastes		✔	✔		✔

fuel, and landfill will continue to play important roles once the practical limits of recovery for recycling are reached.

The relative actual generation and recovery of materials in 1992 is summarized in Table 5 and Figure 3. Paper products and yard trimmings dominate recovery, as they also dominate in generation of MSW.

Table 5

GENERATION AND RECOVERY FOR RECYCLING AND COMPOSTING OF SELECTED* MATERIALS IN MUNICIPAL SOLID WASTE, 1992
(In millions of tons and percent)

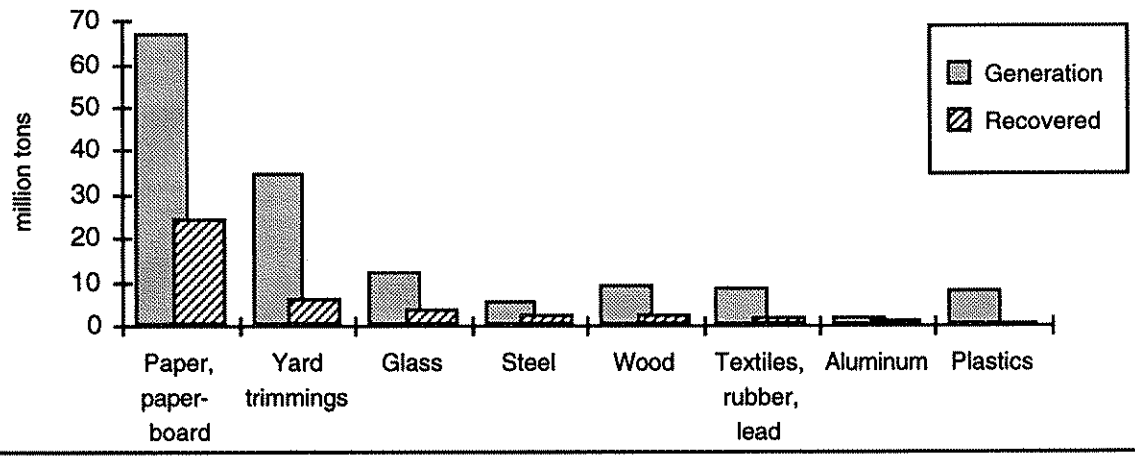
Material Category	Generation	Recovery	Percent of Generation	Percent of Total Recovery
Paper and paperboard	67.4	24.5	36%	58%
Yard trimmings	35.0	6.0	17%	14%
Glass	11.9	3.9	33%	9%
Steel	5.5	2.6	47%	6%
Wood	8.9	2.2	25%	5%
Aluminum	1.9	1.1	57%	3%
Plastics	8.0	0.6	8%	1%
All others**	8.7	1.5	17%	4%
Subtotal	147.3	42.4	29%	100%
Other MSW	55.7		0%	
Total MSW	203.0	42.4	21%	

* Based on products and yard trimmings recovered in measurable quantities in 1992.

** Textiles, rubber in tires, lead in automotive batteries.

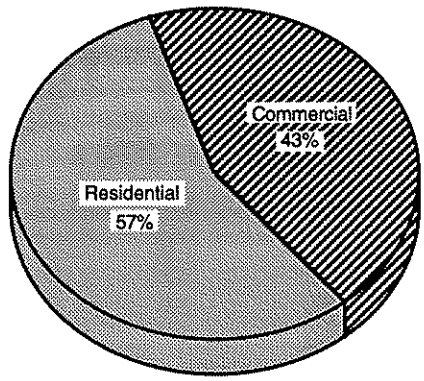
Source: Franklin Associates, Ltd.

Figure 3. Generation and recovery for recycling and composting of selected materials in MSW, 1992 (In million tons)



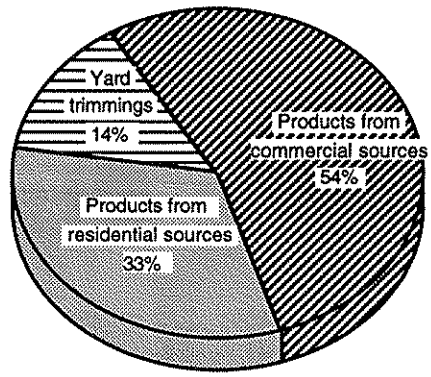
Generation and recovery of materials and products by source can also be contrasted in Figures 4 and 5. While residential MSW generation exceeds commercial MSW generation, the situation for recovery is reversed—more recovery comes from commercial sources than from residential sources.

Figure 4. Potential recovery sources for recyclable/ compostable municipal solid waste, 1992



Residential MSW includes wastes from single and multi-family residences.

Figure 5. Actual sources of recovered products and materials in municipal solid waste, 1992



Residential MSW includes wastes from single and multi-family residences.

Key observations about MSW are:

- The past decade has seen significant changes in the ways municipal solid waste is managed.

- In the United States, there has been a strong trend toward integrated solid waste management, i.e., the use of two or more management techniques such as recovery for recycling and landfilling.

- Recovery of total MSW for recycling and composting reached 21 percent of generation in 1992. The 21 percent breaks down as: 11 percent product recovery for recycling from the commercial sector; 4.5 percent product recovery from residential buy-back, drop-offs, traditional scrap processors, etc.; 2.5 percent product recovery from curbside collection; and 3 percent yard trimmings for composting (Figure 1).

- The majority of MSW generation is from residential sources; the majority of MSW recovery is from commercial sources.

THE ROLE OF SOURCE REDUCTION ACTIVITY IN SOLID WASTE MANAGEMENT—THE EFFECTS ON QUANTITY AND COMPOSITION

Source reduction is increasingly important as a solid waste preventative strategy. Nearly every entity and individual can be or is engaged in some source reduction activity. As a consequence, the solid waste stream is continually changing in quantity and composition. Therefore, the community solid waste management official should anticipate that changes will take place in the future. Different types of source reduction activities are discussed in this report.

Competition among industries that manufacture and companies that sell products and packages means that they are more or less continuously involved in source reduction activity. This takes the form of product or package "design for the environment," lightweighting, combining materials together, and using alternative materials or configurations. This leads to almost continuous small changes in the quantity and composition of the products and packages manufactured.

From the perspective of the community official, several signals may be important. Successful source reduction activity may introduce more of one family of materials into solid waste, while reducing others. For example, flexible packaging (e.g., film) may displace certain types of rigid packaging (e.g., boxes).

Offsetting these factors is the observation that both population increases and economic growth lead to more products and packaging being produced (both existing and new products). Consequently, this growth may offset even

significant source reduction measures, so that MSW generation may continue to grow.

Community educators, businesses, governments, and institutions are focusing attention on source reduction measures. Their combined roles are having an effect in reducing total MSW generation (or at least slowing its growth). These entities have taken measures to reduce and reuse products in everyday activity.

Individuals can have a significant impact by such actions as reducing the disposal of yard trimmings via backyard composting, by extending the life of products, and by reusing products when possible. Consequently, there are source reduction measures that can be undertaken at any level of human activity.

INFRASTRUCTURE OPTIONS FOR RECOVERING PRODUCTS AND MATERIALS FROM MSW FOR RECYCLING AND COMPOSTING

A summary of the various ways by which recyclable materials can be collected and processed from residential sources of MSW is listed below. (Commercial recovery for recycling generally takes place via private sector activity in response to market demand for recyclables.) Options described in this report include:

- Curbside collection and materials recovery facility (MRF)
- Drop-off center
- Buy-back center
- Delivery to scrap dealer or processor
- Collection at transfer stations and/or other disposal sites
- Yard trimmings compost facility
- Multi-family collection.

The key observations for residential MSW are:

- All mechanisms of collection and processing are very important. In fact, traditional scrap collection systems, e.g., paper drives, still account for a great deal of recovery. Recovery for recycling from drop-offs, buy-backs, and deposits accounted for 4.5 percent of total MSW.

- Recovery for recycling from curbside collection accounted for 2.5 percent of total MSW, but is the only current means to capture a relatively high percentage of many products in residential MSW.

ECONOMICS OF MSW MANAGEMENT ALTERNATIVES

Six solid waste management options were evaluated for residential MSW—landfilling only, waste-to-energy, yard trimmings composting, a base case

curbside recycling program for single-family residences, an expanded curbside recycling program for single-family residences, and a combination of recycling/composting with landfill. The average total solid waste management system costs and revenues for five of these options are summarized in Table 6. It is important to note that these are based on national averages; local costs can vary widely. Also, it is important to note that these values are for new infrastructure in all five cases.

Table 6

SUMMARY OF COSTS OF VARIOUS SOLID WASTE MANAGEMENT ALTERNATIVES FOR HOUSEHOLD MSW*
(In dollars per ton)

	Landfill Only	Base Case Curbside Recycling with Landfill	Expanded Curbside Recycling with Landfill	Composting with Landfill	Waste-to Energy with Ash Landfill
MSW collection	63	71	78	85	63
Landfill disposal	24	25	25	25	93 **
Total landfill cost	87	96	103	110	156
Recyclables collection	–	114	91	67	
Recyclables processing	–	50	44	21	
Total recyclables cost	–	164	135	88	
Recyclables revenue	–	(46)	(29)	(0)	(22) **
Net recyclables cost	–	118	106	88	
Total system costs	87	100	104	102	134 †
Incremental system cost over landfill	–	13	17	15	47 †

* In an average metropolitan area of 500,000 population.

** Processing costs at waste-to-energy plant including ash disposal; revenue is from sale of energy.

† From Appendix H.

Source: Franklin Associates, Ltd.

Special note should be taken that a relatively high recovery rate was assumed for each case, i.e., that capture of material is close to a maximum for a well designed program. Said another way, lower recovery rates will result in higher costs per ton for a recycling program.

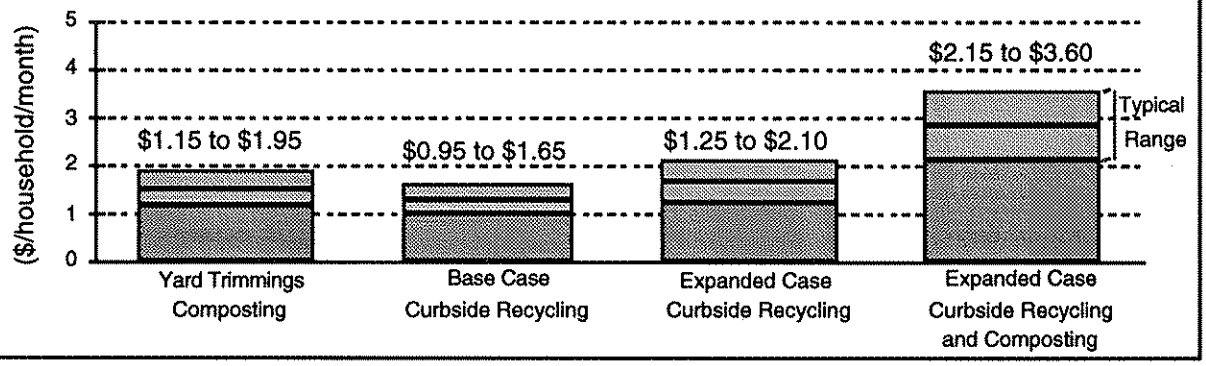
The model metropolitan area analysis represented in Table 6 is based on 155,000 single-family homes served and 185,600 tons per year of household MSW managed. In terms of total solid waste management system costs for one year, the

costs are about $13 per ton, or $2.45 million over landfill only for the base case curbside recycling scenario. This translates to an increase of $1.31 per household per month of total MSW managed.

The comparable differences for the expanded curbside recycling scenario are an increase of $3.13 million, about $17 per ton or $1.68 per household per month. For composting, the values are $2.89 million, or $16 per ton, or $1.55 per household per month increase over landfill only. Waste-to-energy is the highest cost option at $47 per ton increase, or $4.70 per household per month.

These scenarios were also expressed in terms of increased cost ranges over conventional landfill costs in dollars per household per month (Figure 6). The costs are expressed in ranges to demonstrate the variability of different program designs and local circumstances. The data in Table 6 also show how costs behave as different recycling scenarios are displayed. The most significant observation is that total collection costs increase in dollars per ton when two collection systems are used. This is true for both the landfill and recycling system, because the collection systems are less efficient (Table 6). For example, it takes more stops and longer to fill a refuse truck when recyclables are separated out.

Figure 6. Average metropolitan area household solid waste management cost increases with yard trimmings composting and/or curbside recycling (Added cost over landfilling only)



Curbside collection costs in non-urban areas were found to be more costly than in urban areas. For example, the system solid waste management costs for base case curbside collection costs are $17 per ton in a non-urban area compared to $13 per ton in an urban area, or 30 percent higher. The economics of rural and small city recycling beyond curbside collection were not examined in detail. However, programs in which citizens and businesses provide their own collection and delivery to drop-off locations may be the most effective type of program applicable in these areas.

All systems for managing solid waste are evolutionary in nature. While the pattern of multiple truck collection of recyclable and compostable materials and trash now used will likely continue through the balance of the 1990s, technology and economics will require more innovation in the near future. Thus, planning for the future must consider how collection techniques can be developed to drive costs down and yet capture the components of the waste stream in a usable fashion.

When, for example, a multiple service truck is devised that combines recyclable materials, compostable materials, and trash in one collection step *and retains the quality of the recyclables*, the economics of integrated solid waste management can change dramatically. Municipal decision makers should consider how such a system may change the "status quo" system that will likely continue for most of the balance of the 1990s.

The principal observations on the economics of recycling alternatives are:

- Collection and transportation costs dominate.
- Curbside collection for recycling adds total direct costs to a conventional MSW management system. Revenues fluctuate, but partially offset costs.

- Yard trimmings composting is the most cost efficient alternative.

MARKETS FOR POTENTIALLY RECOVERABLE MATERIALS

For the past decade, there has been great concern about adequate capacity for utilizing recovered materials and access to regional scrap users and plants. In fact, "markets" has been the principal focus of attention for those seeking to increase recycling. Several industries have established new or expanded capacity to utilize recovered products and materials, and either actively seek or at least accept materials that become available from community programs and private sector activity. Other markets are in an emerging or potential status.

A detailed overview of the 1992 generation and recovery of recyclable products and yard trimmings in residential MSW is given in Table 7. The general status of the market for each material is also included. It is important to note that established markets (manufacturers' capacity) exist for eight of the materials, which constitute 27.8 million tons of the 46.6 million tons *generated* (60 percent of the total tonnage of recyclable materials). This does not mean that 100 percent recovery is possible or that recycling capacity exists for all of the tonnage, but it does indicate that there is certainly an established demand for the materials being collected.

Table 7

MARKET CLASSIFICATION OF RECYCLABLE/COMPOSTABLE MATERIALS IN RESIDENTIAL MUNICIPAL SOLID WASTE, 1992

(By recoverable product in million tons)

Product Category	Total USA (estimated) Quantity Generated	Total USA (estimated) Quantity Recovered for Recycling/ Composting	Market Status Established	Emerging	Potential
Recyclable Materials					
Newspapers	10.70	6.13	✔		
Glass containers	8.95	3.02	✔		
Aluminum cans	1.27	0.88	✔		
Steel cans	2.25	0.74	✔		
PET soft drink bottles	0.41	0.20	✔		
HDPE natural bottles	0.39	0.11	✔		
Magazines*	3.37	0.64	✔	✔	
Corrugated boxes	2.54	0.13	✔		
Telephone directories	0.41	0.03	✔	✔	
Milk/juice cartons	0.41	<0.01		✔	✔
Paper grocery sacks	1.33	0.33	✔		
Paperboard beverage carriers**	0.46	0.04		✔	✔
Other mixed papers†	8.80	1.25		✔	✔
Other plastic bottles	0.92	0.06		✔	✔
Polyethylene film††	1.35	0.02		✔	✔
Textiles	3.08	0.16		✔	
Compostable Materials					
Yard trimmings	31.50	5.65		✔	

Notes:

* Includes catalogs.

** Recovery estimated as part of mixed papers.

† Includes mail, wrapping papers, folding cartons, etc.

†† Includes trash bags, grocery bags, etc.

Source: Franklin Associates, Ltd.

There are several key observations and conclusions related to markets for materials and products in residential (and commercial) MSW, as follows:

- Scrap markets are, by their nature, commodity-like and have fluctuations in demand. Consequently, the value of materials recovered from MSW can vary widely, especially at the point of generation and collection. For example, in 1994 the market demand for many recyclable materials increased and market prices have risen dramatically. But, true to the cycles of the past, there will be a decline to follow. The message for communities is that residential collection programs should be designed for the long term, recognizing that there

will be fluctuations and volatility in prices. Communities with existing recycling programs will benefit (short term) when these price "spikes" occur. However, increased recovery efforts of all kinds quickly follow price increases, and increased recovery will tend to drive prices down.

- Manufacturing capacity to utilize recovered materials exists or has been put in place in the last few years. The fact that the capacity exists to utilize recovered materials establishes only that demand can exist. At the community level, however, the economics, distance to market, infrastructure, and quality of material are limiting factors. The most critical market requirement for recovered materials is that they meet the quality specifications of those manufacturers that utilize recovered materials.

- Recovery of recyclable materials from commercial sources is based on market demand and generally cost-effective recovery techniques (including avoided disposal costs of the generator).

- Recovery of recyclable materials from residential MSW has tended to follow a pattern in which collection and processing have been carried out first. Industries have established capacity to utilize recovered materials in response to growing supply.

- Considering both total U.S. and regional capacity, the products that offer the strongest market potential in residential MSW are newspapers, corrugated boxes, glass containers, steel cans, aluminum cans, PET plastic containers, HDPE plastic containers and, on an emerging basis, magazines and mixed papers.

THE ROLE OF RECYCLING AND COMPOSTING IN INTEGRATED SOLID WASTE MANAGEMENT IN 2000

By the year 2000, the generation of MSW will likely have increased from 203 million tons to 215.5 million tons (Figure 7).

Three projected scenarios for the year 2000—25 percent, 30 percent, and 35 percent recovery for recycling and composting—are summarized in Table 8. The immediate observation for the highest recovery rate is that about 50 percent of the recyclable/compostable materials would have to be recovered to reach a 35 percent overall recovery rate. Fifty percent is a high recovery rate and represents the practical limits of recovery for most of the products in the recyclable product category. A summary recovery analysis for the 25, 30, and 35 percent scenarios is given in Table 8.

The reason that 50 percent recovery of the selected products is difficult to achieve on a broad basis is a result of three factors that influence recoverability:

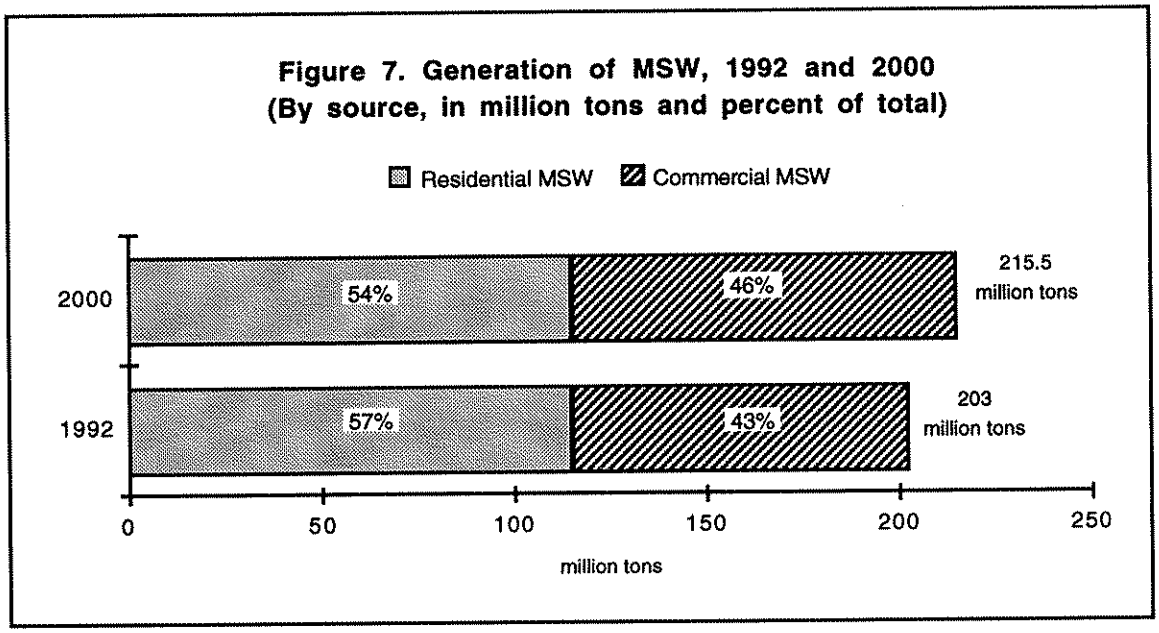


Table 8

SCENARIOS OF PROJECTED RECOVERY FOR RECYCLING/COMPOSTING IN 2000

(In million tons and percent of total)

		Recovery					
		Low Range		Mid Range		High Range	
	Generation	Tons	%	Tons	%	Tons	%
Selected recyclable products	131.3	47.5	36%	55.0	42%	64.5	49%
Yard trimmings	22.2	7.0	32%	8.6	39%	10.0	45%
Total selected products and materials	153.5	54.5	36%	63.6	41%	74.5	49%
Other compostable/combustible materials	33.5						
Other materials	28.5						
TOTAL MSW	215.5	54.5	25%	63.6	30%	74.5	35%

Notes:

Recovery tonnages and percentages are "best estimates".

Residential MSW includes multi-family homes.

Source: Franklin Associates, Ltd. (Appendix K).

1. Citizen access to a collection program
2. Citizen participation in the program
3. "Capture" of the material from participating households.

For example, a newspaper program may have the following profile: 90 percent access, 85 percent participation, and 90 percent capture. The recovery

potential is 69 percent (0.9 x 0.85 x 0.9). Most products in residences will have significantly lower recovery potential (see analysis in Table 9).

The practical maximum residential recovery percentage was estimated for 11 product/material categories and further evaluated for curbside collection based on four factors that could introduce constraints on recovery. They are:

- Infrastructure to collect and process materials
- Market capacity to utilize recovered materials
- Quality of recovered products/materials
- Economics of recovery.

The following observations can be made:

- The economic considerations have a common theme: recovery of residential materials via curbside collection is generally more costly than conventional landfill disposal.

- The quality of recovered materials can substantially affect recovery programs that are not operated to meet market specifications.

- Within the residential recovery potential, there will be adequate market capacity on average in 2000 to utilize essentially all of the materials recovered from residential sources, with few exceptions. Regional situations can have a dramatic effect, however, and need to be considered carefully in any community program.

  In the final analysis, the most critical factors are the infrastructure to collect and process the materials considered for residential recycling or composting, and the economics of starting and operating those programs.

Furthermore, the role of curbside collection in 1992 and 2000 was evaluated using a series of estimates and assumptions (see Appendix K for details). The results of the calculations are summarized in Table 10.

In 1992, curbside collection of recyclable products was an estimated 5.1 million tons, which was 2.5 percent of total MSW generation (and 4.4 percent of total residential MSW generation). To achieve a 30 to 35 percent recovery of MSW by 2000, a doubling of tonnage recovered by curbside collection would be required (10.0 million tons). At the level of 10.0 million tons, curbside recovery would amount to 4.6 percent of total MSW generation, or 8.6 percent of residential MSW generation (Table 10 and Figure 8). In essence, the population served by curbside collection would need to double between 1992 and 2000 to achieve this level, from an estimated 27 to 54 million single-family homes, about two-thirds of all single-family homes. The expansion of curbside collection to

Table 9

EVALUATION OF FACTORS AFFECTING RESIDENTIAL MSW RECOVERY POTENTIAL

BASE CASE MATERIALS

	Infrastructure to Collect & Process	Market Capacity	Quality (Contamination)	Economics	Maximum Practical Residential Recovery (%)
Newspapers	◗	○	◗	◗	60 – 70%
Glass bottles	●	○	●	●	40 – 50%
Steel cans	◗	○	○	◗	60 – 70%
Aluminum cans	○	○	○	○	65 – 75%
PET bottles	●	○	◗	●	40 – 50%
HDPE bottles	●	◗	◗	●	25 – 35%
Yard trimmings	●	○	◗	●	40 – 50%

EXPANDED CASE MATERIALS

Magazines	●	◗	◗	●	40 – 50%
Mixed papers	●	◗	○	●	20 – 35%
OCC*	◗	○	○	◗	20 – 35%
Mixed plastics	●	●	◗	●	15 – 25%

* Old corrugated containers. Includes kraft paper bags and beverage boxes.

● A limiting factor if not in place or favorable.

◗ Some constraints may exist, but not at a limiting level.

○ Generally favorable or beneficial.

Note: Evaluation is for the nation as a whole. Some regions may have other limitations in certain categories. (See Chapter 5.)

Source: Franklin Associates, Ltd.

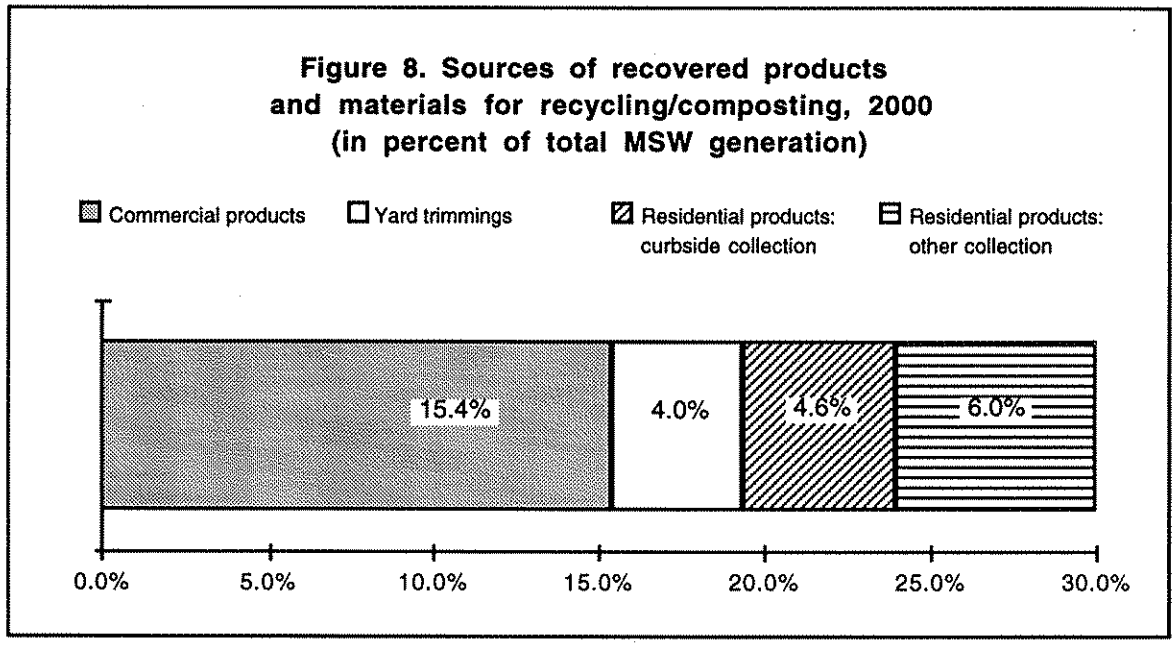
Table 10

ESTIMATED PRODUCT RECOVERY FOR 30 PERCENT RECYCLING FROM RESIDENTIAL SOURCES BY CURBSIDE COLLECTION AND OTHER METHODS, 1992 AND 2000
(In million tons and percent)

	1992			2000 (30% recovery)		
	Million tons	% of Residential MSW Generation	% of Total MSW Generation	Million tons	% of Residential MSW Generation	% of Total MSW Generation
Curbside collection	5.1	4.4%	2.5%	10.0	8.6%	4.6%
Other collection methods*	8.3	7.2%	4.1%	12.9	11.2%	6.0%
Total residential recovery of products	13.4	11.6%	6.6%	22.9	19.8%	10.6%

* Drop-off and buy-back centers; deposit systems; scrap dealers, etc.

Source: Franklin Associates, Ltd. estimates.



thousands more communities and millions more homes is a substantial undertaking, requiring expansion of programs in non-urban areas where costs of curbside collection may be higher on a per-ton basis. Each community will need to consider its own goals carefully.

In addition, there must be substantial expansion of other types of programs including multi-family housing, drop-off centers, paper drives, and traditional scrap facilities. Programs such as drop-offs in non-urban areas must be expanded or put in place as well. In essence, a national average recovery scenario

means that all types of recovery efforts will be important on a broad geographic basis.

The principal conclusions to be drawn from this analysis are:

- Curbside collection captured a relatively small amount of total MSW in 1992 (about 2.5 percent).

- With a doubling of curbside collection and processing, capture in 2000 would be about 5 percent of total MSW. This means that, on average, curbside collection alone cannot achieve a major diversion of MSW from disposal.

It is important to note that the 25, 30, and 35 percent recovery for recycling scenarios apply to a community, a metropolitan area, a state, or a region in roughly the same way. The recovery range identified generally defines local, regional, and national potential. Some communities have been more highly successful and reach above 35 percent recovery for recycling and composting. However, many other communities achieve far below this range (some because yard trimmings composting is not feasible), and may even choose not to make the investment and incur the costs of residential collection programs.

In addition, the commercial sources of MSW are extremely important; they account for well over one-half of all recovery, and will continue to do so. Thus, programs to inform and educate businesses, institutions, and government about recycling are very important.

Residential recovery is, however, where most communities can put infrastructure into place; but it is difficult to achieve higher levels of recovery for recycling from residential MSW alone for the following reasons:

1. Most of the recycled products will be at or near their limits of recovery in a 30 percent recovery scenario, although a few of them can be pushed somewhat higher.

2. The selected recyclable products (exclusive of yard trimmings) constitute 55 percent of all MSW in 1992 and 61 percent in 2000. Thus, to achieve *total* MSW recovery rates in excess of 25 to 35 percent, the capture of selected products from residential (and commercial) sources would have to be at unsustainably high levels.

3. Yard trimmings composted constituted a significant part of recovery from residential sources in 1992 (about 40 percent as much composting as recovery of products from residential MSW). Under the 30 percent recovery scenario in 2000, composted yard trimmings would still be 37

percent as much as the selected products recovered from residential MSW.

Finally, recycling and composting as defined in this study are clearly only a part of MSW management and will likely be peaking out by 2000, absent dramatic changes in technology and infrastructure to collect and process MSW.

STATE, REGIONAL, OR LOCAL RECYCLING OR DIVERSION GOALS

Diversion or recycling goals may be established in a community or state. These fall into two general classes: (1) diversion or recycling goals of 20 percent to 35 percent; and (2) diversion or recycling goals of 35 percent to 70 percent.

In the first instance, diversion of 20 to 35 percent can be achieved with materials recovery and yard trimmings composting (or by eliminating collection of yard trimmings). The logistics and costs of materials recovery become problematic above 25 to 35 percent for the reasons discussed previously.

There are several other management and technology options that deal with a large segment of MSW in a useful way, but are not recovery for recycling as defined here. These are listed below in no particular order of priority because each community may have circumstances that lead to choose one or more. They are:

- Source reducing yard trimmings (through backyard composting of grass, leaves, and brush, or by leaving grass clippings on lawn) so that they do not enter the MSW collection system.
- Converting the vegetable (i.e., non-animal) portion of food waste to a compost or feed for animals.
- Converting paper and other compostable organics, e.g., food waste, to a mixed waste compost.
- Converting paper and/or plastics to a prepared fuel for use in an industrial boiler.
- Waste-to-energy combustion in an MSW-dedicated boiler plant.

One or more of these options may be needed to reach almost any diversion goal above 35 percent by 2000.

percent as much as the selected products recovered from residential MSW.

Finally, recycling and composting as defined in this study are clearly only a part of MSW management and will likely be peaking out by 2000, absent dramatic changes in technology and infrastructure to collect and process MSW.

STATE, REGIONAL, OR LOCAL RECYCLING OR DIVERSION GOALS

Diversion or recycling goals may be established in a community or state. These fall into two general classes: (1) diversion or recycling goals of 20 percent to 35 percent; and (2) diversion or recycling goals of 35 percent to 70 percent.

In the first instance, diversion of 20 to 35 percent can be achieved with materials recovery and yard trimmings composting (or by eliminating collection of yard trimmings). The logistics and costs of materials recovery become problematic above 25 to 35 percent for the reasons discussed previously.

There are several other management and technology options that deal with a large segment of MSW in a useful way, but are not recovery for recycling as defined here. These are listed below in no particular order of priority because each community may have circumstances that lead to choose one or more. They are:

- Source reducing yard trimmings (through backyard composting of grass, leaves, and brush, or by leaving grass clippings on lawn) so that they do not enter the MSW collection system.

- Converting the vegetable (i.e., non-animal) portion of food waste to a compost or feed for animals.

- Converting paper and other compostable organics, e.g., food waste, to a mixed waste compost.

- Converting paper and/or plastics to a prepared fuel for use in an industrial boiler.

- Waste-to-energy combustion in an MSW-dedicated boiler plant.

One or more of these options may be needed to reach almost any diversion goal above 35 percent by 2000.

ENERGY AND SOLID WASTE CONSEQUENCES OF RECYCLING AND LANDFILLING

All human activity, including recycling, has some resource and environmental consequences. Recovery for recycling usually saves energy and reduces solid wastes landfilled. The most obvious benefit to recycling is diversion of recovered materials from conventional disposal, i.e., reduced dependence on landfills.

Each of the solid waste management alternatives was evaluated in terms of net energy consumption (or savings) and related environmental emissions, particularly the net amount of solid waste ultimately landfilled. For example, landfill as a disposal alternative requires minimal fuel for collection vehicles and landfill equipment, but provides no municipal solid waste diversion from landfills. In contrast, recycling diverts waste from landfills and, while recycling requires additional energy for collection, processing, and transporting materials to market, energy savings are often realized by the increased use of recovered materials in the remanufacturing process.

Landfill disposal requires relatively little energy, about 0.5 million Btu per ton of residential municipal solid waste landfilled. Once landfilled, however, the energy "investment" and emissions associated with the original manufacture and use of the product are lost. By contrast, waste-to-energy facilities will capture the heat value in the organic materials with attendant releases to the air, water, and land (via ash). These releases may be similar to or less than power production from coal, and, as in other power plants, must be controlled.

Emissions to the air, water, and land avoided due to the increased use of recyclable materials in remanufacturing is primarily due to the reduction in energy use (versus manufacturing with virgin raw materials). Unlike energy and solid waste, which can each be presented as a single value (i.e., Btu of pounds of waste discarded), individual emissions comprising atmospheric and waterborne emissions cannot be meaningfully added together. Also, these emissions are site-specific and may occur far from the community from which the materials were recovered.

From the standpoint of energy resources, the most significant effects are not from the collection, processing, and shipment of recovered materials. Rather, the most significant effects are realized due to the increased use of recovered materials in the manufacturing step. Approximately 1.5 million Btu of energy are required to collect, prepare for shipment, and transport to market one ton of recyclable materials typically collected through a curbside collection program. The total energy conserved through the increased use of these materials in remanufacturing is over 18.3 million Btu per ton of recyclables recovered.

Based on 5 million tons of recyclable materials collected through curbside programs in the U.S. in 1992, and an average annual residential energy consumption per household of about 100 million Btu, the annual energy conserved is equivalent to the energy requirements of 840,000 residences. Most of the energy conserved is derived from recycling aluminum, some plastics, and newspapers. Typically, the energy and/or environmental benefits occur outside the community from which the material is recovered for recycling (except for reduction of landfill requirements).

The environmental analysis allows communities to begin to identify and understand the energy and environmental tradeoffs associated with different solid waste management alternatives, and provides some perspective on the relative magnitude of net energy requirements and environmental releases of each alternative.

A summary of energy and landfill requirements for two alternatives—landfilling and base case recycling—is shown in Table 11.

Table 11

SUMMARY OF ENERGY AND SOLID WASTE FOR LANDFILL AND CURBSIDE RECYCLING OF ONE TON OF RESIDENTIAL MSW*
(In million Btu and pounds)

	Landfill	Base Case Recycling
Energy requirement (million Btu)		
Energy demand	0.53	0.75
Energy savings	–	-4.05 **
Net energy	0.53	-3.30 †
MSW disposed (pounds)	2,000	1,590

* Using the base case curbside recycling scenario (See Chapter 6).
** Negative number indicated savings through remanufacturing.
† Energy per ton of MSW generated.

Source: Franklin Associates, Ltd.

KEY OBSERVATIONS

- Recovery of materials for recycling will continue to grow in the context of an MSW management technique. At the same time, the practical overall limits are in the range of 25 to 35 percent recovery for recycling/composting. This could possibly be achieved by expanded residential curbside or equivalent programs, but would require doubling the number of single-family homes served. Recovery from commercial

waste for recycling is an absolutely vital part of the materials management options. The most promising area of research is to reduce collection costs without sacrificing the quality of materials recovered.

- There are costs to increasing recovery. Program costs will have growing influence over the decision-making process at the local level. The reality is that recycling at the community level is not free and usually does not reduce the costs of total solid waste management. In fact, it increases costs in most communities. Since collection costs dominate total costs, emphasis on reducing collection costs is important to pursue. This will require innovative collection techniques, which are just beginning to emerge. Revenues from recovered materials help to offset costs, but will fluctuate with scrap markets.

- It will be important to expand existing recovery techniques or introduce other techniques as a way to reach diversion goals above 35 percent. The most promising options may come from diverting yard trimmings from MSW, composting food waste, converting paper and/or plastic to a prepared fuel, and other techniques that may become feasible by the end of the century.

- A 30 percent recovery scenario for recycling and composting in the year 2000 would only offset the total projected growth in MSW generated (driven by increases in population and economic growth), leaving the remaining 152 million tons of MSW to be managed through other integrated solid waste management approaches and emerging technologies.