# RECYCLING IN MICHIGAN

## SUCCESSFUL RECYCLING PROGRAMS, BEST PRACTICES, AND DIVERSION POTENTIAL

*FINAL REPORT | JANUARY 2016*

A PROJECT OF THE NORTHEAST MICHIGAN COUNCIL OF GOVERNMENTS WITH GRANT FUNDING FROM THE MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY

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# EXECUTIVE SUMMARY

## BACKGROUND AND GOALS

In April 2014, Governor Snyder released Michigan's Residential Recycling Plan and announced a statewide recycling initiative to boost material recovery, including the establishment of Recycling Council composed of business leaders representing different aspects of the recycling system. The governor's plan set a clear course of actionable steps for improving recycling in Michigan, including benchmarking and measuring progress, providing education and technical assistance for communities, ensuring widespread and convenient access to recycling, developing markets for commodities, innovating, and a creating sustained commitment to success.

The plan and the Council identified benchmarking and measurement as a first step, and the Michigan Recycling Coalition received a grant from the Michigan Department of Environmental Quality (MDEQ) to launch the Michigan Recycling Index (MRI), measure access to recycling, evaluate participation in recycling, and calculate the rate of recycling for municipal solid waste (MSW). The final report, ***Measuring Recycling in the State of Michigan****, was published in May 2015.*

This report builds on the MRI work. Through a separate MDEQ grant the Northeast Michigan Council of Governments (NEMCOG) contracted with, Resource Recycling Systems (RRS) and Public Sector Consultants (PSC) to identify best practices and metrics for successful recycling programs and profile Michigan communities who have implemented these best practices. The objective of the project was to fully understand the key features of model recycling programs and share the experiences of Michigan communities who have been successfully implementing these best practices.

## PROJECT HIGHLIGHTS AND FINDINGS

### RECYCLING BEST PRACTICES, MEASURES OF SUCCESS AND MODEL PROGRAMS

There are significant lessons from successful recycling programs that can be adopted and expanded in Michigan to improve the state's recycling efforts. Section I provides a comprehensive overview of national best practices for collection and processing, rate structures, multi-family, rural, and commercial recycling programs, and options for addressing construction and demolition recycling. Based on these recycling best practices research, PSC and RRS identified seven recommended measures, or metrics, of successful recycling programs that communities in Michigan should strive to meet in order to increase and improve Michigan's recycling performance:

1. Recycling education programs
2. Easy access to recycling options
3. Providing curbside recycling in all communities with medium to high densities

4. Providing curbside recycling carts to increase the volume of recyclables collected
5. Providing curbside recycling to multi-family housing on the same routes as single-family collection
6. Implementing variable rate pricing for waste to create incentives for recycling
7. Supporting market development, especially for commodities with low market value
8. Supporting local policies
9. Consistent and sufficient funding for recycling
10. Engagement and participation among households and businesses
11. Local capacity and leadership
12. Tracking and measurement systems

We used these metrics to evaluate the success of four high-performing Michigan communities: Benzie County, City of Farmington Hills, Emmet County, and the City of Grand Rapids. Some of the key issues and findings regarding the application of these measures in the four communities include:

- Education and outreach are very important and must be constantly implemented and updated.
- Capacity at the curb makes a difference. Communities that moved to larger roll-off carts have seen significant increases in the volume of recycled materials because it is more convenient and provides more space for a lot of materials.
- Access in rural areas needs to make sense – be in places people go and allow people to easily bring many items
- Strong policies drive strong recycling. The level of policy support varied, and those with the strongest policies, such as Emmet County, have the most robust recycling effort
- Consistent funding is critical and communities must choose the method that best meets their needs. Recycling costs must be spread across the community, not just come from those that participate
- Measuring progress is important for adaptively managing programs. More progress needs to be made on measuring progress in some areas. For example, it can be hard to accurately gauge participation
- Leadership is key. Someone needs to be in charge of keeping the ball rolling at the local level – political support will generally follow

Not every successful recycling program has invested equally in each of these elements, and some are more critical than others. But the most successful communities have knitted these elements together to ensure that residents (and businesses) have access to recycling, understand its value and how to participate, are helping support the cost of recycling, and can follow and track their community's progress.

## Modeling Recycling Performance and Participation

Utilizing existing research, RRS evaluated best practices for superior program performance and participation to serve as a baseline for the purposes of both promoting best practices and comparing program performance across the state. RRS developed a model that provides an estimate of the costs

and avoided disposal savings incurred with different approaches to operating a residential recycling program. The following is represent key findings from the analysis:

- Current recycling collection programs in Michigan range from biweekly pickup dual sort to weekly single sort collection programs.
- The relationship between participation rate and the quantity of material that is recycled is a difficult variable to balance.
- The Net Recycling Cost is the lowest for the Single Sort Semi Automated Bi-weekly collection program by approximately 50% while potentially achieving a 46% recycling rate.
- A Dual Sort Bi-weekly program has an estimated net cost of approximately 56% higher then the Single Sort Bi-weekly program and achieves a 27% recovery rate.

## Waste Characterization

For the purposes of the study, a waste sector is identified by the particular generation characteristics that make it a unique portion of the total waste stream. Each state characterization that was reviewed has a different definition of what material was included in their studies based on their statutory definition and the types of solid waste and recycling program requirements. The characterizations from other states and communities identified 80 different categories of material that were evaluated, however not every category was evaluated within a specific state study. The development of a waste characterization for the State of Michigan is based a review of 27 statewide and municipal waste characterization studies from across the country. An issue that complicates the development of a waste characterization for the State of Michigan by utilizing previously conducted waste characterizations studies from other states and municipalities is the "evolving ton", a term being used to describe the shift in the overall composition of the municipal solid waste stream over the past 20 years. A comprehensive Waste Characterization profile can be found in Table ES-1.

Table ES -1: Waste Characterization of Statewide Disposed Waste

| Material Type | TONS | PERCENT of TOTAL |
|---|---|---|
| Paper Subtotal | **1,901,543** | **23.69%** |
| Plastic Subtotal | **1,009,556** | **12.58%** |
| Metal Subtotal | **487,789** | **6.08%** |
| Glass Subtotal | **143,835** | **1.79%** |
| Electronics Subtotal | **130,285** | **1.62%** |
| Total Wood | **848,002** | **10.57%** |
| Yard Waste, Food Waste and Organic Subtotal | **1,709,554** | **21.30%** |
| Other Materials such as Textiles, Batteries, Carpet | **435,258** | **5.42%** |
| Other Non- Recyclable Materials | **1,360,621** | **16.95%** |
| Total | **8,026,443** | **100.00%** |

## Economic and Environmental Impacts of Recycling

The analysis of the economic impact of recycling includes an evaluation of the current recyclable current market value of materials, market trends, and a discussion of the recycled commodity market drivers. Based on data collected through the MRI project, the economic and environmental impact of current and potential recyclables was calculated to provide information about the revenue-generating potential of those recycled commodities.

- Contractual Arrangements between a municipality and a Material Recovery facility (MRF) where the MRF operator rebates communities based on the value of recycle commodities using a blended commodities pricing index has become a common practice. The average commodity revenue (ACR) contract approach is one of the prevalent mechanisms for a community to hedge the risks of volatile swings in the value of recycled commodities.
- The majority of recycling revenue in a MRF comes from the denser suite of materials like fiber, which represents as much as 65 percent of the weight but about 48 percent of the value
- Beginning in 2014 the general trend in overall average commodity revenue has declined as global demand for all commodities, primarily driven by Chinese demand, has declined.
- The value of recycling material that is currently recycled, based on October 2015 Average Commodity Revenue for the Midwest, is approximately $76 million, which is 70.1% of the value base on the average commodity value over the past 5 years.
- The quantity of landfilled but potentially recyclable material based on the types of material currently collected in recycling programs, as illustrated in Table 18, is approximately 1.879 million tons of material and represents 23.4% of the material landfilled.
- The value of landfilled but potentially recyclable material based on a 5-Year Average Commodity Revenue for the Midwest, as illustrated in Table 18, is approximately $211 million, which is 143% of the value based on the current October 2015 commodity value.
- It is difficult to project future prices for recycled commodities as the value is closely linked to global economic growth and is especially sensitive to the growth in industrialization of emerging markets such as China and India.
- The estimation of the jobs related to recycling indicates that 68 jobs are created throughout all sectors, including collection, processing and recycled manufacturing for every 10,000 tons per year that are recycled.

Waste and recyclables that end up in landfill is lost energy and materials. In a landfill site, organic residuals decomposing in anaerobic conditions produces landfill gas, approximately half of which is methane. When waste is recycled, landfill gas is not formed. In addition to landfill emissions, waste and contributes to greenhouse gas emissions also in other operations. When properly managed, recycling can affect emissions at all of these stages.

The overall benefit gained from recycling depends on a number of questions, such as what are the transport and pre-treatment requirements of the recycled materials, what kind of materials are

produced and, above all, what kind of products are to be replaced by different products using new materials.

The review of the US EPA Waste Reduction Model (WARM) approach to evaluating the environmental impacts of recycling as well as the review of other Life Cycle approaches leads the project team to conclude that the WARM approach is an appropriate method for evaluating certain curbside recyclables and Construction and Demolition materials in the State of Michigan. The WARM Model is useful for comparing internal scenarios for different approaches to a comprehensive waste management approach but should not be used to develop management protocols for individual materials. It is less useful for examining the fate of individual waste streams (e.g. individual paper types such as cardboard or mixed office paper) and has limitations in the application to organics in general. Some key limitations in the WARM are:

- WARM does not differentiate between specific wastes, such as organic wastes that include food wastes, and therefore underestimates the GHG potential of certain materials.
- WARM also does not include GHG emissions or emissions reductions associated with other co-benefits associated with the use of compost, such as water conservation and changes in fertilizer use. WARM also does not differentiate between the potential for varying emissions from compost sites themselves as a function of technology (e.g., anaerobic vs. aerobic composting, or centralized vs. home composting).
- WARM does not currently break emissions and emissions reductions into the years in which they actually occur. Rather, WARM rolls all future emissions and emissions reductions into a single number.

## RECOMMENDATIONS

Based on the project findings, PSC and RRS have identified some potential near-term actions the state and Michigan communities can take to improve Michigan's overall recycling efforts:

- The State of Michigan should adopt statewide policies for ensuring access to recycling as defined in the measures of successful recycling programs
- The state should provide hands-on technical assistance to communities in evaluating and designing appropriate funding options for expanding their recycling programs
- Grant funding should be targeted to build communities' capacities for measuring, tracking, and reporting on recycling progress and providing community education on recycling and on developing recycling education programs
- Communities should evaluate their current access to recycling and develop a plan for meeting at least the minimum access needs identified in this report
- The state and communities should partner to identify appropriate recycled material markets and work with local industries on potential recycled product use.
- The State should evaluate requirements for Construction and Demolition waste recycling.

- The State of Michigan should develop more detailed data on the types of materials to include in a WARM methodology before a comprehensive utilization of this tool can be undertaken to assess GHG impacts.
- The protocols for organics in WARM should be improved or alternative approaches developed for these materials.

## Recommendations for Waste Characterization

Other states that have regularly conducted statewide waste characterization studies have, over time, structured the studies to investigate certain waste streams in greater detail. In addition to measuring the composition of disposed wastes in total and by generator sector, some states have opted to focus on:

- Targeted generator sampling of the most prevalent business types (e.g., grocery stores, manufacturing, retail malls, etc.) that generate significant quantities of waste;
- Enhanced research into waste generation indicators for certain waste streams, especially C&D debris, to improve future sampling plans for this waste stream;
- Measuring contamination rates in disposed material (for both particulate matter and moisture) as a means of investigating dirty MRF processing potential;
- Calculating energy and heating values in disposed waste for incineration and thermal conversion processes; and
- Determining the composition of residuals from recyclables processing facilities to test recovery efficiency and potential for additional processing.

Michigan should conduct a large statewide waste characterization study but it should integrate one or more of these tests in the future. Such future efforts would be limited by available funding, but could provide additional insight into diversion and recycling opportunities in Michigan.

# BACKGROUND AND PURPOSE

Michigan's current recycling rate is only 14.5 percent of total waste diversion. This amount is well below many other states, including several of our Midwestern neighbors. It has been estimated that increasing Michigan's recycling rate from current levels to 50 percent would result in the addition of $435 million to Michigan's economy annually and help improve Michigan's environment.

In order to help recognize these economic and environmental benefits, Michigan's Governor Snyder released a Residential Recycling Plan in 2014 and announced a statewide recycling initiative to boost material recovery. The governor's plan set a clear course of actionable steps to improve recycling in Michigan, including benchmarking and measuring progress, providing education and technical assistance for communities, ensuring widespread and convenient access to recycling, developing markets for commodities, innovating, and a creating sustained commitment to success.

In order to address these goals and maximize the value of material successfully diverted to recycling and composting, the governor has urged that public and private investments be focused on implementing the Residential Recycling Plan. To this end, the Northeast Michigan Council of Governments (NEMCOG) was awarded a State of Michigan Pollution Prevention grant in 2014 to conduct a detailed analysis of recycling in Michigan, including:

1. Evaluating best practices for recycling
2. Identification of metrics of successful recycling programs
3. Highlighting successful community recycling programs
4. Calculating the economic and environmental impact of Michigan's recycling rate
5. Develop a Waste Characterization of Landfilled Solid Waste

Public Sector Consultants (PSC) and Resource Recycling Systems (RRS) partnered with NEMCOG on this grant to help the state and local communities recognize the economic and environmental value of recycling, understand the key elements of a successful recycling program, and learn from the examples of other Michigan communities. This report presents the findings of the first three tasks. A separate report which evaluated the impacts of the bottle bill laws on state and local recycling rates was published in January 2016 in conjunction with this project.

## PROJECT LEADERSHIP

The Michigan Profile of Recycling Programs and Potential Recycling was a project of the NEMCOG, which received a Pollution Prevention Grant (P2) from the MDEQ. Supporting the project was an advisory group comprised of Michigan Recycling Coalition, RRS, Cascade Cart Solutions, Clean Tech Inc., Emterra Environmental USA, Emmet County Recycling, Public Sector Consultants (PSC), the Michigan Association of Regions and Recycle Ann Arbor. The Advisory Group met three times during late 2014 and 2015.

*The Northeast Michigan Council of Governments (NEMCOG) was established in 1968 as a multi-county organization to pool resources for the assistance of local governments in the region. Services are supported by local government appropriations, special services contracts and state and federal grants. NEMCOG is a catalyst for strategic planning, and in this role has assisted local governments obtain millions of dollars in federal and state grants for vital local projects and services. In addition to planning, NEMCOG also sponsors many other programs, including Community Correction and Watershed Projects.*

*The Michigan Department of Environmental Quality promotes wise management of Michigan's air, land, and water resources to support a sustainable environment, healthy communities, and vibrant economy.*

*For nearly three decades, Resource Recycling Systems (RRS) has been a leader in solid waste management systems across the country. Through the years, RRS has worked within many Michigan communities pushing boundaries with progressive solid waste plans, designed multiple material processing systems, developed compost management site plans and conducted compost site operator training courses in conjunction with the MRC. The RRS project team is comprised of experts in waste reduction and recovery, biomass energy, organics management, and corporate sustainability that generate projects with business case justification, actionable solutions and meaningful impact.*

*Public Sector Consultants is a nonpartisan research firm providing policy research in health, education, energy, and the environment. For more than 30 years, PSC has built a reputation for credible, independent research, facilitation, and program management. PSC's uniqueness lies in what they know, how they communicate complex policy issues to experts and informed laypersons, and how they bring together and facilitate diverse stakeholders to look at innovative approaches to policy. PSC's research and facilitation processes are disciplined, with clear goals, and specific and measurable results.*

# PROJECT GOALS AND OBJECTIVES

The goals of this project are to identify current trends and best practices for recycling programs, determine measures, or metrics, that communities can use to evaluate their success, and to highlight the examples of some Michigan communities who are implementing successful recycling programs. The purpose is to help communities learn from each other and develop or expand their recycling programs in a way that builds on best practices.

The Project Team reviewed literature on recycling programs in Michigan and elsewhere in the U.S. to identify best practices. Based on these best practices, the team developed minimum as well as ideal (or "stretch") measures for successfully adopting best practices. We then researched and interviewed four communities in Michigan, representing a mix of geographies and urban versus rural communities, to highlight how they are (or are not) meeting those measures.

The economic and environmental impact of current and potential recyclables is also evaluated to provide information about the revenue-generating potential of those recycled commodities. An objective of this report is to identify model programs, best practices, and the potential of recycling that will provide information important to decision makers at the state and local levels.

# SECTION I
# RECYCLING BEST PRACTICES AND SUCCESS STORIES

# NATIONAL BEST PRACTICES FOR RECYCLING

The goals stated in most community recycling programs are to increase recycling participation, increase the amount of material recycled and reduce the cost of services. To meet those goals, communities often considering establishing what materials should be included in recycling programs and requiring implementation of either dual-stream or single–stream collection. The challenge facing communities is how to increase the current recycling rate to meet the higher recovery goals, while providing a cost-effective program that can be embraced by its residents and businesses.

Many cities and solid waste districts throughout the nation are setting new, ambitious goals for higher recycling, waste recovery rates and even targeting zero waste as an attainable goal. The challenge facing the State and Michigan municipalities is how to gain recycling program efficiencies, providing a cost-effective program that can be embraced by its residents and businesses.

RRS has researched recycling programs across the U.S. and globally for over 30 years. We utilized our research to identify some best practices for residential recycling, including the related impacts on efficiency and program costs. The project team conducted a comparative analysis of communities recycling collection and processing programs to identify the quantity of material collected through the implementation of "best practices". The intention of this analysis was to gather data from comparable cities to provide an overview of each one's experience with possible options that can be incorporated into municipal programs throughout Michigan.

The analysis identified some of the key components regarding recycling best practices in several categories:

- Collection and Processing
- Variable rate pricing
- Multi-family recycling
- Rural recycling
- Commercial recycling

## COLLECTION AND PROCESSING SYSTEMS

### Single Stream Recycling:

Single-stream or single sort recycling – where all fiber grades and recyclable containers are collected commingled together in one compartment on the recycling collection vehicle – has been a growing trend for the past fifteen years and is now considered to be the "best practice" for high volume recovery of recyclables. The prevalence of single-sort collection was first evaluated in a 2000 Survey for the Paper Industry Association Council (PIAC), and has continued to be evaluated in the subsequent surveys. The growth in single-sort recycling has steadily increased. In 2005, only 29 percent of the population with recycling had access to a single-sort program. By 2010, that number had increased to 64 percent. In 2014 the percentage of the population with recycling access to curbside recycling had increased to 72%.

Although the PIAC has not attempted to correlate the trend to single-sort collection with the expansion in fiber products collected in programs, anecdotal evidence suggests such a relationship exists. In addition, the PIAC survey is directed at County government, which the degree to which counties are involved in local recycling programs varies widely from state to state and region to region. The county staff surveyed by AF&PA may not be familiar with the exact material guidelines for specific communities on their survey form, and may have completed the survey with a more general list.

## Factors That Influence Collection Programs

**Carts versus bins**: Carts have consistently shown an increase in the volume of recycling collected. Carts offer greater capacity, more stability and decreased risk of materials becoming wind-strewn or placed in trash when the bin is full before collection. There are concerns, as noted in the later section entitled 'Curb Set Out Options', about the size of the carts and difficulty in handling to the curb. However, with consistent, user-friendly education and if carts are offered in size options, carts yield greater participation and volumes.

**Waste versus recycling**: The combination of waste and recycling collection remains a factor in recovery rates. If unlimited waste disposal, at a low rate of cost is offered to a community, it is very easy to put everything into a waste container. Successful programs focus on discouraging waste disposal and encouraging recycling, composting and source reduction as the better alternatives. This can be accomplished through education and encouraging participation in the recycling programs and through the variable pricing of waste disposal. Where these factors are present, recycling programs tend to be much more successful in both recovering material and generating revenue.

**Frequency**: Many communities have resorted to bi-weekly recycling collection as a cost savings. Communities attaining high recycling rates in the compared cities provide weekly collection. Weekly collection provides residents with a simpler "everything out to the curb" model. Bi-weekly as an option in the interests of cost savings must be balanced by providing adequate containers and reminders of the collection schedule to avoid recyclables being disposed in the garbage because the resident "ran out of room" in the recycling bin.

**Cost**: Converting to a single sort collection system requires some capital investment in equipment, program modifications and public education. Changes in processing fees will be dependent upon the arrangement with the MRF and the revenue sharing arrangement established with the local jurisdiction. These investment factors are balanced against the increase in recycling resulting from a simpler method of setout and collection for the community, and the savings realized from reduced waste disposal fees and collection costs.

## Single-Sort Collection Program

An increasing number of communities have shifted to a single sort collection system. In a single sort system, all materials are collected and placed in a single compartment truck. Each collection vehicle can remain on route until the truck is completely full or the route is complete. Even in that case, dispatchers

may send a less than full truck to another route to help complete collection, based upon proximity and capacity of the truck.

The trucks can be dual-purpose, i.e., collect recyclables and then designated to return to assist in waste or other materials collection. The driver makes a one motion pass at each stop, saving time and labor costs. If the truck is equipped with a mechanical loading hopper or mechanical arm, the driver can save additional time in the collection process. (See photos below)

Semi-Automated Collection Truck

## Curb Container Set out Options

There are two container options communities can offer residents to set out materials for single sort curbside collection. The first option is to provide one or more recycling bins, i.e., plastic boxes of varying size, typically ranging from 13 gallons to 25 gallons. While recycling bins can be equipped with lids, the disadvantage to bin programs with lids is that the lightweight lid can be damaged if it falls or blows into the street, or completely disappear if weather conditions are amply strong.

Automated Recycling Collection Truck

The second option for curbside set outs is a wheeled cart, equipped with an attached lid. Wheeled carts have been the most accepted and growing option for single collection programs over the past 10 years. The wheeled cart encourages residents to recycle more materials and provides the convenience of storage of materials and for hauling to the curb. The most expressed reservation from residents concerning multi-sort programs, the number of containers and the difficulty of moving all of them to the curb without spillage, is also one of the advantages of the cart.

There are circumstances where some residents are concerned that the cart is too big or heavy to move to the curb, especially for the elderly. Operational experience has shown that although cart size can at first be somewhat intimidating, the resident adapts to the cart and its transport and storage options. Optional programs that allow for residents to request a different size cart can also be implemented as part of a switch to cart based programs. Dual sort systems can also use carts, either split 96-gal or two 64-gal for biweekly collection.

Typical Recycling Carts and Bins

Communities can allay these concerns by first, displaying the carts in a prominent location so residents can "check them out" prior to the onset of a program or by offering an optional smaller sized cart. It can also be pointed out that communities seem to have no problem providing a trash cart of the same size or to offering smaller carts for the elderly.

Some cleanliness improvement has been identified with the implementation of carts. A larger container with a cover prevents much of the litter and blowing of paper and plastic that is associated with lidless bin containers. In addition, some residents have indicated that storing recyclables outside in a cart is preferable to keeping bins indoors. This is especially helpful in areas providing alley collection.

## Processing Options

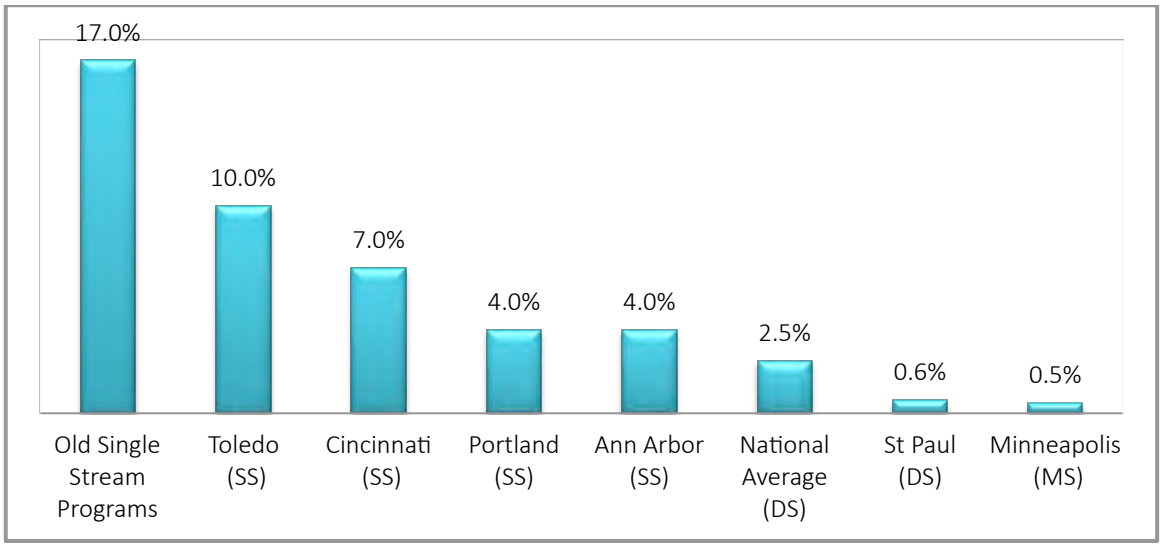
Choices pertaining to sorting technologies and overall processing choices are predominantly driven by curbside collection systems. Substantial improvement in processing capability and efficiency has been experienced in the past 5-10 years. Beyond the initial use of magnets to capture ferrous metals at an efficient rate, and eddy currents to separate and capture aluminum from the sort, more sophisticated equipment and reconfiguration of the sorting systems has resulted in higher recovery rates, greater throughput, and less contamination to meet market standards.

The number of recyclable materials has increased as the ability of secondary and manufacturing industries to convert post-consumer packaging into marketable products has grown. Subsequently, the market demand for the greater variety and volume of materials has driven MRF's to seek equipment that enable them to efficiently recover an increased array of post-consumer plastics and fiber. The processes must also be designed to increase the volumes or tons per day, to justify the investment in such equipment or systems.

MRF's and equipment manufacturers, to remain competitive and derive the greatest value from the collected material, continue to improve the ability of the sorting methodology and performance standards. Systems are configured to provide screening of non-recyclable materials and contaminants from a particular recyclable material to yield a higher value end-of-sort product. Optical sorting technologies have advanced to enable efficient and broader range of sorting plastics and fiber cartons that results in an increased variety of accepted materials for recycling at a higher marketable value.

Residual rates are an indicator of the success of the sorting systems and the recycling collection program. Residual rates in both dual sort and single sort sorting systems have declined over the years, as evidenced in the Figure 1. The ability to recover everything that is recyclable or marketable and to remove waste that cannot be recycled is a key factor in determining the type of recycling program provided. It is also a key measurable in determining overall recycling program success or failure.

*FIGURE 1: MATERIAL RECOVERY FACILITY (MRF) RESIDUAL RATE**




* SS - Single Sort, DS - Dual Sort, MS - Multi Sort

Quality control remains a critical element in MRF recovery. At various points in the recovery process, testing or checking of the commodity destined for markets can result in increased value to the commodity. The community can also play a role in helping to increase the value of materials collected. To ensure quality standards, communities can require contracted MRF's to report volumes and percentages of recovered materials by type, including residue rates; set minimum standards of recovery and residue, and the volume of materials sold as various grades in the recycling markets. A certification process should be applied to MRFs. MRFs require them to report certain operational data for monitoring purposes. This information should include at a minimum:

- Amounts and types of recyclables delivered to the facility;
- Amounts and composition of processing residuals;
- Amounts and types of materials processed and marketed on an annual basis; and
- Amounts and types of materials downgraded or rejected by markets.

Residual rates at the MRF can also be improved by education. As recycling participation increases, it is important to provide direct, simple and positive education about what can be recycled. Consistent, accessible, user-friendly education about what can be recycled makes an impact on the participants' participation to place the materials that are accepted in the recycling container. Even with the most efficient system for sorting materials, if an item that is not included in the recycling program is incorrectly placed in a recycling bin, it must be treated as residual at the MRF.

## Variable Rate Fees and Incentive Schemes

Systems of pricing trash for disposal are known by a variety of names: variable rate, pay by the bag, variable-can rate, volume-based, pay as you throw, among others. However, the basic concept

underlying all these terms is the same and is very straightforward: customers that put out more waste for collection pay more than those who put out less.

Variable-rate programs provide a number of advantages for communities and residents:

- **Equity.** Variable rates are fair: customers who use more service pay more.
- **Economic Signal.** Under variable rates, *behavior* affects a bill, regardless of what disposal choices a household makes. Without variable rates, avid recyclers pay the same as large disposers. Variable rates provide a recurring economic signal to modify behavior, and allow small disposers to save money compared to those who use more service and impose more costs on the system.
- **Lack of Restrictions.** Variable rates do not restrict customer choices. Customers are not prohibited from putting out additional garbage; but those who want to put out more will pay more.
- **Efficiency.** Variable-rate programs are generally inexpensive to implement and, unlike recycling programs, do not require additional pick-up trucks. They also help prevent overuse of solid-waste services. Rather than fixed all-you-can-throw charges, which encourage over-use of the service, volume-based rates encourage customers to use only the amount of service they need.
- **Waste Reduction.** Unlike recycling programs alone, which only encourage recycling, variable rates reward all behaviors—recycling, composting, and source reduction—that reduce the amount of garbage thrown away. Source reduction is the cheapest waste-management strategy and thus of the highest priority—and it is not directly encouraged by recycling and yard waste programs.
- **Speed of Implementation**: Pay-as-you-throw programs can be very quickly put in place—one community installed a variable-rate program in less than three months (although most take longer).
- **Flexibility.** "Pay-as-you-throw" programs can be implemented in a variety of sizes and types of communities, with the broad range of collection arrangements.
- **Environmental Benefits.** Because they encourage increased recycling and waste reduction, variable- rate programs are broadly beneficial to the environment.

Ultimately, it is anticipated that using variable rates to reduce the burden on the disposal system will lead to more efficient use of services, improved environmental and resource use, and lower long-run solid waste system management costs. Research has also demonstrated that rate incentives in solid waste have strong and measurable effects on waste disposal behavior. Adapting pricing principles from energy, water, and other utilities, studies show that paying for more (and more specific) garbage service increases recycling and composting and reduces disposal overall.

## Types of Variable-Rate Waste-Disposal Pricing Systems

Variable-rate programs are very flexible, and adaptable to a wide range of community types. They can be categorized into five major types:

- **Variable Can or Subscribed Can.** In this program, customers select the appropriate number or size of containers (one can, two cans, etc., or 30–35 gallons, 60–65 gallons, etc.) for their standard weekly disposal amount. Rates for customers are higher for customers using a two- or three-cart service than rates for customers that us only on cart.
- **One-can customers**. Some communities also have introduced mini-can (13–20 gallons) or micro-can (10 gallons) service levels to provide incentives for aggressive recyclers.
- **Bag Program.** In this program, customers purchase bags imprinted with a particular logo, and any waste they want collected must be put in the appropriately marked bags. Bags holding from 30 to 35 gallons are most common, but some communities also sell smaller bags at a discounted price. Bags can be sold at city hall or community centers; more commonly, communities work with grocery stores or convenience store chains to sell the bags—sometimes with a commission, although sometimes the foot traffic is enough reward to the retailer. The price of the bag incorporates the cost of the collection, transportation, and disposal of the waste in the bag. In some communities, the bag program is used in conjunction with a customer charge or flat-fee program charge, and in those cases, the bag price reflects only a portion of the cost of collection and disposal, with the remainder collected through the monthly charge.
- **Tag or Sticker Programs.** These are almost identical to bag programs, except instead of a special bag, customers affix a special logo sticker or tag to the waste they want collected. The tags need to be visible to collection staff to signal that the waste has been paid for. Like the bag program, tags are usually good for 30-gallon increments of service. Pricing and distribution options are identical to bag programs.
- **Hybrid System.** This system is a hybrid of the current collection system and a new incentive-based system. Instead of receiving unlimited collection for payment of the monthly fee or tax bill, the customer gets only a smaller, limited volume of service for the fee. Typical limits for the base service in communities across the country are one can, two bags, or two cans. Limits usually vary based on maturity of the program, disposal behavior, and availability and comprehensiveness of recycling options. Beyond the approved base service, customers are required to buy bags or stickers, as described above, for any extra garbage. Under this program, the base service level can be tailored to best suit the community or to achieve a variety of objectives. No new billing system is needed, and bags only need to be purchased for service above the base. Current collection and billing are retained with minimal changes, and many customers see no change in their garbage fee. This system provides a monetary disincentive for those who are putting out higher amounts of garbage.
- **Weight-based System.** This system uses truck-based scales to weigh garbage containers and charge customers based on the actual pounds of garbage set out for disposal. On-board

computers record weights by household, and customers are billed on this basis. Special "chips," called radio frequency (RF) tags, are affixed to the containers to identify households, and these are read and recorded electronically on the on-board computer along with the weights for that household. These programs have been pilot-tested in the U.S., and implemented overseas. Certified scale systems are now available.

- **Other Variations.** Some communities or haulers offer variable rates as an option along with their standard unlimited system. Waste drop-off programs, that use punch cards or other customer tracking systems, are also in place in some communities, especially in rural areas.

Local communities can assess the changes needed for their system, and identify the systems that are most suited for their needs. Using an analysis of key priorities and relative implementation burdens communities may come to very different conclusions on the types of programs that will work best for them. However, there are some patterns. For example, research finds that the percentage of variable-can systems is higher in urban areas, and bag programs are more common in rural areas. This may relate to the greater prevalence of automated collection (compatible with variable-can programs) in urban areas and concerns for low-cost implementation in rural areas, in combination with a variety of other community-specific factors.

## Recycling Incentive Programs

We are all familiar with the old adage "one mans trash another mans treasure." New companies are trying to change that. They say your trash is your own treasure, because you're going to pay you for it. The concept, called Incentive Based Recycling, is to increase recycling rates by providing a direct financial incentive for people to go through the trouble of sorting their garbage. Participating customers receive a 35, 64, or 96-gallon container that has a barcode that identifies their home. As the truck collects the recycling it scans the barcode on the container and translates the value of the recycled items into a dollar amount - that can be redeemed though shopping coupons at participating businesses. The two major programs are: Recyclebank and *Rewards for Recycling*.

Participants use an online interface to choose which coupons suit them best, order the coupons and receive them by mail. Alternatively participants can choose to donate their Recyclebank Dollars to charity. Recyclebank serves both residential and retail customers. Many paper, plastic, metal and glass recyclables are collected and the company supports a single sort recycling system that allows all types of recyclables to be deposited in one single container. Home collection of e-waste is coming soon but in the meantime customers can send in cell phones for recycling by printing a envelope label including stamp directly from the website.

Recyclebank trades the actions a customer makes that have a positive impact on your home by saving energy, community by recycling and the environment by conserving natural resources for points that you can use for rewards you choose. Those rewards come in a variety of options: Products, discounts

and coupons from the world's leading brands (think: Kashi, Footlocker, Dunkin Donuts), or by donating your points to support environmental education in schools.

Because Recyclebank offers coupons and other economic incentives to recycle, the RecycleBank model is particularly attractive to lower-income communities. By rewarding households with coupons for groceries or services, RecycleBank is having a direct positive impact on family budgets. Therefore, recycling becomes something households participate in for financial assistance, rather than altruistic reasons. This is not meant to suggest that the only people participating in RecycleBank are those on the lower end of the income spectrum, only that the incentives inherent in the RecycleBank model become increasingly attractive the lower on the spectrum a household lays.

*Rewards for Recycling* was founded in late 2008 with the express intent to provide a better recycling affinity program option for municipalities and waste haulers. The Recycle Bank program was closely studied and evaluated, and R4R was designed to be uniquely different, addressing all of the challenges we found in the alternate system. The R4R program founders identified multiple challenges in the alternate system, specifically a lack of understanding of basic marketing and consumer behavior patterns.

*Rewards for Recycling* is a community based Recycling program. R4R partners with the municipality, the residents, the community and the local businesses. *Rewards for Recycling* rewards frequency and loyalty for building recycling as a household habit. The program is open and available to all members within the community. *Rewards for Recycling* provides rewards to every household immediately upon start-up, and continues to provide smaller value rewards to all households regardless of recycling activity. This methodology provides the opportunity to continuously convert non-recyclers by showing them the rewards of significantly higher value that will be available to them as soon as they begin recycling.

Local Business participation is a key component of the *Rewards for Recycling* program. The R4R Program features rewards that come from the businesses located within each community. Restaurants, Pharmacies, Dry-cleaners, Oil Changes and other retail products and services. The majority of them are locally owned and operated, and employ local people.

The revenue generated by these businesses stays home and supports the local economy. R4R gives each business an opportunity to offer valuable savings to residents free of charge. These offers can drive traffic to local business. In addition, *Rewards for Recycling* has multiple promotional options available for local businesses that can get them exposure in Direct mail, E-newsletter marketing and even television.

## Incentive System Pros and Cons

Demographics are probably the most important factor to look at when considering an incentive system partnership. An incentive system model is particularly attractive to lower-income communities because it offers coupons and other economic incentives to recycle. By rewarding households with coupons for

groceries or services, an incentive system is having a direct positive impact on family budgets. Therefore, recycling becomes something households participate in for financial assistance, rather than altruistic reasons. The following is a partial listing of the pros and cons of incentive systems.[1]

### PROS

- Incentive-based program rewards recycling participation and builds good recycling habits
- Public awareness and participation in recycling rises
- Substantial rise in material volumes
- Data on the effectiveness of existing and proposed waste collection routes and strategies is collected
- Opportunity to modernize or upgrade the waste collection and recycling infrastructure

### CONS

- System rewards consumption, not waste reduction
- Program may be a poor fit in communities with already high recycling participation
- Success relies on the participation of national and local businesses and retailers
- Upgrade costs could be prohibitively expensive for communities and smaller haulers if not adequately negotiated with Service Provider
- Program not cost effective in areas with low-cost disposal.

## MULTI-FAMILY PROGRAMS

To help communities learn how to create or maintain a successful program, studies have identified and highlighted program characteristics that are associated with high diversion rates. Two important factors play into the success of a recycling program: efficiency and effectiveness. Efficiency refers to measures of the productivity of collection crews and effectiveness refers to how well a program meets policy objectives. A program can be very effective (i.e., high-diversion rate) and not very efficient (i.e., high unit costs). The most successful programs meet both of these criteria. The productivity measures for multifamily recycling used in this study are cost per ton collected, annual cost per household served, number of tons of recyclables collected per household per year, and diversion rates. Table 1 identifies the characteristics of a successful multi-family recycling program and the best practices in those programs.

[1] *Resource Recycling Magazine*, October, 2009

Table 1: Characteristics of Successful Multi-Family Recycling Programs

| Program Element | What Happens In High Diversion Communities | Percentage of High Diversion Communities With This Practices |
|---|---|---|
| Collection | Collect multifamily recyclables on the same routes as single-family recyclables, using the same truck and crew. | 61% of high-diversion group |
| Participation | Ensure compliance through mandatory participation, with sanctions available to local governments for enforcement. | 90% of high-diversion group |
| Containers | Provide container with capacity of at least 90 gallons. Collect materials in sets of containers, with one set per 15-20 households and two to three containers in the average set. | 64% of high- and medium-diversion groups |
| Commodities | Include more recycled commodities: mixed waste paper, OCC, magazines, and phone books in addition to ONP, glass, plastics, and steel and aluminum cans. | 82% of high-diversion group |
| Management | Conduct recycling through a private firm under contract or exclusive franchise to local government. | 82% of high-diversion group |
| Fees | Charge monthly flat fee (usually $2 or more) to units for recycling. Charge variable fee for refuse (reduced solid waste fee as more materials are diverted to recycling). Average fee is lower in high-diversion communities. | 63.6% of high- diversion group |

Some highlights of multi-family recycling programs include:

- Collection
  - Unit cost of collecting recyclables decreases. The average cost per ton to collect multifamily recycling in the low-diversion communities is $177 versus $113 in the high-diversion communities.
  - Quantity of refuse set out for collection decreases. As diversion rates increase, however, the cost per ton to collect refuse increases from $43 per ton in the low- diversion communities to $66 per ton in the high-diversion communities.
  - Decreases in refuse setouts exceed the increase in recycling, implying that waste reduction also is occurring in communities with the most successful recycling programs.
- **Mandatory Participation:**
  - *Buildings:* High diversion programs are more likely to be mandatory. A Portland, OR ordinance requires multifamily buildings to establish recycling programs that collect mixed paper, newspaper and three other materials. The Portland Bureau of Environmental Services found that the proportion of complexes with no recycling program dropped from 10% in 1995 to 2% in 1996 as a result of the ordinance. High

diversion programs are more likely to report the use of fines, liens or other sanctions against complexes that do not recycle properly.

  - *Haulers:* Communities can require haulers to provide multifamily recycling services by ordinance or by contracts or franchise agreements. In Tehema County, California, the County's franchise agreement with a local hauler requires the hauler to provide its multifamily building trash customers with recycling and yard waste collection at no extra cost. The company must provide carts and bins for trash and recyclables and must accept certain materials for recycling.
  - *Require Recycling Plans:* Requiring multifamily owners to develop and file recycling plans stops short of requiring recycling, but motivates some buildings to sign up for recycling.
  - *Require Recycling in the Lease:* Communities can recommend that building managers require residents to recycle as part of the lease.

- **Containers:**
  - High diversion programs are more likely to use 95-gallon carts. They are less likely to use cans or 65-gallon carts or to use 18-gallon bins. The 95 gallon wheeled cart has several advantages, including mobility on site, low square footage required for siting and compatibility with the semi-automated side loading compartmentalized trucks frequently used for single family recycling.
  - Higher diversion programs also serve fewer households (15-19) per set of recycling containers than lower diversion programs (26). Less sharing of containers means each set is located closer to each apartment unit, making it more convenient for residents to drop off their recyclables. Providing bins or baskets for storing recyclable materials within individual apartment units may also lead to higher diversion levels.
- **Materials Accepted:**
  - Communities with high diversion rates include more materials in their multifamily recycling programs, an average of 10.3 materials, compared to 8.2 materials in the communities with low diversion rates.
  - Communities with high diversion rates are more than twice as likely to include mixed waste paper and other plastics. They are also much more likely to include cardboard, magazines and phone books.
- **Tracking Performance:**
  - Keeping track of the performance of a program (in terms of the number of set outs, number of containers distributed, how often the containers are emptied, number of households in complexes receiving service, number of complaints registered and service violation notices issued, and quantity of materials collected) is a probable causal factor in achieving high or improved program performance. For example, communities that know where containers have been distributed and how often they are emptied are

better able to target their program promotions, education efforts and outreach elements, which encourage participation.

- **Education and Outreach:**
  - High diversion programs are more likely to have more frequent mailings to individual households, while communities with lower diversion rates tend to have less frequent mailings and rely more on the property managers.
  - Outreach in multiple languages is important. Some communities are experimenting with outreach materials that are all pictures so the materials do not have to be translated.
  - Because of higher turnover in many multifamily buildings, reaching newcomers is more of an imperative than in single-family homes.
- **User Friendly and Convenience:**
  - The Recycling Education Project at Portland State University in Oregon examined recycling at twelve similar multifamily complexes. Two factors that showed correlation with participation were user friendliness of the collection containers, (defined by visibility, prominence, attractiveness and cohesiveness) and the location of the recycling facilities, (including proximity to the trash container, resident traffic and living units, and the absence of physical barriers to the facilities). Several other surveys also identified these same factors as elements of success.
- **Management Support:**
  - The Recycling Education Project at Portland State University also found that manager commitment (motivation, direct participation, and interest) correlated with participation.
- **Creating Incentives:**
  - *Direct Tenant Incentives:* Pay-As-You-Throw programs can't directly reach tenant generators; one possible strategy is to provide credits on "other" bills to tenants in buildings that meet defined criteria as a participating recycling building. This strategy might be feasible in communities that provide residents with energy or water services. The strategy would give tenants a financial stake in helping make sure that that building continued to have recycling available and that participation was high enough and contamination low enough so that the building would remain "qualified" to receive the credits.
  - *Management Incentives:* Some communities provide incentives to building managers to establish, improve or promote recycling. For example, Seattle's "Friends of Recycling" volunteer program trains individuals who then champion recycling within their building." The volunteer can either be a member of the management staff or a tenant. Seattle issues a one-time $100 rebate on trash bills to the management of buildings with Friends of Recycling volunteers. Seattle has not evaluated the effectiveness of its "Friends of Recycling" program, however. Interestingly, the use of volunteer outreach

coordinators was one of four different outreach techniques tested in 98 multifamily buildings in Portland, OR. In the Portland test, volunteer outreach coordinators were ineffective at increasing the quantity or quality of multifamily recyclables.

  - *Hauler Incentives:* Communities with hauler-provided service (though contract or franchise) can provide financial rewards to their hauler(s) for increasing recycling in the multifamily sector. This provides an incentive to the hauler to become a more active agent in promoting multifamily recycling.

- **Logistical Strategies:**
  - *Hardware Solutions*: Systems are now available that make recycling as convenient as trash disposal in large buildings with central garbage chutes. The chutes are retrofitted for both garbage and up to 6 recycling streams. The tenant pushes the appropriate button at the chute – selecting "containers" for their bottles and cans and then selecting "garbage" for their trash disposal. The systems have been installed in Florida, New York, Canada and other locations and have been assessed in several high-rise buildings in Toronto. Increases in recycling from 25% to 45% were found after the systems were installed. Three-year paybacks from lower garbage bills are fairly typical.
  - *Requiring space for recycling:* Modifying the building codes to require adequate space for recycling in new and remodeled multifamily buildings can help make recycling as convenient as garbage disposal for tenants.
- **Fees:**
  - Multifamily recycling programs can present a challenge for funding in those communities where multi-family refuse collection is considered a service to be paid for by the property owner, typically through a contract between the property manager and a private hauler.
- **Diversion Rates:**
  - A key measure of the success of a recycling program is the diversion rate it achieves. Based on a study of community multi-family recycling programs by the Environmental Protection Agency (EPA), the following observations can be made about diversion rates for multi-family units in sample communities:
    - The quantity of materials recycled increases as diversion rates increase;
    - The quantity of materials discarded as refuse or garbage decreases as diversion rates increase.
    - The aggregate discard stream (i.e. recyclables and refuse for multi-family households) decreases as diversion rates increase.

Many of the same economic benefits generated by residential recycling can be realized by commercial businesses and the State. The State has the potential to not only save additional costs from every business that waste is diverted from the landfill, but can use this extra revenue to help offset the costs of increased commercial recycling at the local level.

## Rural Recycling Programs

Developing a successful rural recycling program is a challenge. When state legislatures wrote waste reduction and recycling mandates into law and placed responsibility with local governments, few gave special consideration to rural areas. Rural communities are striving alongside their urban counterparts to meet recycling and reduction goals of 15 to 70 percent. Rural areas' efforts, however, can be hampered by low population and tax base, limited local government budgets and personnel, low-density housing and limited commercial development.

For some areas, solid waste volumes fluctuate due to seasonal residents or tourists. For many, difficulties accumulating enough processed materials can limit cost-effective marketing options. Rural areas, however, have strengths that can assist them in developing and operating recycling programs. For example, rural residents have a strong sense of community, a history of volunteering and often take a creative and thrifty approach to solid waste management.

Typically, rural waste streams come from residences and small businesses. As a result, they're smaller and contain lighter weight materials than are found in urban waste streams with large amounts of commercial wastes. Many rural recycling program should be able recover approximately 9 percent of the residential waste stream if items such as glass, metal containers and newspapers are recovered. Adding cardboard containers and other commercial wastes can boost the diversion rate.

Consider a regional recycling approach to overcome the barriers facing individual rural governments. Benefits include:

- Increased volumes of recyclables, which opens marketing opportunities;
- Potential for cooperative marketing, which can substantially increase revenues;
- Conserved landfill capacity and avoided tipping fees;
- Regional economic stimulus from new collection and processing jobs; and
- Shared costs for equipment, personnel, processing, transportation, marketing and facility capital and operating costs.

Recycling sales revenues cannot be relied upon to support a regional program because markets can be volatile. Instead, recycling costs must be viewed as part of the entire municipal solid waste (MSW) management strategy. For example, a recycling program should be considered a viable method for reducing overall disposal costs. Although each program will experience different economies of scale, every successful program will require its participating jurisdictions to share costs.

Regional waste reduction objectives, quantities of recyclables in your waste stream and market availability all influence which materials will finally be targeted for recycling. Because waste reduction is measured by decreases in tonnage, try to target the heaviest materials with a positive market value. These include ONP, OCC, other paper grades and some bulky items (white goods and metals). When targeting recyclable materials, also consider ease of collection and processing as well as the degree of cooperation anticipated from your region's businesses and residents.

Rural areas may present unique alternatives for using some recyclables. For example, old newspaper (ONP) and mixed paper can be used as a straw substitute for animal bedding. Wastepaper also can be used for cellulose-type building insulation and as a bulking material for hydroseeding. Potential uses for mixed glass include glassphalt (a mix of glass and asphalt for road paving), landfill cover, fiberglass, glasscrete (a mix of glass and concrete), sandblasting, backfill, road bed material, erosion control, septic fields and as a sand supplement or substitute.

Individual rural governments are often not in a position to negotiate optimal market terms due to small volumes of materials. Cooperative marketing allows rural regions to offer larger volumes to potential end-markets. This strategy helps them to achieve higher market value, to obtain better transportation rates and to increase the types of materials accepted by the manufacturer. In general, cooperative marketing acts as a region's broker to secure end-user markets, maintain all recycling records and arrange for cost-effective transportation to end-users. Local governments can also share costs for public education, technical assistance, equipment purchases and legal assistance.

Cooperative marketing requires centralized management. Staff from a “lead” city or county, a solid waste authority or a non-profit organization can undertake the daily administration. State or federal grants typically provide funds for establishing market coops. Membership fees, technical assistance consulting charges and revenue from the sale of recyclables also are used to fund cooperatives.

## Commercial Recycling Approaches

### Recycling Ordinance Role

An ordinance should describe commercial recycling requirements for owners and managers of all commercial business types. The requirement of the ordinance should be to recover materials collected in the local or regional recycling facility. Should a business need to use an alternative recycling service provider to comply with the ordinance, they would have to meet requirements to fill out a simple recycling checklist plan to either recover 50% of their waste stream or to recover the top two materials in their waste stream, whichever is greater. The checklist required would need to identify the recycling provider that would make recycling possible for the business.

### Commercial Solid Waste Franchise Role

Local units of government could franchise commercial solid waste collection to one or more haulers under a long-term franchise contract. A request for proposal process could be initiated early in the implementation process to specify service options, pricing, and use the franchisee selection process to make decisions on how to structure the franchise.

Specifications for the franchise should describe all details of how solid waste services would be provided, including time of day that services are allowed in different areas of the local jurisdiction, container location requirements, special needs, as well as procedures for resolving service issue sand complaints and more. An important feature of the specifications is the requirement that reductions in

waste service (frequency or size of containers) and thus cost of service would be accommodated as recycling increases.

## Construction & Demolition (C&D) Recycling

Construction and demolition (C&D) waste accounts for an enormous amount of the waste stream in the United States. While most of this waste accrues to landfills, estimates are that 90 percent of the waste stream is potentially reusable or recyclable. There are two main approaches and a third emerging practice for systematically addressing the C&D debris cycle.

1. *Central Processing Facility:* Transporting of mixed C&D waste to a central processing facility where high graded material is sorted from the debris. The mixing of the reusable materials with other debris such as nails, paint, oil or plastic can limit their potential to be recycled due to contamination.
2. *Job Site Material Recovery:* Separation of selected materials at the job site followed by transporting the materials directly to the markets for those materials. This approach can result in a larger amount of material recovered but is a less common practice due to factors such as lack of experience with this method, lack of on-site space and the timeline set for building completion.
3. *On-site Material Processing:* This emerging method consists of processing selected materials for end of life use at the job site. It takes tactics from the two main approaches and deploys the technology to the site through on-site grinding using a portable residential scale grinder. This technique is inspired by the biological notion that waste equals food. The concept of waste equals food is exhibited by nature every day and human emulation of such concept can enhance natures abilities.

### Central Processing Facility

The centralized facility approach is the most common facility arrangement. Typically, mixed C&D debris is tipped at a central facility, and the materials with a high market value, such as large pieces of sawn lumber, are removed. The remaining mixed C&D materials are then processed using one of two primary methods. The mechanized size reduction method uses a crusher, a dozer, or a compactor. The materials are then passed through a series of screens, magnets, and other separation equipment. The manual labor method relies on human sorters to pick out materials and place them in specific containers. Screens and magnets may also be employed with the human labor method, but the materials are left in their original form rather than crushed so that they can be easily distinguished and sorted. The most common approach is a blend of the mechanized size reduction and the human sorter methods.

A primary success for a C&D recycling operation hinges on the degree of contamination of the C&D materials by other types of waste such as nails, paint, foil, oil or plastic. Some processing facilities that aggressively handle a mixed waste stream may cause contamination of the C&D materials, thereby

limiting their potential to be recycled. Table 2 summarizes the methods employed by central processing facilities and also includes the estimated volume of material that is rejected from the recycling stream for each method

Table 2: Sorting Methods Used By C&D Central Processing Facilities

| Approach | Description | Reject volume |
|---|---|---|
| Manual separation only | Waste is tipped. Large identifiable materials with ready markets are removed by hand. The remaining material is land filled. | High (>50%) |
| Combination Manual and Mechanical separation (most common approach) | Waste is tipped and screened. Manual labor is used to remove the components on a conveyor belt. | Medium (25-50%) |
| Heavy mechanical processing and separation | Waste is tipped and processed (often crushed) and sent through a complex train of mechanical equipment for separating the materials. | Low (<25%) |

Source: Florida Department of Environmental Protection (FDEP), 2001

## Job Site Material Recovery

The practice of sorting and processing materials at the job site can result in a higher degree of material recovery but is less commonly used in residential C&D practice. To sort C&D materials onsite, contractors need to either arrange for C&D debris haulers to visit the site during the different stages of C&D activity and waste generation or set out different containers for the different waste materials. Some of the factors that have limited this approach are a lack of experience with job site material recovery, a lack of space for different containers on the job site, and the need for rapid completion of many C&D projects. Various types of equipment are available for C&D processing and recycling, either at a central processing facility or at the job site.

## On-Site Material Processing

The third approach on-site processing of materials presupposes to take tactics from the two main approaches and deploy the technology to the site and to do what makes sense in terms of processing. In the *On-site Grinding of Residential Construction Debris: the Indiana Grinder Pilot* conducted by the NAHB Research Center in 1999, concluded that 90% of the waste stream is potentially recyclable or reusable on-site.

On-site processing has been evaluated in numerous states and has found to be highly successful in all of the studies conducted regardless of geographic location. The likelihood that this will become the dominant method of processing east of the Mississippi River is very high. The primary element leading to the successful deployment of residential scale on-site materials processing is a portable residential scale grinder capable of handling wood, shingles, drywall, nails, concrete, cardboard, and brick.

## C&D Waste Mitigation and Salvage

Numerous waste mitigation strategies exist for C&D waste. Contractor strategies, building code specifications, and a technique called "optimum value engineering" can all help to minimize the C&D waste stream. However, the most important factor is the policy prospective of the political jurisdiction that operates the landfill. The following list offers examples of strategies that different cities and agencies have employed to mitigate C&D waste, (some of the strategies may have been employed in the commercial industrial marketplace but the concept could be transferred to the residential setting).

- For the construction of the EPA's Research Triangle Park office in North Carolina, the agency incorporated waste separation and recovery into general contractor specifications. Overall, the project had an 80% recovery rate for C&D debris. "As far as recycling is concerned, [contractors] are generally not used to it, but they are capable of doing it," said Chris Long, EPA Project Manager (EPA, 2003:5).
- Santa Monica, California's Green Building program includes requirements for C&D waste management, including the following: (1) a requirement to recycle C&D waste is included in construction contracts; (2) the reuse of salvaged building and landscape materials is required; and (3) interior building components are designed for future disassembly, reuse, and recycling (EPA, 2003:6).
- Portland, Oregon's building codes mandate that all construction projects over $25,000 must recycle materials generated at the job site (EPA, 2003:6).
- In Portland, Oregon and Chicago, Illinois, haulers that charge by the square foot, do not require roll-off containers and recycle more than 50% of the jobsite waste are the normal service that builders can buy. The haulers time their pick-ups to coincide with the different phases of construction, so that the different materials are picked up separately. Such cleanup services have been effective in areas that have high disposal costs and established existing recycling markets for common construction waste materials.
- "Optimum value engineering," also called "efficient framing," is an engineering technique from the homebuilding industry that reduces the amount of wood used in the framing process without compromising structural integrity (EPA, 2003).
- King County, Washington, (Seattle), operates the C&D recycling program and has two goals: "First, to assure that job-site material is recycled to the greatest extent possible. And second, to accelerate the adoption of green building practices, technologies, policies and standards in residential and commercial development." The program is active in the educational and outreach arena and operates cutting edge web based tools to assist contractors in gaining knowledge and information. Of particular note are: 1) A section with case studies generated by the contractors themselves, 2) A directory of recycling businesses, and 3) A step by step guide on how to recycle construction and demolition waste.
- The City of Los Angeles has formally adopted a 70% diversion goal for the year 2020. To achieve that goal they are actively engaged in the community and in the education and outreach

business. One particular innovation which they feel will facilitate reaching their goal is the requirement that all new developments or building expansions must include sufficient space in the building or on the project site to collect and store recyclable materials. This ordinance applies to commercial, mullet-family, and residential construction. (City of Los Angeles Solid Resources Citywide Recycling

- The City of San Diego has formally adopted an immediate 50% reduction goal and has implemented selected demolition permit fee, waste disposal fee Waivers as a method to induce businesses to utilize "acceptable recycling facilities for recycling concrete and bricks (City of San Diego Manager's Report).

The US EPA recommends that, when contractor bids are initially solicited, that the contractors submitting a bid also be required to submit a plan for reducing, reusing, or recycling the wastes generated onsite. Contractors may be offered the incentive of allowing them to keep the revenues from recycling and savings from avoided landfill costs due to waste reduction. Although it can be difficult to find recycling or reuse markets for some materials, one resource that contractors can consult is the Construction Materials Recycling Association (CMRA), which is an association of C&D debris generators, haulers, processors, recyclers, and re-manufacturers. The contractor plan should include a discussion of the following items (EPA, 2003:7):

- Carefully estimate the number of materials that will be needed;
- Identify markets for recyclable materials; and
- Establish recycling systems onsite and make sure that both contractors and subcontractors receive instructions on sorting their own waste.

Deconstruction, rather than demolition, can also maximize the salvage of materials for reuse or recycling by disassembling buildings and removing materials in stages. Items such as flooring, siding, windows, doors, bricks, plumbing fixtures, ceiling tiles, and structural components can be salvaged. Apart from increased C&D material salvage, deconstruction often brings benefits such as job creation. Deconstruction requires more time and manual labor than demolition, and in some areas deconstruction is used to train at-risk youth and welfare-to-work program participants (EPA, 2003).

# ADOPTING BEST PRACTICES IN MICHIGAN: RECOMMENDED MEASURES FOR SUCCESSFUL RECYCLING PROGRAMS

## THE RECYCLING PROCESS IN MICHIGAN

### Material flows

MSW in Michigan to be divided into three primary streams: disposal, recycling, and compost, as described below:

Disposed Material: Disposed material from Michigan is sent to a Michigan landfill, a Michigan incinerator, or shipped out of state. The first two categories are quantified through the Department of Environmental Quality's (DEQ) reports of solid waste landfilled in Michigan as well as public reports on the quantity of solid waste disposed at Michigan incinerators. Michigan is believed to be a net importer of solid waste so the third category is relatively small. In determining the total quantity of disposed material, incinerator ash was excluded from the total landfilled volume, as this waste was accounted for pre-incineration via the data from Michigan incinerators.

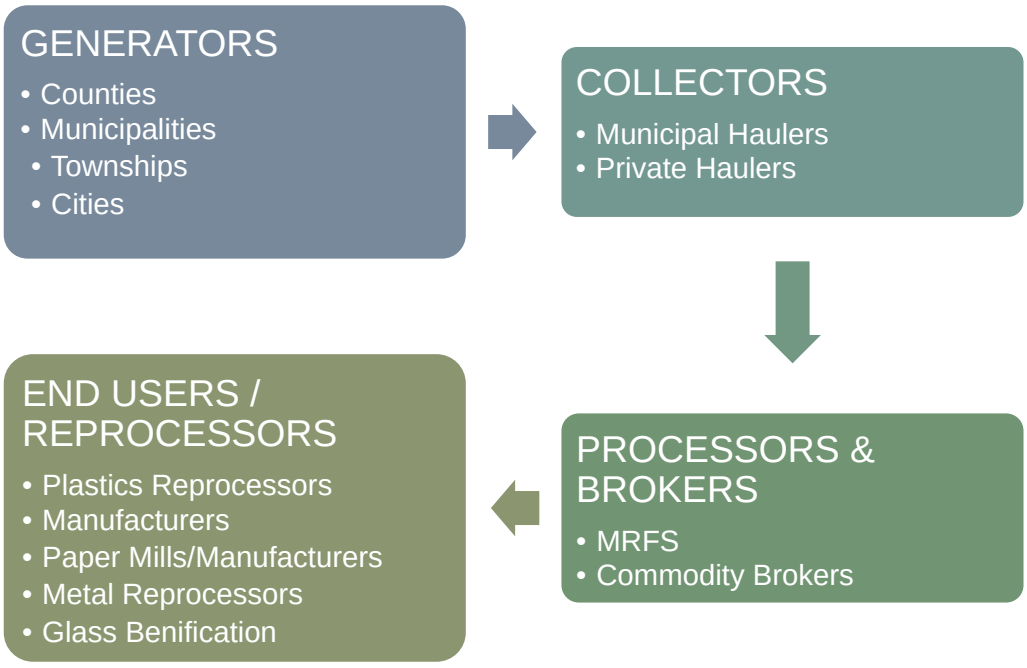
**Recycled Material:** Recycled material from Michigan is processed in three ways: it may be sorted at a Michigan MRF, sorted at an out-of-state MRF, or sold to brokers and/or end users without further sorting. The study measured material collected by communities, counties, and take-back programs, as well as material sorted at Michigan MRFs through a survey. These included single, dual and multi-stream MRFs and operations that are baling (bundling and preparing them for shipping) source separated materials.

**Composted Material:** Composted material from Michigan is processed into finished mulch and compost either at Michigan compost facilities or out-of-state compost facilities. Only large scale commercial composters were considered for MSW diversion; onsite, backyard composting was not part of the study as it is excluded from the EPA's definition of MSW.

### Supply Chain for Recycled Material: Stages of Diversion

Material diverted from disposal moves through a number of stages before being reprocessed into new items. The MRI study considered four primary stages, while noting intermediate steps between them. These stages of the diversion process are:

*FIGURE 2: SIMPLIFIED MATERIAL FLOW DIAGRAM*




Program performance can be measured by a diverse set of factors, including average household diversion, overall efficiency, cost-effectiveness, and community benefit, to name a few. Factors affecting participation rates include program convenience, limitations on waste set out, education, and storage capacity. The following section describes these factors, best practices on contracting, and education programs, as well as highlights program design.

## RECOMMENDED MEASURES OF SUCCESS

Based on our review of best practices, PSC and RRS worked with the project advisory team to identify elements of successful programs and corresponding metrics, or measures, for evaluating communities' strengths in recycling performance. Studies consistently show that any successful recycling program must focus on high-quality service that best matches the community's preferences, aspirations, and circumstances. The seven elements of successful programs identified by PSC, RRS and the advisory group are:

1. Recycling education programs
2. Access to recycling options
3. Supporting local policies
4. Consistent and sufficient funding
5. Engagement and participation among households and businesses
6. Local capacity and leadership
7. Tracking and measurement systems

The sections below describe the elements of successful recycling programs and the corresponding metrics of success.

## Recycling Education

Educating the public about the importance of recycling, how and where to recycle, and what benefits the community receives by recycling is critical for increasing participation and efficacy. At a minimum, successful recycling programs will have an education program, including a website with information on recycling options and contact information (i.e., what materials are accepted, where and when to recycle) and direct, quarterly distribution of recycling information to consumers, newspapers, and/or other media outlets.

Ideally, communities will have a dedicated recycling education budget, equal to about $2 to $2.50 per household, which is used for more extensive outreach delivery (e.g., additional materials to customers, school programming, education events, and facility tours).

## Access to Recycling Options

Access to recycling collection and/or drop off sites is one of the single biggest determinants of recycling participation and volume collected. The best recycling programs will provide the same level of residential and business services for recycling that is available for waste collection. At a minimum, successful programs should provide the following services based on community type:

- In urban and suburban areas (communities over 7,500 people[2]), curbside recycling is offered with at least twice-per-month collection, using large roll-off carts, and collecting at least four (4) materials and organics.
- In rural areas, recycling drop-off centers are available and located either: 1) within six miles of every household; 2) within a 15 minute drive on major travel routes in the community (as defined in regional Council of Governments' transportation improvement plans); or 3) at locations that are commonly used, regular destinations in the community (e.g., grocery stores). To be most successful, drop off centers must collect at least five (5) materials, and provide public access on at least four days per week (for a total of 20 hours of access time).
- In all areas, commercial and/or multi-family recycling is offered (either curbside or as drop-off), and a convenience center is available in the community for drop off of bulky and hard to recycle items (e.g., appliances, household hazardous materials).

[2] The urban/suburban community population size was determined in order to be consistent with Michigan's waste regulations that prohibit the open burning of grass clippings and leaves in municipalities greater than 7,500 people (Section 324.11506(7) of Part 115, Solid Waste Management, of the Michigan Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Act 451))

## Supporting Local Policies

Policies which help establish the market for recycled goods and ensure convenient access are critical to helping increase participation in recycling efforts. The most successful communities in the U.S. and elsewhere have policies that, at a minimum:

- Ensure access to recycling as described above
- Include "pay-as-you-throw" pricing which includes a participant cost for waste disposal and free recycling
- Ban illegal dumping or burning of recyclable materials
- Ban scavenging of recycling and waste containers
- Include an enforcement mechanism for the above policies

To increase program success, communities should adopt one or more additional supporting recycling policies such as landfill bans, hauler licensing requirements, or material flow control policies.

## Consistent Funding

To ensure high-functioning services, communities must find ways to consistently and fairly fund recycling efforts. At a minimum, successful communities ensure there is no economic disincentive for household and business recycling (i.e., extra charge for recycling but free waste pick up).However, the most successful programs will have dedicated funding for recycling in their communities based on a range of financing options such as revenue sharing with the material processors, signing franchise agreements, passing a waste and recycling millage, charging participant fees (for waste and recycling combined), using general fund, and seeking grants.

## Engagement and Participation of Households and Businesses

Participation rates can be challenging to track because not every household or business puts out recycling each week. However, understanding the general level of business and household participation is important to ongoing program improvements and evaluating options for program efficiency. In addition, greater participation among residents and businesses can be a strong social cue, or even pressure, to help spread the word about recycling in communities.

Successful communities will have participation rates of at least 65 percent of residential customers and 25 percent of commercial customers (if offered).

## Local Capacity and Leadership

To ensure community buy-in and participation for recycling, community staff and elected leaders must be supportive and lead by example. At a minimum, successful communities will have a dedicated recycling liaison whose job it is to oversee recycling outreach and efforts for the community, and will lead by example (i.e., require recycling at municipal facilities, purchase recycled content materials where feasible, and provide recycling in public spaces).

The most successful communities will have a dedicated recycling coordinator whose job is to promote recycling, develop and implement recycling service options, and track progress/benchmark the community's recycling efforts. Successful communities will also have strong recycling leadership, including the support of the municipal manager and/or elected officials, and partnership with local businesses and related local manufacturing companies.

### Tracking and Measurement Systems

Tracking and measuring progress is essential for continually improving recycling programs. Successful communities will track and benchmark their recycling performance, including participation rates, volume of recycled materials, number and type of materials collected, customer satisfaction, and recycling costs and revenues. For added progress, communities will annually report on these measures in an easy-to-read format and widely share the results with their community.

## Spotlight on Success: The Experiences of Four Michigan Communities

In order to help communities in Michigan better understand how these elements can be deployed effectively, we used the metrics to evaluate the success of four high-performing (based on overall recycling rates) communities. RRS provided PSC with a list of the top twelve recycling communities in Michigan (based on their recent recycling measurement project), and PSC selected four to highlight here—representing a range of geographies, sizes, and types of government (i.e., city versus County):

1. Benzie County
2. City of Farmington Hills
3. Emmet County
4. City of Grand Rapids

We researched each of the communities' recycling programs and conducted interviews with community recycling coordinators in order to understand how each community was performing on the seven metrics for successful recycling programs.

The following pages highlight the experience of four communities in establishing and maintaining a successful recycling program. Each of these communities has made significant progress in expanding recycling—both participation and overall volume collected—over the last decade or more. They have all met or exceeded most of the measures of successful recycling programs described in the previous section as well. Their experiences provide examples that other communities can learn from and adopt in order to advance their own programs.

### Benzie County

Benzie County is a community of about 17,000 people, located along Lake Michigan in the northwest part of the state. The largely rural County is 860 square miles and has an annual County-wide budget of just over $40 million.

The County has a robust recycling program and meets or exceeds several of the identified elements and measures of successful recycling programs.

## RECYCLING EDUCATION


Benzie County has an active recycling education effort. The County's website provides substantial information on their recycling efforts, and provides residents with information on what materials can be recycled, where they can bring their recycling, frequently asked questions, and tips for increasing their household and business recycling.

In addition, Benzie County has a dedicated recycling coordinator, Marlene Woods, who is very active in the community and passionate about the program. She provides substantial education and outreach to her community on recycling opportunities. For example, she organizes field trips for schools to the American Waste facilities, visits schools to do on-site recycling programs, hosts story hours for children, provides classes on composting, and makes presentations at community events and meetings (such as the Rotary Club). In addition, she spends a lot of time in the field at drop-off centers educating residents about the recycling program.

These efforts have helped increase awareness of recycling opportunities and created a strong ethic for recycling in the community.

## ACCESS TO RECYCLING OPTIONS

Given its rural geography, Benzie County does not offer curbside pickup of recycling. They operate seven recycling drop-off centers conveniently located throughout the community in highly accessible locations such as schools and shopping centers. The drop-off centers are open 24 hours a day, seven days a week. The centers are dual stream, with one roll off cart that accepts a single mix of clean tin and aluminum containers; all numbers of plastic, including plastic bags; paper and flat boxes, including magazines and junk mail; aseptic packaging; #6 polystyrene packaging; shredded and mixed paper; and a separate bin for glass.

Benzie County also provides recycling containers to any community event or festival in the area in order to encourage everyone in attendance to recycle more. Event organizers can request small carts or a roll off bin for use at these events, and the cCounty's contractor will drop off the bins and pick them up after the event to transport it to theCounty waste and recycling transfer station.

In the past, Benzie County's recycling program has been limited to residential participation. Recently however, the County adopted a Green Biz permit program that allows businesses to pay a yearly donation of $80, which allows them to bring their recycling to any of the drop-off centers. Over forty businesses participate, and several hire a local organization called Centra Wellness Network, which creates new job opportunities by employing adults with special needs, to transport their recycling to the drop-off centers. .

## SUPPORTING LOCAL POLICIES:

Benzie County has interlocal agreements with all of the communities in their County to provide recycling. It is an opt-in program, but all of the townships within the County have been participating since 2006. These policies ensure access to recycling facilities for all residents of the County.

In addition, the cCounty has adopted a unique policy for supporting recycling of cardboard in partnership with Packaging Corporation of America. Schools and other organizations can host roll-off carts for cardboard recycling, which is ultimately recycled by the County, and they get $50 for every ton of cardboard they recycle. This program significantly increases the amount of cardboard recycled and is a great fundraiser for schools.

The city does not currently have other recycling-related policies, such as required recycling at municipal facilities, fines or other enforcement tools, or bans on scavenging of recycling and waste containers, in place. However, as recycling coordinator, Ms. Woods has worked with the Michigan Department of Natural Resources to identify illegal waste dumping sites and organized efforts to help pull tires and other recyclables from those sites.

## CONSISTENT FUNDING

Benzie County's recycling program operates under Public Act (PA) 69, which allows communities to charge households an annual fee to fund residential waste and recycling programs. Residents pay $22/year for recycling at drop-off centers, but contract with private waste companies to pick up their garbage from their homes. Waste haulers charge those residents by the bag, so there is incentive for people to utilize the recycling centers in order to reduce their household waste collection costs.

The cCounty contracts with American Waste to pick up the recycling from the seven drop off centers and haul it to a central transfer station. Because the amount of recycling varies by season, American Waste only picks up the roll-off carts at drop-off centers when they are full (i.e., not on a regular schedule), which helps the County save money. The contract is structured as a "not to exceed" amount in order to accommodate that variability and ensure that the County is only paying for the amount of recycling service it receives. The County recently signed a five-year contract with American Waste, which is longer-term than previously done. It allowed them to negotiate a better rate and ask more of the company than they could get in a single-year contract.

American Waste offers a revenue sharing program, which provides a rebate of 5% to the County on all the paper and cardboard recycled, as determined by the pulp and paper industry, on a monthly basis. This is the only non-fee revenue the program receives.

The funding the County receives from fees and revenue sharing is used to fund the drop-off centers, collection of those materials by American Waste, and education and outreach efforts by their recycling coordinator.

### ENGAGEMENT AND PARTICIPATION OF HOUSEHOLDS AND BUSINESSES

Benzie County has not done any formal surveys to determine what percentage of their households participate in the recycling program. However, the recycling coordinator estimates that it could be as much as 80 percent of their residents based on the amount of material collected and her informal monitoring at drop-off centers.

### LOCAL CAPACITY AND LEADERSHIP

As described in the education section, Benzie County has a dedicated recycling coordinator, Marlene Woods, who is very engaged with the community and oversees the management and tracking of the recycling program. She works with American Waste to determine when recycling carts need to be picked up from drop off centers, helps coordinate requests for special event recycling bins, develops and reports on the County's recycling budget and contract, and ensures that the County's website is providing accurate recycling information.

Benzie County has also been proactive in pursuing partnership opportunities to expand recycling services in the County. As discussed, they have helped local businesses connect with a nonprofit organization, Centra Wellness, to haul commercial recycling to drop-off centers. The County also partnered with the National Park Service (NPS) to place some of the County's old roll-off bins, which they were no longer using, at NPS campgrounds, to encourage recycling by campers. The County leases the bins to the NPS for $1, and the NPS hauls the bins to the American Waste Central Lake transfer facility when they are full.

Benzie County does not have a "buy recycled" policy for municipal purchases, and recycling at municipal facilities is not required, but the recycling coordinator is looking at how to improve their lead-by-example efforts.

### TRACKING AND MEASUREMENT SYSTEMS

Benzie County's recycling coordinator tracks the County's monthly and annual recycling performance, including total volume and tons of recycled material collected at the drop-off centers, amount of materials collected at special events and festivals, and costs. The County recently began partnering with Networks Northwest to use Re-TRAC Connect, an online waste diversion measurement and tracking system. The recycling coordinator hopes to use this data to make information on the cCounty's recycling performance more widely and easily available to stakeholders and decision makers in the County.

## Farmington Hills

Farmington Hills is a community of about 80,000 people in southeast Michigan. The city is largely urban/suburban in nature and is an established business and residential center within the greater Detroit region.

The city is part of the Resource Recovery and Recycling Authority of Southwest Oakland County (RRRASOC), "an intergovernmental, municipal solid waste authority created in 1989 by the member communities of Farmington, Farmington Hills, Novi, South Lyon, Southfield, Walled Lake, and Wixom," which provides waste and recycling collection and processing and program management (RRRASOC, n.d.). RRRASOC owns a material recovery facility (MRF) in Southfield, which is operated by ReCommunity Recycling through a public private partnership. RRRASOC also has a large drop-off center in Novi. As part of this partnership, the city has a strong recycling program which meets or exceeds several of the identified elements and measures of successful programs.


### RECYCLING EDUCATION

RRRASOC provides the majority of Farmington Hills' recycling education to residents and businesses. Partnering with an organization called Iris Waste Diversion Specialists, RRRASOC develops and provides outreach materials to customers on what types of materials can be recycled and how, when, and where to recycle in their community. These materials are provided electronically through the website , electronic newsletters, and through a direct mail piece to customers every year. In addition, RRRASOC provides recycling tips and information on recycling (including special events) through its Facebook page.

The City of Farmington Hills also maintains a recycling website on its main municipal page. The website provides information on curbside and drop-off recycling options as well as special event recycling opportunities (e.g., household hazardous waste events).

Finally, RRRASOC provides on-site tours and recycling education at its MRF in Southfield,[3] and makes presentations to schools, community groups, and other organizations in all of its member communities, including Farmington Hills.

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[33] Tours at the MRF are temporarily suspended due to a fire at the facility in 2014. RRRASOC anticipates the MRF will be re-opened in spring 2016.

## ACCESS TO RECYCLING OPTIONS

Through a contract procured by RRRASOC, the City contracts with Waste Management to collect materials curbside from all single-family households and small multi-family properties (less than four units) on a weekly basis, including single-stream recycling, yard waste, garbage, and bulky item pick up. Currently, the program provides the service for 23,328 households in Farmington Hills. In 2012, the City and RRRASOC began using roll-off carts for the collection of curbside recyclable materials in order to increase the volume and level of participation.

Materials collected through the curbside recycling program include:

- Plastics: #1, #2, #4, #5, #6 (no Styrofoam), and #7 , as well as bulky #2 plastics (e.g., cat litter boxes)
- Newspaper, magazines, and catalogues
- Junk mail, office paper, and phonebooks
- Cardboard and boxboard
- Paper drink cartons
- Glass (all colors)
- Household metals
- Yard waste from early spring through late fall using yard waste bags and stickers
- Bulk items (e.g., refrigerators)

Commercial recycling is fairly limited in Farmington Hills. RRRASOC has two drop-off centers, one in Southfield and one in Novi, which are available to residents and businesses throughout the RRRASOC service area.

Farmington Hills composts residential yard waste (as well as other organic material from municipal sources) and makes the compost available to residents free of charge, from dawn to dusk, between May and September at its soccer complex.

Finally, the city and RRRASOC provide special recycling events, such as household hazardous waste recycling events and senior citizen document shredding at the Senior Center, which help residents more easily recycle these materials.

## SUPPORTING LOCAL POLICIES

The City of Farmington Hills' Code of Ordinances, Chapter 14, addresses waste and recycling in the city and helps ensure a robust and effective recycling program. Specifically, the ordinance:

- Defines garbage, recycling, yard waste, and other related waste management and recycling terms
- Bans the scavenging of waste and recycling containers in the city
- Requires the licensing of anyone collecting, transporting, or disposing of solid waste
- Mandates separation of recycling into separate containers and placement of approved containers at the curb

- Mandates the disposal of yard waste on site in a manner that does not cause a nuisance or disposal through the city's yard waste collection system
- Authorizes city employees or representatives to enforce, including the issuance of citations, the recycling ordinance requirements (City of Farmington Hills 2015)

These policies help manage waste disposal, control flow of materials, and ensure that the city's participation in RRRASOC is not undermined.

### CONSISTENT FUNDING

Farmington Hills spends about $3.6 million a year on waste and recycling, including collection and processing of residential recycling, waste collection from parks and other places, household hazardous waste recycling, and contribution to RRRASOC to help cover administration, programming, and education costs (which is $99,675). These costs are largely paid through a refuse collection and disposal dedicated millage and recycling user fees.

RRRASOC operates the material recovery facility, provides outreach and education, and negotiates a contract for recycling and waste collection on behalf of its partners, including Farmington Hills (currently with Waste Management).

The collection costs for the city in 2014 were just over $500,000 total—or $21.97 per household. During that year, 532.74 pounds was recycled per household, resulting in a total collection cost of $82.47 a ton. Under their agreement with ReCommunity Recycling (an organization which processes recycled materials), RRRASOC communities also get revenue sharing based on the value of the materials. In 2014, revenue sharing was $11.03/ton, bringing the net collection cost for recycling down to $71.44 per ton.

*In 2012, Farmington Hills switched to the use of single-stream roll-off carts. The contract for recycling and waste collection with Waste Management (WM) included a provision that WM provide and maintain roll-off carts at no cost to the city. The contract also specified that WM switch from diesel to cleaner burning compressed natural gas trucks. Since switching to roll off carts, total tons per household increased by 62% and the collection cost dropped by almost $55 per ton (Csapo 2015).*

### ENGAGEMENT AND PARTICIPATION OF HOUSEHOLDS AND BUSINESSES

Neither Farmington Hills nor RRRASOC do formal surveys to determine the level of household and business participation in the city. Waste Management tracks set out rates (the number of households putting out their cart each week). On average, approximately 70 percent of households participate, which is above the metric of at least 65 percent of households participating for recycling communities to be considered successful.

### LOCAL CAPACITY AND LEADERSHIP

The City of Farmington Hills has shown strong leadership on recycling and environmental issues in general. RRRASOC provides dedicated recycling coordination on their behalf, but the city works with

them to do joint outreach. The city promotes recycling on their website, provides information on what materials can be recycled, and refers people to RRRASCOC for further information.

In addition, the city leads on other environmental initiatives, including recycling at municipal buildings and green building policies. The city made upgrades to City Hall in 2011, and in the process the building was rated as "gold" under the Leadership in Energy and Environmental Design (LEED) rating system. The upgrades included the addition of solar panels on city hall that meet most of the building's non-heating and cooling electrical needs (City of Farmington Hills, n.d.).

### TRACKING AND MEASUREMENT SYSTEMS

RRRASOC provides all of the recycling tracking and measurement for the City of Farmington Hills based on collection data provided by WM, material collected at events, and processing information from the MRF. RRRASOC uses a cloud-based system, ReTrac Connect, to manage and report data. Each year, RRRASOC provides the city with a "dashboard" of recycling metrics which RRRASOC and the city use to track progress on increasing and improving recycling performance over time. Table three shows Farmington Hills' recycling dashboard for 2014.

**Table 3.** Farmington Hills Solid Waste and Recycling Dashboard, 2014

| | |
|---|---|
| **Material Utilization** | |
| Total Solid Waste (tons) | 28,318.15 |
| Materials Recycled (tons) | 5,856.04 |
| Household Hazardous Waste (tons) | 53.8 |
| Yard Waste (tons) | 6,407.08 |
| *Total Tons Utilized (i.e., recycled)* | *12,315.92* |
| Utilization Rate (i.e. Total Recycling Rate) | 43.50% |
| **Costs** | |
| Rubbish and Recycling Expenditures (per capita) | 45.32 |
| Regional Median for Southeast Michigan* | $69.33 |
| **Environmental Impact** | |
| Energy Saved (million Btu) | 76,904 |
| Energy Saved (annual household equivalents) | 761 |
| Reduced Airborne Pollution Emissions (tons) | 8,632 |
| Number of Trees Saved | 57,582 |

* Based on data from a RRRASOC 2014 s*olid waste expenditure benchmark study*
*Source: City of Farmington Hills 2015/2016 Budget (City of Farmington Hills July 2015)*

## Emmet County

Emmet County is a community of about 33,000 people located along Lake Michigan in the northwest part of the state. The County is largely rural, covering 882 square miles.

Emmet County has a very successful recycling program and was recognized in 2015 with a governor's Leadership in Recycling award for its high rate of recycling, increased access, and strong recycling education and outreach. The County has also been very successful in advancing the other elements of recycling programs.

### RECYCLING EDUCATION

Emmet County actively promotes and provides education on recycling opportunities through its informative website, which was recently revamped and is now very user friendly. The website highlights awards and recycling news, as well as provides detailed information on what types of materials can be recycled, where and how to recycle, tips for recycling and composting, frequently asked questions, and videos on recycling topics. The County also publishes an annual report—*The Whole Works*—that summarizes program statistics and describes program highlights and challenges.

Emmet County also actively promotes recycling efforts through actions such as:

- Providing public-space recycling in Petoskey and Harbor Springs.
- Providing on-the-ground education for the public through literature, signs, and social media.
- Helping to provide recycling education for fourth graders by paying for school buses to transport the children to the recycling facility for tours and by working with teachers to create appropriate curriculum. The County also conducts curriculum-specific tours for other grade levels.
- Providing tours of the MRF for community, business, and government groups.

These efforts help residents and businesses understand why and how they can recycle, create enthusiasm for participating, and celebrate recycling successes.

### ACCESS TO RECYCLING OPTIONS

For most of its residents (i.e., those who live in Bear Creek Township, Little Traverse Township, Resort Township, Harbor Springs, Petoskey, and Bay Harbor), Emmet County offers weekly dual-stream curbside recycling. Residents can put newspapers, magazines, catalogues, books, office and writing paper, cardboard, paperboard, brown paper grocery bags, and plastic bags in one bin. In a second bin, they can recycle:

- Plastic bottles, jugs, and jars
- Tubs, trays, and cups
- Juice boxes, milk cartons, and paper cups
- Metal cans, foil, and trays
- Glass bottles and jars

The County also operates 13 drop-off recycling sites, which accept 60 different materials free of charge. Twelve (12) of the sites are open 24 hours a day, seven days a week. The other facility is a transfer station and drop-off "super center" which is open Monday through Saturday. The super center is designed with multiple loops for various materials intended to make drop off easy. The loops include places for textiles and shoes, unlimited garbage disposal (for a fee), e-waste, household hazardous materials, and bulky recyclables such as scrap metal, clean wood, asphalt shingles, rubble, freon-containing devices, appliances, and tires. A seasonal loop of the MRF also exists from spring through the fall season for recycling less common materials including mattresses, plant plastics, latex paint, asphalt shingles, and marine shrink wrap (the plastic covering on boats and watercrafts when they are shipped). Emmet County marinas have succeeded in reducing annual waste by 90 percent from the ability to recycle marine shrink wrap.

The transfer station also allows for drop-off yard waste. Leaves, stems, weeds, grass clippings, and twigs that are made into compost onsite are free to recycle. Woody brush, logs, and branches, which the County makes into woodchips, cost $0.50 per 30-gallon can/bag (with discounts for larger volumes).


Commercial and multi-family recycling is also provided curbside in Emmet County. Resort Township offers commercial curbside recycling free of charge, but in all other communities there is a charge of $39 per tote/year and $116 per cart/year for weekly service. Multifamily recycling is available for smaller units (less than six to eight units), using a mix of individual bins per apartment or centralized cart depots depending on the building size. The County does not provide curbside recycling for multi-family buildings larger than this, although multi-family properties can lease a drop-site bin or utilize the County drop-off centers.

Finally, Emmet County conducted a food scrap collection pilot with commercial entities in 2015. Through the pilot program, food scraps were picked up twice a week from twenty (20) commercial entities including restaurants, grocery stores, florists, and bakeries. The pilot required the modification of a County truck to include a cart tipper and a sprayer for onsite clean-up. The County hopes to move toward an expanded program next year, but full implementation will likely take several years. They have evaluated the pilot program results and developed a business case model for the program. The pilot was supported with County recycling fund dollars, but as the program expands it will likely require a fee for participants.

### SUPPORTING LOCAL POLICIES

Emmet County has had intergovernmental agreements with the cities and townships within their County to provide recycling services since 1991. The County's authority over waste and recycling allows them to protect the flow control of waste and recyclable material. For example, the County's Solid Waste Ordinance:

- Bans illegal dumping or burning of recyclable materials
- Licenses waste and recycle haulers, requiring them to offer all commercial entities a dumpster for cardboard and use of the County transfer station
- Uses a "Pay-as–You-Throw" system that charges for garbage disposal on a volume basis
- Bans scavenging of waste and recycling containers

These policies are based on the recognition that recyclable materials are a resource and provide an economic value to the County and its recycling program. They drive material markets and make the recycling program sustainable by providing revenue from material sales.

In addition, the County has implemented policies to encourage recycling in municipal facilities and programs. Recycling is established at these facilities and the County has recommended a purchasing policy that requires use of recycled-content materials whenever feasible.

### CONSISTENT FUNDING

When it was initially established, Emmet County's recycling program was funded through a millage of .25 mills for 2 years. Now operation of the program is covered through a highly diversified system which uses enterprise budgeting[4] to ensure the program is self-sustaining. Emmet County is a major tourist destination in the state, particularly during the summer months. The County's population triples during the summer season, which adds complexity to the capacity planning and budgeting for its recycling program.

***Public-Private Collaboration***

*Emmet County is a neighbor of East Jordan Iron Works (EJ). The company's cast iron products average about 85 percent recycled content. But they had very specific needs for the size and consistency of the "bricks" of recycled cans they needed to get from MRFs. The county purchased and refurbished a bricker and partnered with EJ to create the type of bricks they needed for their process. EJ now purchases over 100 tons a year of bricked cans from Emmet County.*

The County is very proactive in expanding and developing connections to recycled material markets. Emmet County employs two individuals who are focused on the development and maintenance of relationships that better allow them to market the County's recyclable materials. They have created partnerships with local companies like East Jordan Iron Works, Petoskey Plastics, Great Lakes Tissue Company, and East Jordan Plastics to utilize materials from Emmet County's recycling program in the production of those companies' products. Because of this, the sale of recyclable materials covers about half of Emmet

[4] The county's enterprise budget is a separate accounting and financial tool which keeps the recycling and solid waste revenues and expenditures separate from general funds. It allows the county to project revenues and costs and adjust fees and other revenue sources to cover the costs of the program.

County's recycling program costs, including the trucks, staff, collection of recycling, and operating the County's MRF.

The remainder of the costs are covered through curbside recycling contracts with participating cities and townships (between 16-18% of the costs); fees from communities outside the County (between 16-18%), including Otsego, Cheboygan, and Presque Isle; and process fees from transfer station revenues (about 15% of costs). The County shares a portion of its recycling revenue with its partner communities.

Emmet County charges $24 per cubic yard for waste disposal at its transfer station, less than any other transfer station in northern Michigan. Some of those disposal fees are used to support the recycling program.

### ENGAGEMENT AND PARTICIPATION OF HOUSEHOLDS AND BUSINESSES

In 2001, Emmet County conducted an exhaustive survey of their communities. The findings showed that more than 80 percent of residents recycle. In the spring of 2016, Emmet County will be moving from recycling bins to bins plus carts that are equipped with radio-frequency identification (RFID) tags, which will allow the County to better track participation. With the move to recycling carts, Emmet County will maintain dual-stream recycling, so residents will have two 18-gallon bins for plastics, metals, and glass, and use a 64 gallon cart for cardboard, paper, magazines, and books, tripling capacity at the curb to 100 gallons per week. The County expects a significant increase in participation as well as overall material volume.

### LOCAL CAPACITY AND LEADERSHIP

In 2015, Emmet County recycling celebrated 25 years of service. The County opened its first recycling center in 1990 and developed their Solid Waste Management Plan that included recycling and household hazardous waste programs. The County hired its first Department of Public Works Director, Elisa Seltzer, to oversee the recycling program. Ms. Seltzer still serves as the director and, in partnership with several other recycling program staff, oversees all program operations, material market development, outreach and education, and coordination with participating communities. The County's solid waste ordinance was passed by the County Board of Commissioners in 1991, and was adopted by a majority of townships and municipalities in the cCounty (since then, all but 2 of 21 communities in the County have adopted the solid waste ordinance).

The Department of Public Works has been recognized by the state for their leadership and creativity in advancing recycling, not only in Emmet County but in the state as a whole, and its director was named "recycler of the year" in 2000 and Michigan Recycling Coalition's Member of the Year in 2011 (Michigan Department of Environmental Quality 2015).

### TRACKING AND MEASUREMENT SYSTEMS

In 2013, Emmet County conducted a benchmarking study to measure their recycling performance, including tons of material recycled. According to the 2013 report, Emmet County recycled 42 percent of their waste stream.

Emmet County utilizes Re-TRAC Connect, a nation-wide online recycling measurement tool, to evaluate and develop reports on the cCounty's recycling performance. Results from these reports are provided to all of the communities, highlighted in local newspapers, and showcased on the Emmet County website. The County is also considering developing an easy to read recycling dashboard for its website.

## City of Grand Rapids

Grand Rapids, with a population of 193,792, is Michigan's second largest city and the fastest growing metro area in the state. The city is a recognized leader in environmental sustainability and its recycling efforts have been a key part of that success. As highlighted in the following sections, Grand Rapids has made great strides in advancing the seven elements of successful recycling programs.

### RECYCLING EDUCATION

The City of Grand Rapids has a recycling and solid waste website that identifies the city's recycling goals, highlights what recycling efforts the city is undertaking, provides information on what can be recycled and where, answers frequently asked questions, and gives recycling tips.

In order to foster participation in the recycling program, the city offers the myGRcitypoints program, which allows residents the opportunity to earn points by recycling that can be redeemed at local businesses such as Anna's Hammocks, Boxed GR, Brewery Vivant, Derby Station, Eastern Floral, Logan's Alley, River City Improv, and The Rapid (transit) for products and services. More than 13,000 people have participated in the myGRcitypoints program, and the City was recognized by the Michigan Department of Environmental Quality and Gov. Rick Snyder for the program in 2015 (City of Grand Rapids, n.d.).

The city is also home to Kent County's Recycling and Education Center, a new MRF that was opened in 2010. The Center provides tours and educational programming to school and community groups. Visitors can see the facility's state-of-the-art sorting equipment which sorts from a single stream that contains plastic, glass, metal, and paper waste products.

### ACCESS TO RECYCLING OPTIONS

Grand Rapids provides its residents with bi-weekly curbside collection of recyclable materials. Since 2010, the city has utilized single-stream recycling in roll-off carts. Partnering with Cascade Cart Solutions, city residents are provided with roll-off carts equipped with RFID tags for both garbage and single-stream recycling. Under the THROW (tip-based household reduction of waste) program, residents can put their recycling carts out for collection free of cost, but are charged when they put out their garbage. Collection crews scan the RFID tags and customers are billed for garbage based on the size of the cart and the number of times it is set out for collection.

The city's curbside recycling program collects the following materials:

- Paper
- Cardboard and paperboard

- Glass
- Plastic containers #1–#7
- Aluminum and tin cans
- Plastic grocery bags with a #2 or #4
- Telephone books
- Yard waste

All of the City of Grand Rapids' curbside recycling is brought to the Kent County Recycling and Education Center (MRF) in Grand Rapids for processing. Residents can also bring recyclable materials to any of the three drop-off recycling centers in Kent County, including the Recycling and Education Center, for free. Kent County also provides four locations for household hazardous waste dropoff which are each open at least one day a week and do not require an appointment.

Businesses in Grand Rapids that have access to the street or regular residential route can participate in the city's recycling program by utilizing the 64-gallon, single-stream carts. Multi-family buildings do not have access to the city's recycling program and must work with their waste hauler to provide recycling services for their residents.

### SUPPORTING LOCAL POLICIES

The City of Grand Rapid has a solid waste ordinance which requires that the city provide recycling, refuse, and yard waste services. The ordinance requires licensing of any hauler providing waste and recycling services in the city and establishes the "pay-as-you-throw" approach for waste disposal. The ordinance does not prohibit scavenging of refuse or recycling containers or ban the illegal dumping or burning of recyclable material.

In addition to its solid waste ordinance, the City of Grand Rapids has a comprehensive sustainability plan that includes over 200 specific targets for environmental sustainability. The plan commits to expanding reuse and recycling opportunities as well as composting of yard waste. It includes eight recycling and reuse targets, including:

- "Target 1: Increase participation in recycling to at least 45,000 households by June 30, 2013.
- Target 2: Increase the number of households composting yard waste by an additional 5% over FY12 results by June 30, 2015.
- Target 3: Recycle or reuse 100% of recyclable/reusable City-owned equipment and supplies annually
- Target 4: Decrease the number of tons of City's waste diverted to landfills by an additional 2% over FY12 results by June 30, 2015.
- Target 5: Decrease the amount of the City's waste sent to hazardous waste landfills by at least 5%, over FY 2012 results, by June 30, 2015.
- Target 6: Increase the reuse of materials from City deconstruction/demolition projects by 15% by June 30, 2015.

- Target 7: Implement recycling in City owned parks, if an appropriate and efficient collection method is identified, by June 30, 2015.
- Target 8: Increase residential refuse cart service by an additional 5% over FY12 results by June 30, 2015." (City of Grand Rapids 2013)

The city has made significant progress in meeting these targets. For example, all city-owned equipment is reused or recycled, and refuse tonnage diverted to landfills has decreased by almost 25 percent. The City's Office of Energy and Sustainability provides an annual comparison of completed targets on its website (City of Grand Rapids, n.d.).

### CONSISTENT FUNDING

The City of Grand Rapids uses a mix of funding sources to provide solid waste and recycling services. Refuse and yard waste collection in the city are paid 100 percent through Pay as You Throw (PAYT) user fees and yard waste fees. Residents pay between $2 and $6 per tip (depending on the size of the cart) every time they put out their refuse. Yard waste collected curbside is also funded through user fees (a one-time fee of $27 and a $6 yellow yard waste bin tag each time the container is put out), but residents can drop off yard waste at the city's yard waste site free of charge.


Residents disposing of bulk items and appliances are charged a fee, but the city's solid waste millage helps modestly support those programs.

Recycling is 100 percent funded through the City's refuse millage of 1.5 mills. This funding supports curbside collection of recycling and transport to the Kent County MRF. Kent County has historically allowed the city to dump recycling at the MRF for free, but beginning in August, 2015, the county is charging a $10-per-ton fee for processing. The County has not historically provided any revenue sharing from the sale of materials with the City of Grand Rapids (Miller 2015).

### ENGAGEMENT AND PARTICIPATION OF HOUSEHOLDS AND BUSINESSES

Based on the data gathered through the RFID tags on residents' and businesses' recycling carts, the city estimates that participation has increased by almost 80 percent since 2010, and that about 45,000 households are participating in the recycling program. As with the other communities described in previous chapters, exact estimates of participation are challenging (even with RFID technology) because not everyone participates every week or even every month.

### LOCAL CAPACITY AND LEADERSHIP

The City of Grand Rapids is a recognized leader in environmental sustainability, and its recycling efforts are among the many areas of environmental leadership and capacity that the city has excelled in. The City's recycling program, including implementation of the city's curbside recycling programs, outreach,

and education, is overseen by the Director of the Department of Public Services (DPS). DPS is the primary contact for the city's recycling program, but the Office of Energy and Sustainability also plays a role in tracking progress on recycling targets and communicating about program achievements.

The city has been recognized by the state and the Michigan Recycling Coalition (MRC) for its leadership on recycling, including the 2015 Governor's Award for its myGRcitypoints program and the MRC Award of Excellence in 2012. In addition, the city's adoption and implementation of a comprehensive sustainability plan has resulted in recognition from numerous organizations and media outlets, including:

- One of Twelve Cities Leading the Way in Sustainability identified by journalist Bill Moyers
- Large city top winner in the 2012 U.S. Conference of Mayors and Walmart Mayors' Climate Protection Awards
- Clinton Global Initiative's Billion Acts of Green® Cities Campaign recognition in 2012
- Named "America's Greenest City" by Fast Company magazine
- Number 1 in Leadership in Energy and Environmental Design (LEED) buildings per capita for mid-sized U.S. cities. (City of Grand Rapids Office of Energy and Sustainability, n.d.)

### TRACKING MEASUREMENT SYSTEMS

The City of Grand Rapids tracks it progress in meeting all of the targets identified in the city's Sustainability Plan, including the eight recycling and reuse targets. Progress on the residential recycling program is tracked by the DPS, who works with the City's Office of Energy and Sustainability. In addition, other city departments track and provide updates to the Office of Energy and Sustainability on municipal recycling, construction, and purchasing-related recycling targets.

# CONCLUSIONS

It is clear from research on recycling programs throughout the U.S. and other countries that communities which have made significant progress in recycling, and reducing diversion of materials to landfills overall, have invested time and resources in the seven elements of successful recycling programs discussed here. These elements, while each important individually, work together to create strong recycling programs in communities.

Not every successful recycling program has invested equally in each of these elements, and some are more critical than others. However, the most successful communities have knitted these elements together to ensure that residents (and businesses) have access to recycling, realize its value, understand how to participate, help support the cost of recycling, and can follow and track their community's progress.

# SECTION II
# RECYCLING PROGRAM PERFORMANCE AND COST

# MODELING RECYCLING PARTICIPATION AND COST IN MICHIGAN

Utilizing existing research, RRS evaluated best practices for superior program performance and participation to serve as a baseline for the purposes of both promoting best practices and comparing program performance across the state. RRS developed a model that provides an estimate of the costs and avoided disposal savings incurred with different approaches to operating a residential recycling program. Included in this analysis is a detailed financial analysis of collection costs and route density. The variation in route density can be due to low population density or low participation, both increasing the drive time between stops and potentially the amount of material at each stop. Modeling was completed for multiple collection scenarios, including carts, bins, biweekly, weekly, and other factors.

In general, the model accepts a wide range of variables describing the community, capital investments, labor costs, and the market value of recycled commodities, and in turn provides a detailed financial breakdown of different approaches to collecting material at the curb. It is intended to help decision makers evaluate potential expansions or adjustments to existing programs, or to provide an estimate of the costs of building a new program. Naturally, as with any large municipal service, recycling programs can vary widely due to unique local conditions and market forces, and this model should not be assumed to be completely accurate in all potential sets of circumstances.

## COMPARATIVE CITY INFORMATION

The cities included in the comparative analysis that have single sort systems are Ann Arbor, Kansas City, and Cincinnati. Keeping glass separate from the remainder of the recyclable materials modifies Kansas City's single sort collection.

Table 4: Comparative Recycling Rates

| Program | Recycling Rate* |
|---|---|
| St. Paul | 30% |
| Ann Arbor | 37% |
| Portland | 34% |
| Kansas City | 16% |
| Cincinnati | 18% |

Communities that have converted to dual sort or single sort collection experience an immediate, significant increase in the volumes collected. Residents do not have to provide as much space for sorting and storing materials in preparation for their collection day, and find it easier to carry materials to the curb in fewer containers. Further, the routes can be expanded to serve a larger number of stops, which saves in truck usage, labor and travel time on the street. It has been demonstrated throughout the country that cart based systems increases the amount of recyclable material that can be collected in a bi-weekly or weekly program.

Table 5: Comparative Recycling Quantity Rates

| Description | Ann Arbor | St. Paul | Kansas City | Cincinnati | Portland |
|---|---|---|---|---|---|
| **Recycling Collection** | Single Stream Weekly | Single Stream Weekly | Single Stream Weekly | Single Stream Biweekly | Single Stream Weekly |
| **Container** | Cart | Cart | Bin | Cart | Cart |
| **Collection Cost/Ton** | $131 | $165 | $168 | $148 | $205 |
| **Collection Cost/HH/month** | $3.70 | $3.30 | $2.11 | $2.39 | $5.62 |
| **Lbs./HH** | 726 | 477 | 302 | 386 | 659 |

The five comparable cities offer a variety of service combinations to consider. Each has its own success story. Each has adapted to its own program, so additional review would be beneficial in evaluating which options would be the most applicable.

## Recycling Collection Model

The most important community information is primarily the number of households (typically provided by the US Census) and the participation rate. The participation rate determines the number of households actively served by the program – if the number of participating households is known but not a rate, the rate can be back-calculated from available data. The reason that the households served is important is that the 'pounds per household' metric is typically in reference to the total number of households in the community, this helps differentiate the productivity and success of a program that is very active but only serves a subset of a community from a similar program with a wider reach. Current recovery information and MSW generation rates are used to determine improvement, and local tip fees contribute to the total system as an avoided disposal benefit.

Capital assumptions are straightforward – borrowing rates and payback periods for infrastructure, as well as the number and types of carts used in different scenarios contribute to an annual capital expenditure that is normalized to a per-ton basis. The number of staff involved is also determined for each scenario – these can be fractional full-time employees if needed (e.g. a service and maintenance technician is also allocated to other fleet responsibilities outside of the recycling program).

Operations and maintenance assumptions cover labor rates (using hourly rates), the general efficiency of the program (measured by stops per route), fees, equipment maintenance, and fuel costs. Additionally, the estimated educational spend per household served by the program is an expense commonly overlooked or undervalued, but is a critical component of a well-run recycling program.

Finally, the market assumptions take as inputs an average bale composition, commodity values, and processing costs. An analysis was done with the Average Commodity Revenue for October 2015 for the Midwest region as well as an analysis using the 5 Year Average for the Commodity Revenue. These compositions vary regionally, and are best sourced from a waste characterization of the local recycling stream. The values used in the model are values used in the estimate of the value of currently recycled materials described later in this report.

All of these financial inputs are then calculated against the size of the community to determine the number of routes needed and the necessary equipment and staff needed to provide service. The model generates two tables summarizing the impacts of different types of programs on the local recycling rate and detailed costs.

The following table identifies the general assumptions that were modeled for collection. A comprehensive table is provided in the Appendices. Assumptions were developed based on the analysis of programs in other cities that have dual and single sort collection programs. The three key assumptions derived from this information are the participation rate, the number of stops per day that a collection truck can achieve in a constrained alley environment, and the increase in the amount of material that participants will recycle on an annual basis.

The quantity of material collected for each household was based on the average of the quantity of material collected, or 433 pounds per household per year, identified in the report evaluating current recovery rates in Michigan. The 750 pounds per household is the quantity of material collected per household from single stream recycling in high performing communities in Michigan. Other related assumptions include the size of the cart and the capacity of the collection vehicle.

Table 6: Model Assumptions

| Model Parameter | Value |
|---|---|
| **# Of Households** | 45,000 |
| **Participation Rate** | 84% |
| **# Of Participating Households** | **37,800** |
| **Current Household Recovery (lbs./HH/yr.)** | 433 |
| **MSW Generation (lbs./HH/yr.)** | 1,620 |
| **Landfill Tip Fee** | $30 |

| Collection System | Dual Stream Semi-Auto | Dual Stream Auto | Single Stream Semi-Auto | Single Stream Full Auto |
|---|---|---|---|---|
| **Stops per Day per Truck** | 600 | 650 | 650 | 1,000 |
| **Lbs. per Household per year** | 433 | 433 | 750 | 750 |

The four types of programs were modeled based on information from the comparative review of programs from across the country and on the communities reviewed in Michigan. The relationship between participation rate and the quantity of material that is recycled is a difficult variable to balance. The frequency of collection on a weekly or bi-weekly basis has a major impact on the costs for trucks and staffing. Current recycling collection programs in Michigan range from biweekly pickup dual sort to weekly single sort collection programs. A semi automated rear load collection truck program results in a similar operation level as the collection system that is also a semi automated rear load operation.

Table 7: Recycling System Estimated Costs by Program Type

| | Weekly Collection | | | Bi-Weekly Collection | | |
|---|---|---|---|---|---|---|
| | DS Side Load Auto | SS Side loader Auto | SS Rear Load Semi Auto | DS Side Load Auto | SS Side loader Auto | SS Rear Load Semi Auto |
| **Assumptions and Factors** | | | | | | |
| Number of Weekly Participating Households | 45,000 | 45,000 | 45,000 | 45,000 | 45,000 | 45,000 |
| Number of Carts | 75,600 | 37,800 | 37,800 | 75,600 | 37,800 | 37,800 |
| Number of Trucks (including extras) | 13 | 8 | 13 | 7 | 5 | 7 |
| Number of Staff & Managers | 14 | 9 | 26 | 8 | 6 | 14 |
| Estimated Recovery Rate (lbs./HH) | 433 | 750 | 750 | 433 | 750 | 750 |
| Estimated Recovery Efficiency (lbs./HH/stop) | 8.33 | 14.42 | 14.42 | 16.7 | 28.8 | 28.8 |
| Estimated Tons Recovered per Year | 9,743 | 16,875 | 16,875 | 9,743 | 16,875 | 16,875 |
| Estimated Recycling Rate | 27% | 46% | 46% | 27% | 46% | 46% |
| **Financial Impacts with Oct. 2015 ACR** | | | | | | |
| Total Annual Labor Cost with Capital | $(2,476,815) | $(1,500,287) | $(3,315,653) | $(1,594,341) | $(1,074,832) | $(1,917,291) |
| Additional Education Costs | $(112,500) | $(112,500) | $(112,500) | $(112,500) | $(112,500) | $(112,500) |
| Gross Recycling Cost | $(2,589,315) | $(1,612,787) | $(3,428,153) | $(1,706,841) | $(1,187,332) | $(2,029,791) |
| Gross Recycling Cost per ton | $(265.78) | $(95.57) | $(203.15) | $(175.20) | $(70.36) | $(120.28) |
| Cost per HH/month | $(5.71) | $(3.56) | $(7.56) | $(3.76) | $(2.62) | $(4.47) |
| Material Revenue (Revenue-Processing) | $193,735 | $335,569 | $335,569 | $193,735 | $335,569 | $335,569 |
| Gross Recycling Costs with Revenue | $(2,395,580) | $(1,277,218) | $(3,092,584) | $(1,513,106) | $(851,764) | $(1,694,222) |
| Gross Cost per ton w/Revenue | $(245.89) | $(75.69) | $(183.26) | $(155.31) | $(50.47) | $(100.40) |
| Value of MSW Diverted | $292,275 | $506,250 | $506,250 | $292,275 | $506,250 | $506,250 |
| Net Recycling Costs | $(2,103,305) | $(770,968) | $(2,586,334) | $(1,220,831) | $(345,514) | $(1,187,972) |
| Net Cost per Recycled Ton | $(215.89) | $(45.69) | $(153.26) | $(125.31) | $(20.47) | $(70.40) |

The final analysis includes the impact on the revenue and disposal costs on the overall program cost. The Net Recycling Cost is the lowest for the Single Sort Semi Automated Bi-weekly collection program by approximately 50% while achieving a 46% recycling rate. The Dual Sort Bi-weekly program has a net cost of approximately 56% higher then the Single Sort Semi Automated Bi-weekly program and achieves a 27% recovery rate. The participation rate, or the number of pickups per route, and recovery rate driven by the total pounds collected per household can dramatically affect the overall cost per household. The interaction of these two parameters is a key to increasing the recovery rate in a cost effective manner.

## Sensitivity Analysis

A sensitivity analysis was completed to evaluate the impact of different assumptions that affect collection costs. Three sensitivity scenarios were evaluated: 1) A 10% reduction on the participation rate, 2) A 10% reduction in the Stops per Truck per Day, and 3) An analysis using the 5 Year Average Commodity Revenue. Table 8 illustrates these sensitivities for gross Cost per Ton, Cost per Household per Month and the Net Cost per Ton including Revenue and the Value of MSW Diverted from landfills.

Table 8: Sensitivity Analysis of Recycling System Estimated Costs

| | Weekly Collection | | | Bi-Weekly Collection | | |
|---|---|---|---|---|---|---|
| | DS Side Load Auto | SS Side loader Auto | SS Rear Load Semi Auto | DS Side Load Auto | SS Side loader Auto | SS Rear Load Semi Auto |
| **Baseline Assumptions and Factors** | | | | | | |
| Gross Recycling Cost per ton | $(265.78) | $(95.57) | $(203.15) | $(175.20) | $(70.36) | $(120.28) |
| Cost per Participating HH/month | $(5.71) | $(3.56) | $(7.56) | $(3.76) | $(2.62) | $(4.47) |
| Net Cost per Recycled Ton | $(215.89) | $(45.69) | $(153.26) | $(125.31) | $(20.47) | $(70.40) |
| **Baseline Assumptions and Factors with 10% reduction in Participation** | | | | | | |
| Gross Recycling Cost per ton | $(250.68) | $(87.17) | $(189.34) | $(175.20) | $(70.36) | $(120.28) |
| Cost per Participating HH/month | $(5.98) | $(3.60) | $(7.83) | $(4.18) | $(2.91) | $(4.97) |
| Net Cost per Recycled Ton | $(200.79) | $(37.28) | $(139.45) | $(125.31) | $(20.47) | $(70.40) |
| **Baseline Assumptions and Factors with 10% reduction in Stops** | | | | | | |
| Gross Recycling Cost per ton | $(280.87) | $(103.98) | $(216.96) | $(190.29) | $(78.76) | $(134.09) |
| Cost per Participating HH/month | $(6.03) | $(3.87) | $(8.07) | $(4.09) | $(2.93) | $(4.99) |
| Net Cost per Recycled Ton | $(230.99) | $(54.09) | $(167.08) | $(140.41) | $(28.88) | $(84.21) |
| **Baseline Assumptions and Factors with 5 Yr. ACR** | | | | | | |
| Gross Recycling Cost per ton | $(265.78) | $(95.57) | $(203.15) | $(175.20) | $(70.36) | $(120.28) |
| Cost per Participating HH/month | $(5.71) | $(3.56) | $(7.56) | $(3.76) | $(2.62) | $(4.47) |
| Net Cost per Recycled Ton | $(179.19) | $(8.99) | $(116.56) | $(88.61) | $16.23 | $(33.70) |

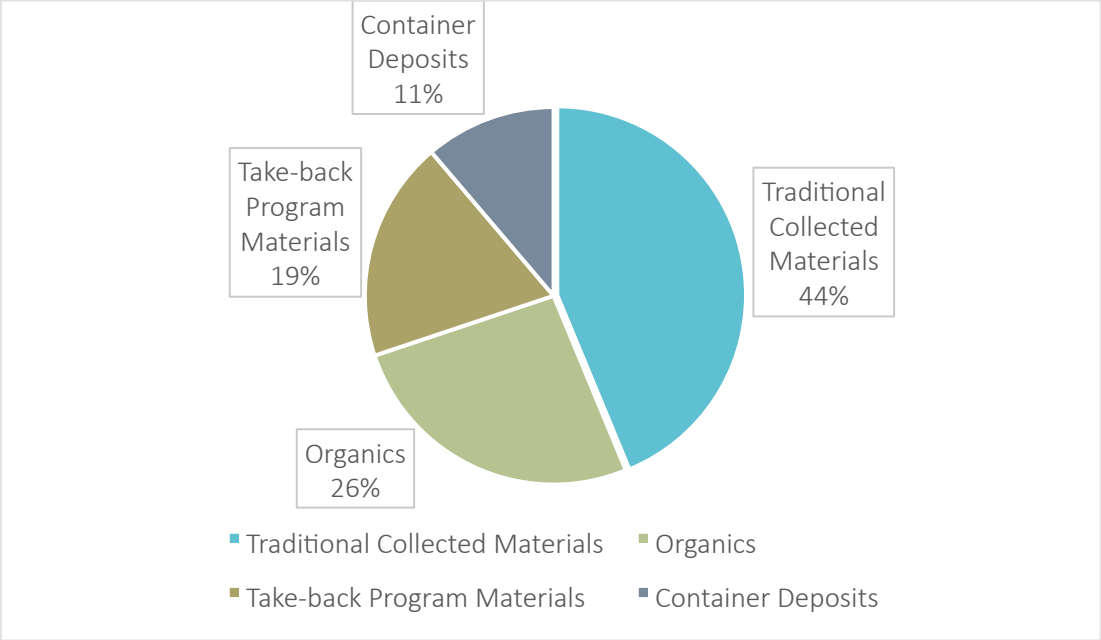
# SECTION III
# ECONOMIC IMPACT OF RECYCLING: COMMODITIES AND JOBS

## THE STATE OF RECYCLING IN MICHIGAN

In 2014, Michigan produced about 9,440,472 tons of MSW, of which about 15% was recycled. The quantity of municipal waste is about 1,620 lbs. per person each year.

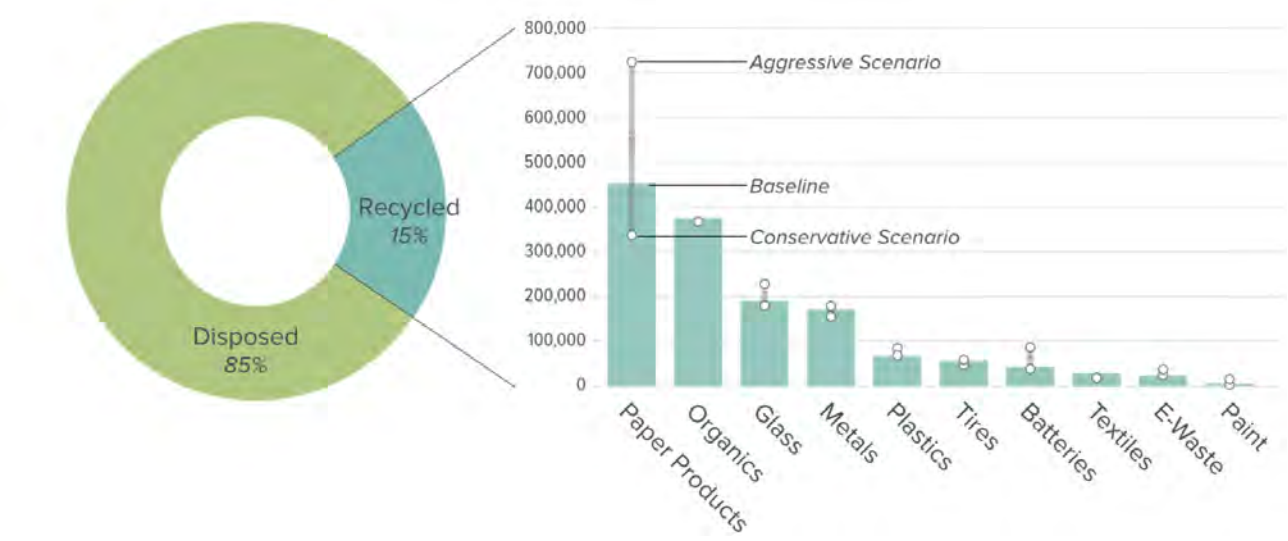
Through the Michigan Recycling Index (MRI) project, sources and quantities of materials from Michigan curbside and drop-off programs were collected from respondents and analyzed, in addition to materials that are sent from commercial sources and recycled into new products. In addition to curbside and drop-off collection programs, direct outreach and research was conducted to measure materials collected through take-back programs for e-waste, tires, organics, beverage container deposits, textiles, hazardous household waste and batteries.

*FIGURE 3: MATERIAL RECYCLED BY CATEGORY IN 2013*




Traditional household recyclables collected from commercial and residential sources comprise 44% of the recycling stream, while 26% of the total is composed of organics including yard waste. The container deposit program accounts for 11%, and other materials that are collected through a variety of take-back programs such as lead-acid batteries, appliances, tires, e-waste, and textiles comprise the remaining 19% of the recycling stream. Paper recycled by households is made into newspaper, while white office paper is used in soft tissue production. Small amounts of recycled paper are used to make insulation products, such as cellulose wool. Metal waste is reused to make new metal, while glass provides raw material for packaging glass and glass wool and can replace gravel in earthworks.

*FIGURE 4: MATERIALS RECYCLED IN 2013*




## ECONOMIC IMPACT

The analysis of the economic impact of recycling includes an evaluation of the current recyclable current market value of materials, market trends, and a discussion of the recycled commodity market drivers. Based on data collected through the MRI project, the economic and environmental impact of current and potential recyclables was calculated to provide information about the revenue-generating potential of those recycled commodities. All materials collected and ultimately processed in a recycling program are considered commodities. This means that in spite of market demand fluctuations and associated price increases or decreases, the total collected tonnages must yield a value to maintain a healthy, stable recycling programs.

Recycling opportunities vary from one municipality to the next. In Michigan, paper, corrugated, paperboard, plastics, glass, metal are generally collected, and several municipalities have also organized the collection of organics, cartons and energy waste. Collection points are property-based, or collection is organized regionally. Most municipalities in Michigan towns have reuse centers, flea markets or second-hand shops, which also help promote recycling and reuse.

Residents can take household waste electrical and electronic equipment free-of-charge to the collection points provided by major retailers or drop off locations operated by municipal governments. Used tires without rims can be taken to the local tire shop, again free-of-charge.

### THE RECYCLING BUSINESS PROPOSITION

Arrangements with a MRF in which haulers rebate communities based on the cost per ton using a blended commodities pricing index has become a common practice. Taking competitive bids for commodities as they become available can maximize prices that municipalities can receive for the recycled commodities. Many municipalities do not operate a MRF but use a contractor to process and market its recyclables. Municipalities often manage residential refuse collection. Communities can

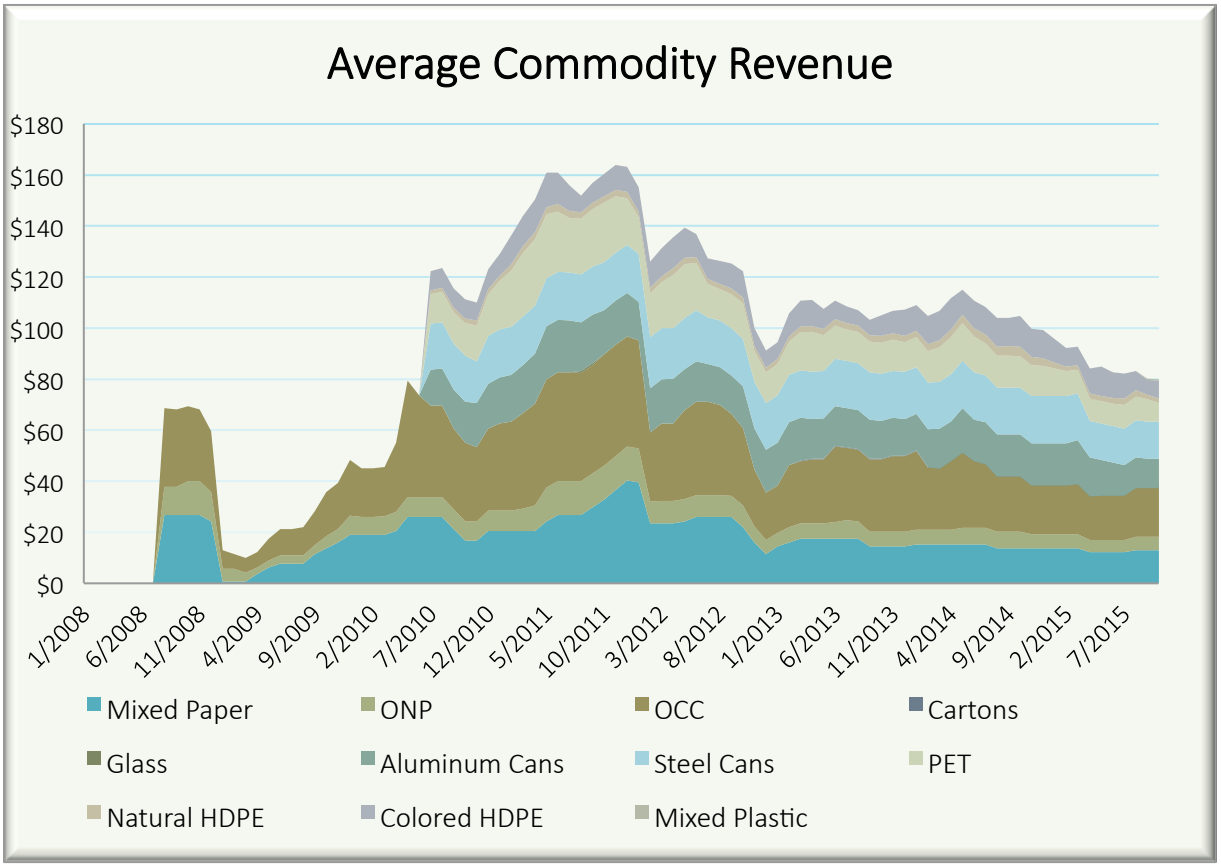
choose to request MRF's to share in the market value of materials that are sold, as contracts are prepared. MRF operations are usually covered by the tipping fee and receive additional compensation based on the prices for recyclables.

This is a typical practice when separate contracts are awarded for collection and for processing and marketing of materials. A revenue sharing arrangement provides an incentive for both the MRF to maintain high quality and market standards and for the community to encourage residents to participate in the recycling program and educate residents how materials should be set out to maximize the benefit of the program. A market share arrangement generally includes an established floor price, which guarantees a minimum price per ton paid to the community for materials brought to the MRF. The floor price can be fixed based on the market value of a select number of items or the total mix of recyclable materials collected. When the market value of the recyclable tonnages exceeds the established floor price, the community and the MRF share in the value of the sold commodities, based upon an established percentage split.

The average commodity revenue (ACR) contract approach is one of the prevalent mechanisms for a community to hedge the risks of volatile swings in the value of recycled commodities. The approach provides flexibility and helps to maximize revenues. If a community wants a minimum guaranteed price, bidders would be tempering their bids with lower expectations in order to ensure that they're not incurring large losses in instances of a market depression. Some MRFs are requesting that glass be removed from the recycling stream due to its negative value. With processing costs at about $65 to $85 a ton, communities that had received a rebate from a regional MRF when they deliver that material are now facing the prospect of a payment to process material or a "payment for diversion".

An analysis of the ACR value approach to commodity sales is illustrated in the following table for several different periods over the past 7 years. During the first period from December 2008 to September 2009, the recession was in full swing but fiber prices had not yet fallen. The ACR basket price began to increase in late 2010 carried by the higher fiber prices. The period (January 2011 to November 2011) portrays overall higher prices and the considerably higher ACR price as a result of higher demand. Beginning in 2014 the general trend in overall average commodity revenue has declined as global demand for all commodities, primarily driven by Chinese demand, has declined. After accounting for negative-value glass and residue in the recycling stream, the blended value per ton, or Average Commodity Revenue value was estimated at $73 per ton as of October 2015 in the Midwest region.

*FIGURE 5: AVERAGE COMMODITY REVENUE (ACR) ANALYSIS*




Several trends can be seen in the graph above, especially in terms of rank in per ton prices for materials. Aluminum tends to sit much higher in price while experiencing slightly less of the volatility found in #1 and #2 plastics. PET and Colored HDPE have switched rank several times since 2008. In fact, all plastics have experienced peaks and valleys at different points over time. There is less volatility in commingled plastics #1-7, likely due to the broader range of materials although the unit price is lower due to the mixed bales. Finally, both steel and glass dropped in value due to the current global downturn in commodity values; however they remain extremely stable compared to other materials.

## Economic Value of Current Recycling

Based on the data collected in the related MRI project, the economic impact of the current recycling rate was calculated. Both the value of the material diverted from the landfill (recyclables and organics) and the landfill cost savings is calculated.

Table 9: Value of Current Recycling

| RECYCLED COOMMODITY | TONS | Percent of Total | 5 YEAR Average $/TON | 5 YEAR VALUE | OCTOBER 2015 VALUE | CUURENT VALUE |
|---|---|---|---|---|---|---|
| Soft Mixed Paper | 225,875 | 25.7% | $62.83 | $14,190,625 | $42.50 | $9,599,707 |
| Special De-ink Quality News (ONP) | 56,431 | 6.4% | $82.92 | $4,679,053 | $57.50 | $3,244,770 |
| Corrugated Containers (OCC) | 166,475 | 18.9% | $112.50 | $18,728,396 | $77.50 | $12,901,784 |
| Aseptic Cartons | 4,112 | 0.5% | $49.37 | $203,014 | $113.75 | $467,782 |
| Glass 3 Mix | 182,685 | 20.8% | -$3.53 | -$645,488 | -$11.50 | -$2,100,882 |
| Aluminum Cans (Sorted, Baled) | 6,394 | 0.7% | $1,539.00 | $9,840,093 | $1,090.00 | $6,969,267 |
| Steel Cans (Sorted, Densified) | 166,046 | 18.9% | $113.29 | $18,811,587 | $90.00 | $14,944,107 |
| PET (Baled, picked up) | 31,222 | 3.6% | $420.29 | $13,122,306 | $210.00 | $6,556,574 |
| Natural HDPE (Bailed, picked up) | 3,575 | 0.4% | $708.40 | $2,532,539 | $520.00 | $1,859,007 |
| Colored HDPE (Bailed, picked up) | 22,046 | 2.5% | $486.67 | $10,729,011 | $360.00 | $7,936,529 |
| Comingled (#3-7, Baled, picked up) | 14,300 | 1.6% | $1.96 | $28,076 | $50.00 | $715,003 |
| TOTAL | 879,161 | 100.0% | | $92,219,212 | | $63,093,646 |
| OTHER MATERIAL | | | | | | |
| Organics | 378,097 | | $15.00 | $5,671,462 | $15.00 | $5,671,462 |
| Textiles | 29,850 | | $4.00 | $119,400 | $2.25 | $67,163 |
| Computers | 24,548 | | $500.00 | $12,274,170 | $350.00 | $8,591,919 |
| Paint | 225 | | -$12.00 | -$2,700 | $0.00 | $0 |
| Tires | 56,960 | | -$10.00 | -$569,602 | -$10.00 | -$569,602 |
| Batteries | 45,187 | | $0.00 | $0 | $0.00 | $0 |
| TOTAL Other MATERIAL | 534,868 | | | $17,492,730 | | $13,760,942 |
| TOTAL | 1,414,029 | | | $109,711,942 | | $76,854,588 |
| AVOIDED LANDFILL DISPOSAL | | | | | | |
| Recycled Material | 879,161 | | $35.00 | | $35.00 | $30,770,630 |
| Other Recovered Material | 534,868 | | $35.00 | | $35.00 | $18,720,381 |
| TOTAL Value Of Avoided Disposal | | | | | | $49,491,010 |

The current value of recycling based on October 2015 Average Commodity Revenue for the Midwest is approximately $76 million, which is 70.1% of the value base on the average commodity value over the past 5 years. The decline in value over the past two years is driven by the global decline in commodity demand driven in large part by the slowdown in the Chinese economy. There are other factors that also affect the commodity value. The value of the avoided disposal cost, based on the average gate rate for disposal of $35/ton is approximately $49.5 million. It should be noted that many communities and private haulers have negotiated long-term disposal rates that are as low as 50% of the average gate rate.

The “evolving ton” is the term being used to describe the shift in the overall composition of the municipal solid waste stream over the past 20 years. One of the trends responsible for this evolution has been the light-weighting of packaging, especially through the use of materials like plastics and aluminum that have displaced materials like glass and steel. More recently, even rigid plastic packaging formats have started to be displaced by rapidly growing formats in flexible packaging. But plastics are not alone in driving the waste shift: Electronic media have played a major role in changing the composition of our recycling stream by reducing the absolute volume of newspaper and office paper.

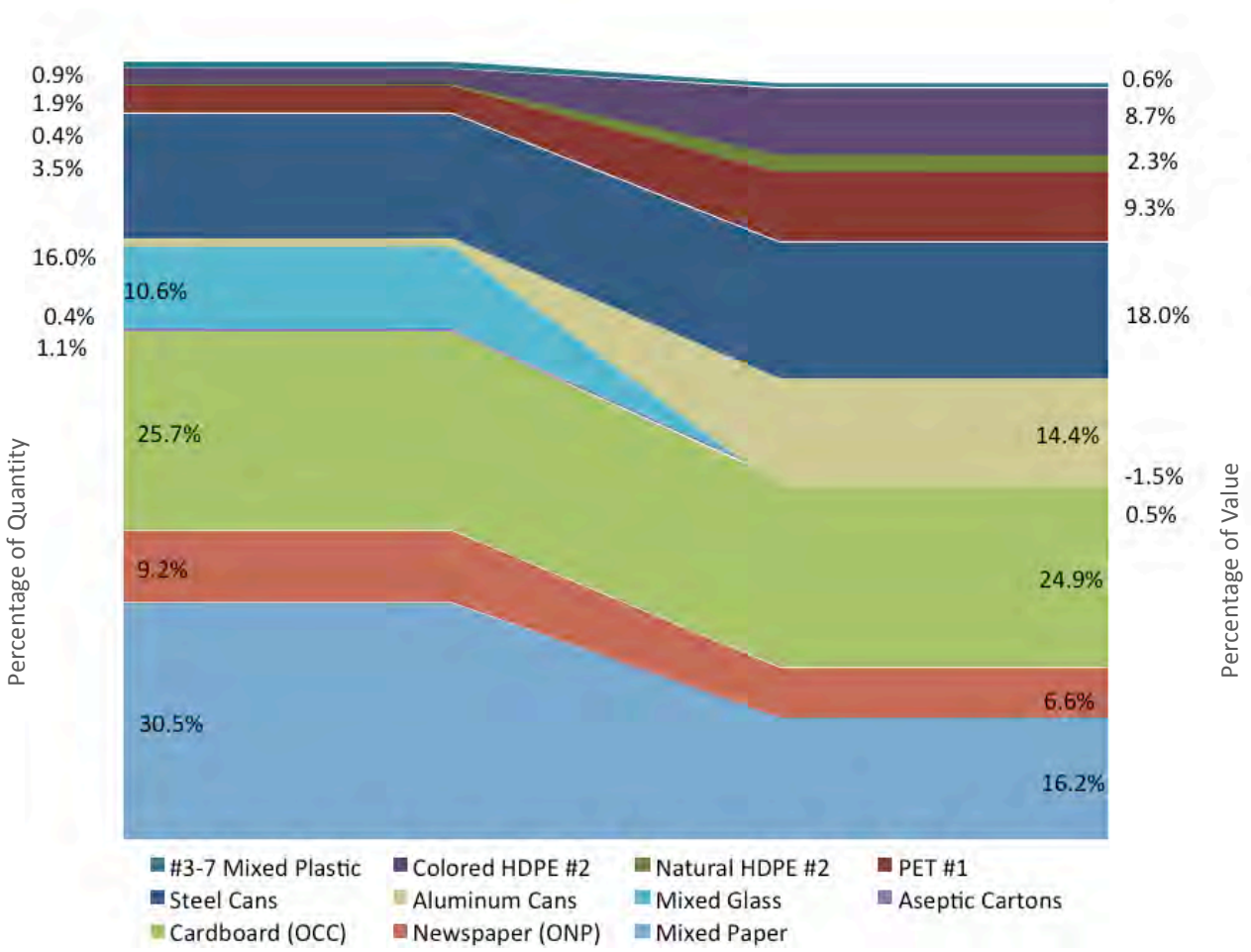
A recent presentation by Amity Lumper from Cascadia Consulting showed the results of residential curbside composition studies that tracked the recycling stream of several cities from 2000 to 2010. Cascadia's research found an 8 percent increase in residential curbside collection of recyclables by weight but an 18 percent increase by volume, and researchers determined the volumetric changes were due almost exclusively to plastic. Most municipalities in the last decade have made a switch to single-stream recycling, collecting all recyclables in one bin. The shift to single-stream collection allowed community programs to collect more, and that has been especially true in the plastics realm.

One major consequence has been greater inefficiency in sorting as measured by residue rates. As discussed earlier in this report there are individual MRFs that provided services to specific municipalities that have achieved high efficiencies and low residual rates. Two recent surveys (from Moore Recycling Associates and GBB Consultants) documented increases in average residue rates at MRFs from 8 percent to 16 percent over the last eight years. The shifting stream also has resulted in more contamination within the commodities produced by MRFs, lowering yields of desired material for all and increasing disposal costs. A recent MRF study conducted for the Carton Council, the American Chemistry Council, the National Association for PET Container Resources (NAPCOR), the Association of Plastic Recyclers (APR), and the Foodservice Packaging Institute documented an average loss rate of plastic bottles to the paper stream of 5 percent and showed clamshells having a loss rate of 29 percent.

According to analysis by RSS on the average commodity revenue per processed ton, the majority of recycling revenue in a MRF still comes from the denser suite of materials like fiber, which represents as much as 65 percent of the weight and about 48 percent of the value per processed ton generated at an average MRF (see Figure 6). Aluminum, which is about 1.1 percent of a process ton by weight, accounts for about 14.4 percent of the revenue. Plastics, mostly PET and HDPE, meanwhile, represent about 6.7 percent of the weight of a processed ton and about 20.8 percent of the revenue.

The graph was updated October 15, 2015 and continually fluctuates with markets and recycling participation. Pulling from numerous recycling composition studies from across the U.S., RRS determined the average weight composition of incoming materials to MRFs, which is represented on the left side of this graph. The right side represents the average commodity revenue per ton of processed material and excludes residue. MRF operators adapt their operations to respond to these numbers or risk missing out on revenue, regardless of equipment, techniques or contamination.

*FIGURE 6: THE MRF BUSINESS PROPOSITION*




## RECYCLING MARKETS TRENDS

In reviewing the Market Trends Data, the market demand and commodity prices for fiber, plastics, aluminum and steel have declined over the past few years. The commodity revenues associated with these materials have over time provided the financial foundation for most recycling programs, whether publicly or privately sponsored. Manufacturing techniques using post-consumer materials also have kept pace with technology and knowledge of the materials sorts. Mills have improved their equipment and systems to predict and adapt to a degree of contamination and to capture contaminants to minimize damage to equipment and maintain quality product standards.

End markets for even more materials, especially the #3-#7 plastics, has provided opportunities for Material Recovery Facilities (MRF's) to increase their list of accepted materials and collected volumes. In fact, the capabilities of both dual and single sort collection programs to easily add materials types to their collection programs has led to the expansion of recycling programs nationwide. Without these inherent flexibilities, the successful recycling of cartons, juice boxes, textiles, boxboard, and exotic plastics (#3 - #7) would not have grown as quickly over the last five to ten years.

Environmental concerns, lower commodity prices and increased regulation are making recycling increasingly difficult. While the recession reduced consumer demand for products in general, demand for products manufactured with recycled goods has risen over the past five years. Further, in the future demand will continue rising, as voluntary product stewardship requirements of the major retailer in the world, Walmart, require manufacturers to use more recycled content as inputs.

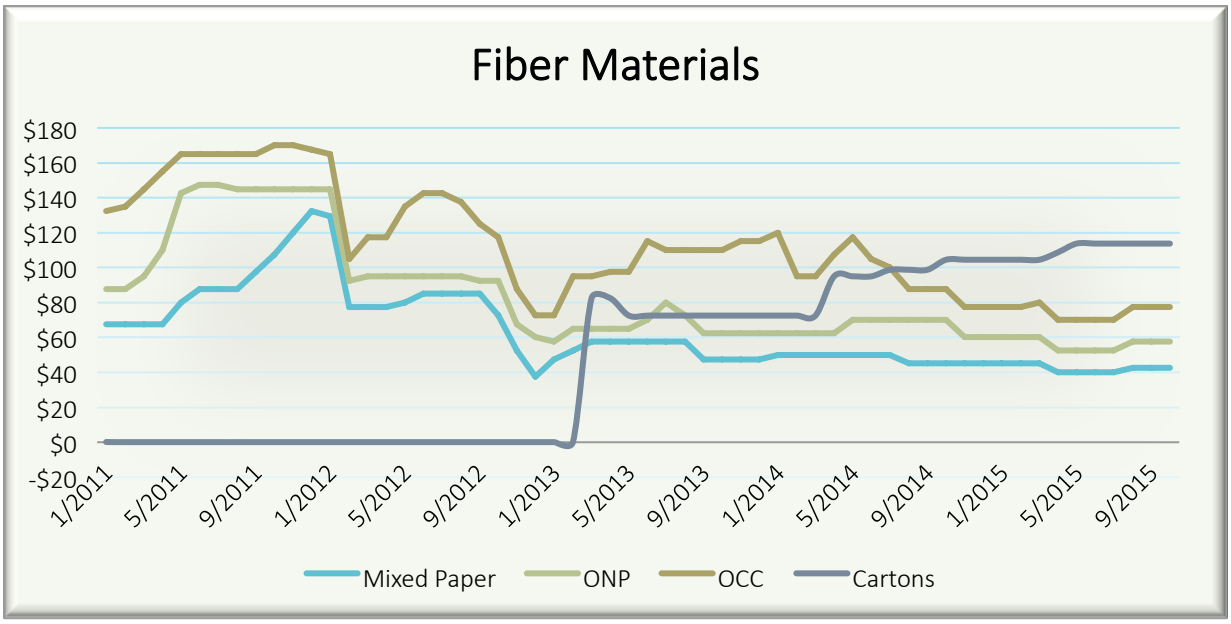
The recycling industry is a mature industry, understands and controls it cost structure and has well-established relationships with end markets and had expanded at an average annual rate of 4.4% until the recent downturn in global commodity demand. There is considerable volatility in recycled commodity prices, which dropped during the recession in response to slumping consumption. During 2009, recycled commodity prices were particularly low, resulting in lower revenues for the industry. Revenue volatility became a concern for industry players, and many sought to consolidate operations to become more stable and achieve greater economies of scale.

It is difficult to project future prices for recycled commodity as the value is closely linked to global economic growth and is especially sensitive to growth of industrialization of emerging markets such as China and India. Higher levels of government regulation and voluntary manufacturing and product requirements for recycled content will benefit the industry by pushing potential downstream customers to use recycled goods in manufacturing processes. This trend is expected to boost the overall market for recycled goods and help stabilize revenue volatility.

## Fiber Markets

Fiber materials experienced a drop due in prices in 2015, which was not simultaneous with that experienced in containers. News and Magazines tend to have a more stable price over time than other corrugated containers, office paper, and mixed paper, which show more dramatic drops and rises. This suggests a larger variety of cleaner, sorted product can insulate the basket price from intermittent price swings and even dampen larger economic busts.

*FIGURE 7: MARKET HISTORICAL DATA – FIBER ($ PER TON)*




RISI—which provides analysis on pricing, markets, and trends in paper recycling—reports that newsprint volumes have declined significantly due to major decreases in worldwide demand, although the market for recycled fiber remains strong overall. The market for old newsprint (ONP) peaked in the late 1990s and has declined by more than half since in the United States, while Europe and Asia have also seen significant declines. Fifteen to 20 years ago, ONP was 60% of the material that a MRF processed—now it's down to an average of 25%.

A second grade that has seen continued strong foreign demand is packaging fiber, which consists mainly of recycled paper and old corrugated container (OCC) paper. The box business in the United States has been flat to declining, especially recycled paper board, which is primarily boxes—cereal boxes, shoe boxes, pizza boxes. China has become a major manufacturer to the world, so box production has really skyrocketed in China while falling in the US in the past 10 years, however the boxes still wind up here. The amount of OCC and, to a lesser degree, old boxboard has been increasing In the residential waste stream, Twenty years ago, of the amount of paper in the residential stream, OCC was a couple of percent—now that amount is as much as 15% to 20%.

Another grade for which demand is growing is the "away-from-home-tissue" business, which consists of napkins, paper towels, and tissue other than high-end facial tissue for businesses such as institutional, restaurants, and airlines. China's government incorrectly perceives hygienic issues with using recycled paper for tissue and uses virgin pulp in this market. However, because tissue does not ship well overseas, China does not ship tissue to the United States, which sees widespread use of recycled paper in tissue. The feedstock is office papers, a subset of what we call printing and writing papers, which, just like newsprint, are declining in the US. Over the last five years, because of electronic documents, there is

less printing and writing paper in the recycle stream, and that's keeping prices high because of the supply shortage. There's also less export of it.

The fourth major grade in recycled fiber is "printing and writing paper." The least economical recycling is converting printing and writing papers to printing and writing papers, primarily because of the yield loss, and it requires fairly labor- and capital operating cost-intensive operations to get it up to the quality for reuse. A little is used in the US and Western Europe. India, a distant second to China in importing recycled paper, is an anomaly and uses a lot of recycled printing and writing paper.

Communities within the Midwest five-state region, which comprises Illinois, Indiana, Michigan, Ohio, and Wisconsin, market large volumes of paper to mills in Michigan, Wisconsin, and Indiana. Markets for fiber have not changed much for these regions since the economic slowdown made its presence felt in 2014. The mixed paper grades and some of the ONP grades go overseas and have more demand than domestically, whereas OCC and cardboard still tend to stay domestic. In this region, it appears that it's not that economically viable to ship to the ports on the coasts and still get the value that you could get by keeping it local. Even though the export markets seem to be paying more, there are freight issues that tend to increase shipping costs. Finally, there is still a lot of demand within the five-state region for OCC.

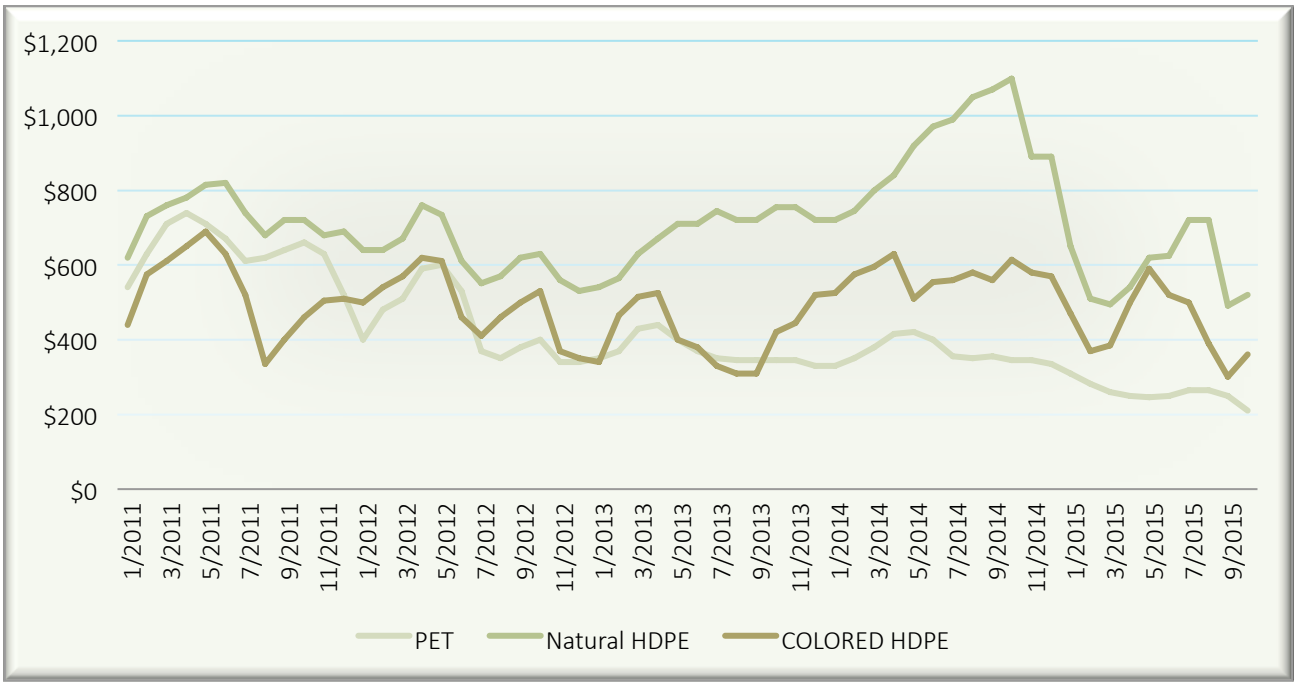
Overall, recycled fiber represents a steady market for communities in the Midwest region. The challenge with ONP is volume. Newspapers are thinner, fewer people are buying them, and they've even gone as far as taking a couple of inches off of the sides of them. In turn, consumers are not putting as much paper in their recycling bins. OCC is the one fiber grade that appears to be in demand-supply balance.

## PET, HDPE Still Lead Plastics Recovery

Plastics markets have experienced a fairly sharp downward trend over the year. Led by a slump in polyester, many plastic scrap grades have been hit by a combination of lower oil prices, a slumping economy throughout Europe and a slowing Chinese buyers' market.

China, which had been one of the driving forces for surging plastic scrap prices in 2011, is now becoming a much more difficult market to serve. Several reports note that Chinese customs agents are prohibiting many container shipments of plastic scrap, which is forcing more plastic scrap recyclers in Europe and the U.S. to redirect shipments to other destinations. Demand for mixed post-consumer plastic grades has fallen off quite significantly. This can be attributed to tighter regulations throughout Asia, as well as higher freight rates that are curbing the appetites of many potential consumers. Virgin LDPE prices have dropped significantly, while PET also has taken "a big hit."

*FIGURE 8: MARKET HISTORICAL DATA – PLASTICS ($ PER TON)*




On the other hand, the plastics reprocessing sector is characterized by strong domestic demand. However, finding raw material to meet customer demand can be challenging. Recovered PE (polyethylene) and PP (polypropylene) are moving well, though at lower prices than earlier this year. Demand for recycled PP continues despite a considerable decline in virgin PP prices. Pricing for virgin PP declined from 20 to 25 cents per pound. Post-industrial engineering grades were sliding slowly in price for the past year, though pricing seems to have stabilized as of mid-July.

Declining oil prices, which correlate to virgin and recycled plastics pricing, do offer a benefit in the form of less expensive transportation. Pricing is more affordable and more trucks are available, now that demand from the produce industry is decreasing.

Predictably, demand for polyethylene terephthalate (PET) and high-density polyethylene (HDPE) remain highest among plastic grades. In addition to being reused for containers, these grades are in demand for such items as plastic decking material, plastic picnic benches, and outdoor seating. For other grades, such as low-density polyethylene and polypropylene (PP), the region doesn't have the regional demand. There are few established industries for PET and HDPE. Industries that demand PET include textiles and carpet; and a big market for HDPE is containers for consumer package goods such as laundry detergent bottles. A major user of recovered PET is Mohawk Industries, which manufactures carpeting.

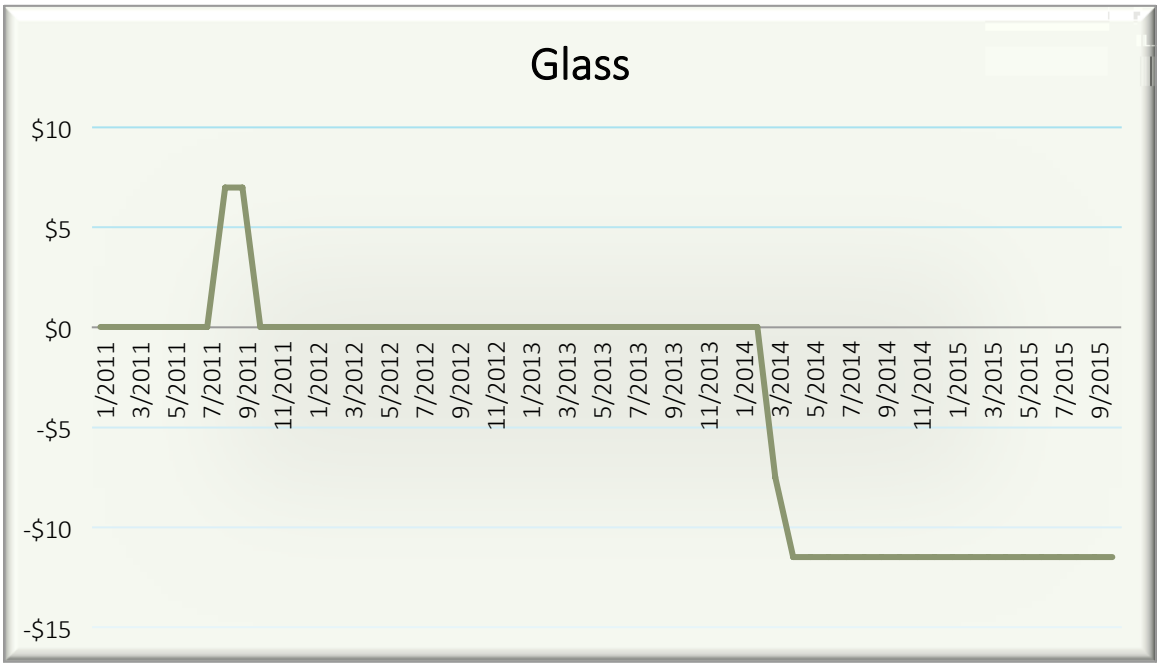
The other grades have smaller volumes and less availability. It's harder to process them off of a stream, and MRF technology has begun to improve to address these materials. Few MRFs are running near infrareds, not many MRFs are running optical sorters, and manual sorting is time-consuming and expensive as well. If you're not able to get much stuff out of the stream, it is not economical to sort it.

There is a shift from PET to PP in some non-bottle-grade materials. A major recent development that has increased PP use was Starbucks Coffee Co.'s switch from PET to PP for its cold cups. This change resulted from a study indicating that PP cups use 15% less plastic than PET cups and emit 45% fewer greenhouse gases during production. Additionally, they do not contaminate other PP containers when commingled for recycling and are easier to recycle than PET cups in most communities, according to Starbucks.

## Glass Recovery

Similarly, glass is a regional product. Modern, high production bottle manufacturing requires very clean and uniform feedstock. Over the past decade there has been a growth in the glass benefaction sector. These are intermediate processors that receive glass from recycling programs and run it through a series of steps to remove any contaminants (rocks, ceramics, metal caps, etc.) and provide a uniform feedstock to the bottle manufacturers. These reprocessors provide an excellent market for recycling programs that do not have the volume or ability to produce glass for direct mill delivery.

*FIGURE 9: MARKET HISTORICAL DATA – GLASS ($ PER TON)*




Glass beneficiation plants use sophisticated optical sorting machines to separate the glass into the three-color types. They may also x-ray the glass to detect any rocks or ceramics, which are then removed. Magnets and eddy current separators are used to remove magnetic and non-magnetic metal contamination from caps and lids. The end product is a uniformly sized load of ground glass that is free of contaminants readily acceptable by bottle manufacturers. Lower grades of recycled glass that are too mixed or contaminated, may be used in concrete or in road paving material called "Glassphalt".

Houston-based Strategic Materials has a large beneficiation facility on Chicago's South Side. Glass grades in the most demand include "flint," aka "clear," which is used for bottling such items as beer and pickles,

followed by brown and green, the latter of which comes in a distant third in demand. Most MRFs in the area crush all three types of glass together for a "three-mix glass" that is shipped to a processor like Strategic Materials that separates the material optically. Glass is a "negative-value material but the cost to recycle the material is often lower than landfill tipping fees.

Rumpke Recycling in Ohio partnered with the Ohio Department of Natural Resources and Owens- Illinois to build enhanced technology to process glass. Rumpke first opened its Dayton glass processing facility in 2002 in an effort to process the broken, mixed color glass screened from the single stream sorting process. The new system creates a product suitable for the glass container industry. State-of-the-art optical scanning will make the recycling of glass containers used by consumers as well as bars and restaurants easier and more economical. While a significant portion of the material processed at Rumpke Recycling will be prepared for use in container manufacturing, long-standing glass recycling partner Johns Manville, a fiberglass manufacturing firm with a production facility in Defiance, Ohio, will continue to use 50 percent of the processed glass as a raw material.

## Metals

After falling $50-$55 in October, many in Detroit felt the market had finally reached bottom. One broker said in late October he felt "a little bit better about this market. It appears the bleeding has stopped." Detroit mills came in at $20 lower across the board in November 2015, with the exception of shredded scrap, which was down $15. One broker said everybody is going to have to get used to today's conditions. In the short term, the prediction is that the market won't drop too much further, but it's unlikely to increase much either.

After dropping $50 in October, the Chicago market was off a solid $20-$30 in November on light mill demand. The big lakefront mills in Chicago proper bought a reported total of 15,000 tons in November, with dealer bundles reported at $155 and turnings delivered at $65. Bundles, busheling, shredded, and plate and structural steel were all trading in the $160 range. When all was said and done, what little scrap had been traded was generally down $30 for prime grades, down $20 for cut grades, and down $15 for turnings and borings. With prices so low, and the Chicago market spread out from Iowa to eastern Indiana, several brokers said they were ready to begin pulling back from rail shipments because of high rail freight rates. One broker said the only positive he had heard in the last month or two was the fact that export prices seemed to be strengthening on the East Coast. The following illustrates current market indicator for scrap steel.

Table 10: Shredded Scrap

| Consumer: SDI Indiana (Butler, Ind.) |
|---|
| Delivered price: $162 reported |
| Tonnage: 10,000+ tons reported |
| Iron Age price: $161-$162 |

The recycled aluminum can (sorted and baled) price in October 2015 in the Midwest region was $1082/ton. This reflects a 44% decline in value from the most recent high for aluminum can of $1926/tin in May 2011. The value of steel cans (sorted and baled) in October 2015 in the Midwest region was $74/ton. This reflects a 43% decline in value from the most recent high for steel cans of $129/ton in May 2012. Steel can prices in February of 2015 were at $122/ton demonstrating that the majority of the loss in value occurred in the past 8 months.

*FIGURE 10: ALUMINUM CANS*
*($ PER TON)*

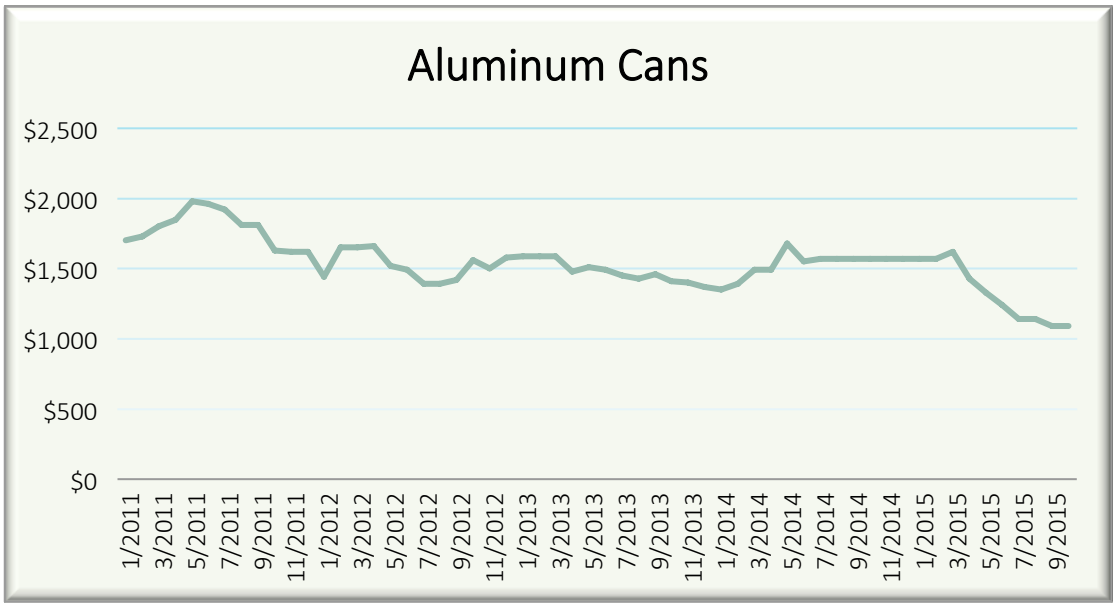
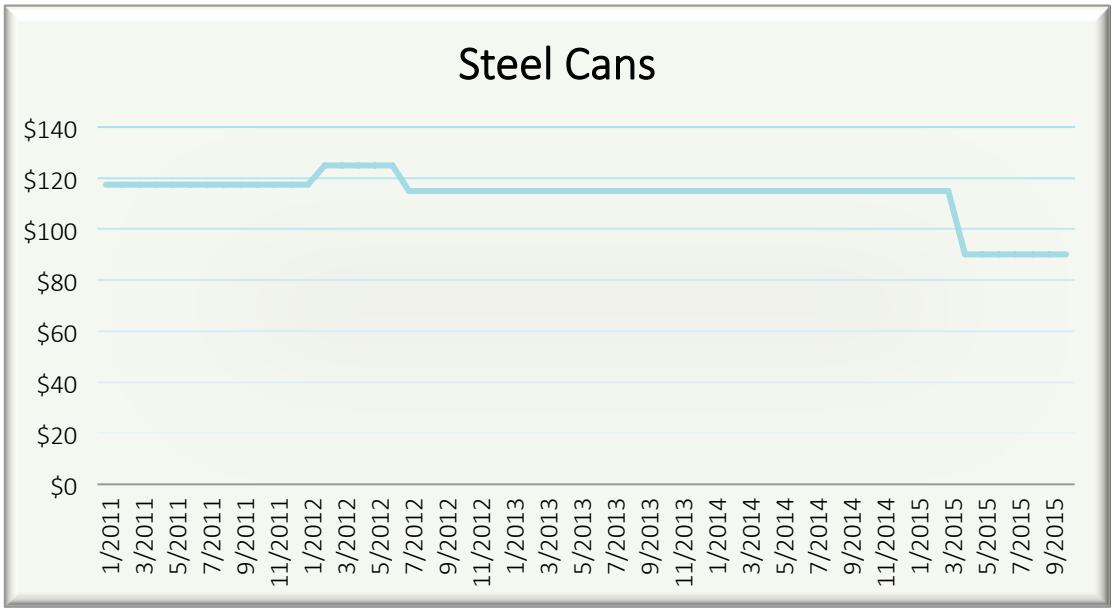



*FIGURE 12: FERROUS SCRAP PRICING*
*($ PER TON)*



# RECYCLING AND THE ECONOMY: JOBS AND ECONOMIC DEVELOPMENT

Based on published reports of job creation for recycling, an assessment of the number of jobs created by recycling and an assessment of the number of jobs that could be created by increasing the recycling rate has been performed. Recycling is a diverse industry. Securing these raw materials for manufacturing through recycling is an integrated system that starts with collection of materials from the curb, at drop-off centers or from businesses. The U. S. Recycling Economic Information Study (REI)[1] identified 26 different types of recycling businesses from collection to manufacturing, including processing, equipment manufacturing, foundries, education, training, and many more.

Potentially recyclable materials encompass newspapers, bottles and cans, glass, steel, textiles, organics, industrial materials such as asphalt, concrete, fly ash, construction and demolition debris, and electronics. The list of potentially recyclable materials is lengthy and could be more so with governmental support.

Recycling is cost competitive with other extractive industries. As a driver of economic activity, the recycling industry compares favorably to heavy industries, such as automobile manufacturing and mining. It outpaces the solid waste disposal industry for job creation (see table below) and recycling adds value to materials and contributes to growing the labor force. Recycling supports U.S. manufacturing jobs and increases U.S. competitiveness through cost savings.

Table 11: Recycling Jobs Created

| Types of Operation | Jobs per 10,000 TPY* |
|---|---|
| Computer Reuse | 296 |
| Textile Reclamation | 85 |
| Misc. Durables Reuse | 62 |
| Wooden Pallet Repair | 28 |
| Recycling-based Manufacturers | 25 |
| Paper Mills | 18 |
| Glass Product Manufacturers | 26 |
| Plastic Product Manufacturers | 93 |
| Conventional Materials Recovery Facilities | 10 |
| Composting | 4 |
| Landfill & Incineration | 1 |

- *TPY = tons per year

Studies have been undertaken over the past years that look at recycling and waste diversion activities (also called materials management) with an eye to determining what impact recycling and waste diversion have on the economy, both in individual states as well as on the United States as a whole.

Applying the job creation numbers to a hypothetical program to collect 10,000 tons per year that includes trucks for collection results in the creation of 68 jobs to manage the material collection, processing and recycled manufacturing (Table 12).

Table 12: Economic Development Impact

| Single-stream Material | |
|---|---|
| **Capital Investment**[5] | |
| Collection Trucks | $281,250 |
| Carts | $500,000 |
| MRF Infrastructure | $400,000 |
| | **$1,181,250** |
| **Market Efficiencies**[6] | |
| Avoided Disposal | $350,000 |
| Material Value | $1,510,200 |
| | **$1,860,200** |
| **Job Growth** | |
| MRF Operations | 10 |
| Plastic Manufacturing | 9 |
| Glass Manufacturing | 4 |
| Paper Mills | 10 |
| Recycling-Based Manufacturers | 25 |
| **Total Number of Jobs** | **68** |

MRF access near population centers will provide the infrastructure to grow diversion and push material into the recycling economy. Across the state, local communities have varied programs collecting a range of different materials. Some include glass; others do not. Some collect all plastic; others just plastic bottles. A growing number of communities have moved to single-stream programs, others still source separate or collect dual stream. Some single-stream programs accept cartons (gable-top containers and juice/wine/soup boxes), which are a growing portion of the waste stream, and others do not. These are just a few examples of the variation in collection programs.

- Moving toward a processing model that involves a network of single-stream MRFs is one strategy to drive more diversion. The remaining counties and municipalities rely on varied programs designed around convenience sites and recycling drop-off locations.
- Integration across Michigan will help to broaden the list of materials collected, drive more diversion, and create the critical mass to grow the recycling economy.

[5] Collection trucks: 10 @ $225,000 each = $2.25 million, initial investment amortized over 8 years. Carts: @ $50/95-gallon cart, estimated 50,000 carts needed per 10,000 tons, amortized over 5 years. MRF Infrastructure: Building amortized over 20 years, equipment over 10.

[6] Avoided Disposal: Residential disposal cost estimate based on $35/ton tipping fee. Material Value: % mix of single-stream material based on Resource Recycling "A Common Theme," Collins, S. February 2012. Value is based on pricing from material value chart above.

- The potential for increased diversion from residential recycling programs could drive economic growth from this sector.
- The economic growth will come from the market value of recovered material, investment in collection and processing infrastructure, job growth, efficiencies in transport and collection, and decreased disposal costs for local government. Table 10 calculated the potential level economic impact per 10,000 tons of additional diversion, including the creation of 68 jobs.

## The U.S. Scrap Recycling Industry Creates Jobs in Michigan

An analysis of the impact of jobs related to the scrap recycling industry conducted by the Institute of Scrap Recycling Industries (ISRI) that includes residential, commercial and industrial recycling provides a broad overview of the impact on the State of Michigan. The ISRI analysis stated the following conclusions:

> "From the earliest known uses of scrap thousands of years ago, to the optical scanners, x-rays, air jets, high-tech shredders and other technologically advanced equipment used today; scrap recycling has evolved into a major industry dedicated to transforming end-of-life products to create new commodity grade materials that boost national, state and local economies.
>
> With a continuing societal focus on protecting our natural resources, energy savings and reducing greenhouse gas emissions, the scrap recycling industry is recognized as one of the world's first green industries, while playing a prominent role as an economic leader, job creator, major exporter and environmental steward. In fact, the people and firms that purchase, process and broker old scrap to be manufactured into new products provide 16,673 people with good jobs in Michigan.[7]

Table 13: The Economic Impact of the Scrap Recycling Industry[2]

| | Direct | Supplier | Induced | Total |
|---|---|---|---|---|
| **Jobs** | 5,129 | 6,134 | 5,410 | 16,673 |
| **Wages** | $373,712,300 | $382,205,200 | $257,852,200 | $1,013,769,700 |
| **Economic** | $1,579,780,40 | $1,248,387,900 | $851,907,100 | $3,680,075,400 |

> 5,129 jobs are being supported by the manufacturing and brokerage operations of the scrap recycling industry in Michigan in 2015.[8] These are good jobs paying an average wage of $72,863.

[7] Based on the Economic Impact of the Scrap Recycling Industry in the United States (2015), produced for the Institute of Scrap Recycling Industries, Inc. by John Dunham and Associates, 2015.

[8] This includes firms involved in the purchasing, processing, recycling and brokering of scrap materials including ferrous and nonferrous metals, paper, electronics, rubber, plastics, glass and textiles.

In addition to this, the scrap recycling industry through suppliers and the indirect impact of the industry's expenditures indirectly supports 11,544 jobs.[9]

- All of this activity generates nearly $3.68 billion in economic benefits in Michigan.
- When all scrap materials are taken into account, the U.S. scrap recycling industry accounts for 0.68 percent of the nation's total economic activity,[10] making it similar in size to the data processing and hosting industry, the dental industry, and the automotive repair industry.
- The value of the scrap sold in Michigan is created through the capital and job intensive processing operations of the American scrap recycling industry that transforms old and obsolete materials into commodities that meet the exacting needs of manufacturers worldwide. This not only benefits workers, but also the government. All told, the scrap recycling industry generates $232.06 million in tax revenues for the federal government and $131.89 million in state and local revenues."

[9] Direct impacts are those associated with scrap processors and brokers. Supplier impacts are associated with firms providing goods and services to scrap recyclers and brokers, including peddlers, and induced impacts are those resulting from the re-spending of wages by workers in the direct and supplier sectors.

[10] Bureau of Economic Analysis. GDP based on fourth quarter 2014, value of $17.703 trillion, see: *Gross Domestic Product: Fourth Quarter and Annual 2014* (Third Estimate); *Corporate Profits: Fourth Quarter and Annual 2014*, March 27, 2015.

# SECTION IV
# LANDFILL CHARACTERIZATION FOR MICHIGAN

# MUNICIPAL SOLID WASTE DEFINITIONS

The US EPA defines Municipal Solid Waste (MSW) as "discards from residential and commercial sources that does not contain regulated hazardous wastes." (EPA, State Measurement Program Template, 2013) The EPA has provided a detailed description of materials that are considered MSW and those that are not, and the full table is appended to this document. Key considerations in the definition of MSW include:

- MSW excludes waste from industrial operations, manufacturing, construction and demolition, and transportation equipment (automobiles).
- MSW excludes sludges and combustion ash.

## Recycling

Recycling is defined by the US EPA as "the series of activities by which discarded materials are collected, sorted, processed, and converted into raw material and returned to the economic mainstream by being used in the production of new products. It does not include the use of these materials as a fuel substitute or for energy production." (EPA, State Measurement Program Template, 2013) Similar detail by material identifying the activities that are and are not considered recycling is excerpted from "Measuring Recycling: A Guide for State and Local Governments" and appended to this document. Key activities that are not considered recycling are:

- Combustion of material for energy recovery;
- Backyard (onsite) composting of food scraps and yard trimmings;
- Reuse (e.g. of refillable packaging, textiles, pallets, plastic products, etc.);
- Recycling of non-MSW such as waste from industrial processes; and
- Recycling of wood waste or yard trimmings from C&D debris.

Effectively, the EPA definition of MSW was used in this methodology, and is based on the historical management of municipal solid waste. Although it is common practice to landfill materials such as municipal sludge, nonhazardous industrial process wastes, and construction and demolition (C&D) debris along with MSW, these materials are not included in the standard scope of MSW or a recycling rate.

## Michigan Definition of Solid Waste

For the purposes of the study, a waste sector is identified by the particular generation characteristics that make it a unique portion of the total waste stream. This study is limited to analysis of the statutory definition of municipal solid waste (MSW or solid waste), which is defined by Michigan law as "garbage, rubbish, ashes, incinerator ash, incinerator residue, street cleanings, municipal and industrial sludges, solid commercial waste, solid industrial waste, and animal waste" as per Act 451 of 1994, Part 115, Solid Waste Management. Each state characterization that was reviewed has a different definition of what material was included in their studies based on their statutory definition and the types of solid waste and recycling program requirements. The characterizations from other states and communities identified 80 different categories of material that were evaluated, however not every category was evaluated within a specific state study.

The definition of MSW in Michigan excludes the following materials from the definition of Solid Waste:

(a) Human body waste.
(b) Medical waste.
(c) Organic waste generated in the production of livestock and poultry.
(d) Liquid waste.
(e) Ferrous or nonferrous scrap directed to a scrap metal processor or to a reuser of ferrous or nonferrous products.
(f) Slag or slag products directed to a slag processor or to a reuser of slag or slag products.
(g) Sludges and ashes managed as recycled or non-detrimental materials appropriate for agricultural or silvicultural use pursuant to a plan approved by the department.
(h) The following materials that are used as animal feed, or are applied on, or are composted and applied on, farmland or forestland for an agricultural or silvicultural purpose at an agronomic rate consistent with GAAMPS:
(i) Materials approved for emergency disposal by the department.
(j) Source separated materials.
(k) Site separated material.
(l) Coal ash, when used under specified circumstances
(m) Inert material.
(n) Soil that is washed or otherwise removed from sugar beets, has not more than 35% moisture content, and is registered as a soil conditioner.
(o) Soil that is relocated under section 20120c.
(p) Diverted waste that is managed through a waste diversion center.
(q) Beneficial use by-products.
(r) Coal bottom ash, if substantially free of fly ash or economizer ash, when used as cold weather road abrasive.
(s) Stamp sands when used as cold weather road abrasive in the Upper Peninsula by specified agencies:
(t) Any material that is reclaimed or reused in the process that generated it.
(u) Any secondary material that, as specified in or determined pursuant to 40 CFR part 241, is not a solid waste when combusted.
(v) Other wastes regulated by statute.

## DEVELOPMENT OF LANDFILL CHARACTERIZATION FOR MICHIGAN

It is important to understand the types and quantities of materials generated, the generating sectors, the quantities that are potentially recoverable and those that are otherwise disposed to enable sound policy and program design, implementation and program analyses for both the public sector and private sector in Michigan. Many states and counties throughout the country conduct waste characterization studies at regular intervals to evaluate recycling program effectiveness, monitor changes in the disposed waste

stream, confirm the effectiveness of landfill disposal bans, identify potential diversion opportunities, and otherwise help manage their waste streams. Generation data can be used for strategic planning; developing future legislative initiatives; evaluating effectiveness of current recovery efforts; targeting programs and educational efforts to advance recovery of commodities; providing guidance to state agencies and local governments; and aid in fulfilling the responsibilities required under the Governors Initiative.

The development of a waste characterization for the State of Michigan is based a review of statewide and municipal waste characterization studies from across the country. Additionally, the RRS completed a literature review for any new waste characterization studies. Resource Recycling Systems (RRS) developed a national landfill characterization estimation tool based on 27 different landfill characterization studies. These studies range from individual municipality studies to statewide studies. For each study, RRS standardized the list of materials and summarized the composition of the landfill by percentage of each material. The studies are categorized as coming from low-, medium-, or high-diversion communities, since as more material is diverted from the landfill the composition of the remaining material changes.

Each study was evaluated for inclusion in the tool to ensure compatibility with the existing studies. Based on the unique characteristics of the waste characterization studies the Project Team performed a statistical analysis of existing composition studies to quantify the effects of each. For example, the waste characterization for states with landfill bans (or strong policy promoting the diversion of organics) will be compared with those without to determine the deviation from the average. This analysis was completed for each of the factors to fully understand the effects of specific policies and conditions now present in Michigan.

Another consideration that complicates the use of waste characterizations studies for the development of a waste characterization for the State of Michigan is the “evolving ton”, a term being used to describe the shift in the overall composition of the municipal solid waste stream over the past 20 years. One of the trends responsible for this evolution has been the light weighting of packaging, especially through the use of materials like plastics and aluminum that have displaced materials like glass and steel. More recently, even rigid plastic packaging formats have started to be displaced by rapidly growing formats in flexible packaging. But plastics are not alone in driving the waste shift: Electronic media have played a major role in changing the composition of our recycling stream by reducing the absolute volume of newspaper and office paper.

It’s also critical to understand that while more types of plastics are getting collected, complexity has increased even within the resin types the recycling system has traditionally handled. In response to growing pressure to recycle more, many companies are shifting to “recyclable” materials, often defining them as those accepted in community recycling programs. One of the best examples of this trend has been PET replacing PVC or PS thermoforms and heavier jar and container material like glass. The unforeseen consequence of this well-intentioned transition is the recent diversification of PET in the

recycling stream, a phenomenon that has lowered the yield of usable materials (the PET used in clamshells, blisters and ketchup bottles is not the same as that used in a soda bottle).

## Methodology

The studies were reviewed and evaluated on the basis of thoroughness and accuracy, date conducted, and relevance to the material types under consideration. Each study was assigned to a low, medium, or high diversion profile based on the characteristics of the states or communities represented in each study and the per capita amount of landfilled material. By averaging across several studies, generic profiles for low, medium, and high diversion states and communities were developed. The profiles were adjusted to take into account overall drops in landfill tonnage in recent years as a result of the economic downturn and the changing material mix. Each profile consists of an estimate of per capita generation, and the composition of this material, as well as residential and commercial generation and composition from studies that included separate characterizations of those sectors.

The Project Team reviewed recent landfill characterization studies from other states, including Pennsylvania, Illinois, Tennessee, and Nebraska. Only state studies that had specific characterizations for residential material were included. All four of these states have less than 15 percent diversion. The percentage of standard residential recyclables in the residential waste stream was on average 37 percent and ranged from 35 percent to 39 percent. Reviewing characterizations from states with medium diversion (15%–40% statewide) including California, Connecticut and Washington, the range is similar with California at the upper end of the diversion range and only 19 percent of the landfilled material was recyclable to Connecticut at 25 percent diversion and 24 percent material recyclable.

Table 14: Characterization Studies Reviewed

**Low-Diversion Profile**

- Pennsylvania, 2003
- Illinois, 2009
- Georgia, 2005
- Indiana, 2012
- US EPA, 2012

**Medium -Diversion Profile**

- Wisconsin, 2003
- Connecticut, 2010
- California Integrated Waste Management Board, 2009
- US EPA

**High-Diversion Profile**

- Thurston County, WA, 2007
- Snohomish County, WA, 2009
- Clark County, WA, 2008
- Seattle, WA Public Utilities, Residential-2007; Commercial - 2008
- San Francisco, 2006
- Palo Alto, CA, 2006
- California Integrated Waste Management Board, 2009
- US EPA, see above

**Additional Studies Consulted**

- Delaware, 2007
- Iowa, 2011
- Missouri, *2008*
- Nebraska, 2009
- Oregon, 2002
- Vermont, 2002.

It should be noted that the national and world economy experienced the effects of a significant economic downturn in 2008-2009, with the effects impacting several of the studies that were reviewed. While it is beyond the scope of this study to quantify the impacts, it can be qualitatively asserted that waste generation patterns may have been affected and generation of specific types of material have changed for a number of reasons:

- Slow or negative business growth has resulted in absolute and per-capita decreases in waste generation.
- Construction was lower than average for both residential and non-residential projects.
- Markets for recycled materials, like many commodities markets, dropped precipitously during the recession.

The original approach was to generate three separate compositions specifically for Michigan: low, medium, and high diversion communities. Based on data from Michigan Recycling Index project, each of the counties was to be classified in one of these categories based on its diversion rate (less than 15% for low diversion and greater than 40% for high diversion). In this manner, the characterization would be applied to each county, based on the reported tons generated in that county in the most recent MDEQ Landfill Report. An average statewide residential composition would then be generated from this analysis for Michigan-generated material that does not include imported material. A key issue is that Michigan has one of the more effective deposit container (Bottle Bill) programs in the country.

The data collected in the Michigan Recycling Index project did not result in data that allowed for each county to be classified as low, medium, and high diversion communities. The Recycling Index project results indicated a 15% Recycling (diversion) rate that would put Michigan at the boundary of the division between a low and a medium diversion categorization.

An alternative approach was developed that utilized the average of the low, medium, and high diversion compositions from the review of waste characterizations studies as well as a diversion categorizations for states with bottle deposit systems and states with yard waste bans. Several studies also included a breakdown between residential and Institutional, Commercial, and Industrial (ICI) categories. The Project Team believes strongly that when a state is classified by its diversion rate, a credible estimation can be made of the percentage of materials that are recyclable and the value of that material relative to the State of Michigan.

Separate characterizations were created specifically for states with a bottle bill. Table 15 illustrates a sample of the comparison of the study results. The table for plastic shows the variability of studies for specific categories of material. These characterizations show that there is a difference of 4.29% in the total plastics from the low estimate to the high estimate. The medium diversion characterization is very similar to the bottle bill diversion characterization.

Table 15: Percentage of Total Plastic Landfilled

| | PET bottles | PET containers non-bottles | HDPE Bottles Natural | HDPE Bottles not specified/Colored | LDPE (includes some bags, film) | Expanded Polystyrene (foam) | Plastic bottles and #3-7 (general) | Durable and Rigid containers | All other Plastics | Plastic subtotal |
|---|---|---|---|---|---|---|---|---|---|---|
| Low Diversion | 1.09% | 0.03% | 0.15% | 0.84% | 5.73% | 1.02% | 0.42% | 3.95% | 0.65% | 13.88% |
| Medium Diversion | 0.63% | 0.03% | 0.07% | 0.37% | 4.00% | 0.67% | 0.17% | 2.43% | 3.27% | 11.63% |
| Low Diversion – GL Residential | 1.31% | 0.29% | 0.25% | 0.93% | 5.53% | 1.04% | 0.78% | 1.22% | 4.56% | 15.92% |
| Medium Diversion - GL Residential | 1.77% | 0.00% | 0.10% | 3.14% | 3.61% | 1.65% | 0.00% | 0.80% | 3.18% | 14.79% |
| Bottle Bill Diversion | 0.63% | 0.03% | 0.08% | 0.46% | 4.59% | 0.91% | 0.30% | 1.66% | 3.47% | 12.11% |

All of the Great Lakes states that were evaluated have some type of organics or yard waste bans in place while other states and states with container deposit laws do not have comprehensive organics management programs or landfill bans. The higher percentage of organics in states without organics management programs is primarily driven by higher percentages of leaves and grass. Leaves and grass make up approximately 3.7-3.9 % of the total waste stream in the states without organics management programs. Reducing the organics fraction for this category of materials for characterization based on data from states with deposit container programs would require this fraction to be distributed on a weighted basis to all other categories to ensure a 100% distribution. An adjusted bottle bill diversion allocation was performed to compensate for the yard waste disposal ban in Michigan. It is our opinion that utilizing the adjusted bottle bill diversion characterizations would present a useful approach for the State of Michigan but may overstates the quantity of organics (leaves and grass).

Table 16 provides the characterization for all major categories of materials. The compositions provided in the table show that the average of states that were classified as a medium diversion, including both residential and commercial material, is very consistent with the characterization of states with deposit container programs. The other comparison that was calculated was to states in the Great Lakes region (Illinois, Indiana, Wisconsin, Iowa). These composition estimates were compared to select an appropriate statewide composition to be applied to Michigan. A comprehensive table of the percentage allocation of all major categories of studies is included in Appendix V.

Table 16: Percentage of Categories of Landfilled Materials

| | Paper | Plastic | Metal | Glass | Electronics | Total Wood | Organic | Auto related | Household Items (Carpet, Textile, | Other Non-Recyclables |
|---|---|---|---|---|---|---|---|---|---|---|
| Low Diversion | 32.69% | 13.88% | 5.33% | 3.28% | 2.23% | 8.67% | 20.79% | 0.16% | 6.10% | 6.87% |
| Medium Diversion | 21.30% | 11.63% | 4.93% | 2.00% | 2.50% | 11.87% | 23.90% | 0.27% | 5.93% | 15.67% |
| Low Diversion – GL Residential | 26.72% | 15.92% | 7.48% | 2.51% | 2.40% | 11.90% | 20.07% | 0.37% | 6.32% | 6.33% |
| Medium Diversion - GL Residential | 34.12% | 14.79% | 4.68% | 3.45% | 2.10% | 6.85% | 18.78% | 0.30% | 3.99% | 10.95% |
| Bottle Bill Diversion | 22.81% | 12.11% | 5.85% | 1.73% | 1.56% | 10.17% | 24.39% | 0.05% | 5.18% | 16.17% |
| **Bottle Bill Diversion – Adjusted** | **23.69%** | **12.58%** | **6.08%** | **1.79%** | **1.62%** | **10.57%** | **21.30%** | **0.05%** | **5.37%** | **16.95%** |

The final step was to combine the over 80 categories of material that were identified in the characterization states into a classification system that typifies broader categories consistent with market specifications. The estimate of landfilled material was calculated by multiplying the quantity of total landfilled material by the average percent of material types selected as representative of Michigan.

Table 17 provides a consolidated profile of the statewide disposed waste stream. In addition, the current recovery of material as developed in for the Michigan Recycling Index project was included for comparative purposes. The Adjusted Bottle Bill scenario is he recommended framework for the State of Michigan Waste Characterization.

Table 17: Michigan Waste Characterization

| Material Type | Current Diversion Tons | Medium Diversion Tons | Medium Diversion Percent | FINAL ADJUSTED TONS | FINAL ADJUSTED PERCENTAGE |
|---|---|---|---|---|---|
| High Grade - White and Colored Ledger | 4,849 | 101,668 | 1.27% | 114,234 | 1.42% |
| Mixed/ unspecified Office | 32,792 | 32,106 | 0.40% | 56,492 | 0.70% |
| Low Grade - general (OMG), Boxboard, Paper Bags, Phonebooks other recyclables | 193,055 | 329,084 | 4.10% | 447,557 | 5.58% |
| ONP | 55,699 | 139,125 | 1.73% | 154,466 | 1.92% |
| OCC | 140,265 | 390,620 | 4.87% | 455,686 | 5.68% |
| Cartons, Aseptics and Poly-coated | 26,233 | 5,351 | 0.07% | 11,257 | 0.14% |
| Compostable/ soiled and all other paper | | 711,678 | 8.87% | 661,642 | 8.24% |
| Paper Subtotal | **452,893** | **1,709,632** | **21.30%** | **1,901,543** | **23.69%** |
| PET bottles and containers | 5,742 | 53,510 | 0.67% | 54,616 | 0.68% |
| HDPE Bottles Natural & Colored | 5,076 | 34,781 | 0.43% | 44,818 | 0.56% |
| Plastic bottles and #3-7 (general) | 2,153 | 13,377 | 0.17% | 25,015 | 0.31% |
| All other Plastics and Packaging, LDPE, Polystyrene (foam), Durable and Rigid containers and PP tubs) | 58,172 | 832,075 | 10.37% | 885,107 | 11.03% |
| Plastic Subtotal | **71,143** | **933,743** | **11.63%** | **1,009,556** | **12.58%** |
| Aluminum cans | 17,459 | 16,053 | 0.20% | 13,758 | 0.17% |
| Ferrous metals (includes Tin/Steel Cans, tin) | 121,354 | 243,469 | 3.03% | 357,295 | 4.45% |
| Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans | 33,626 | 136,450 | 1.70% | 116,736 | 1.45% |
| Metal Subtotal | **172,439** | **395,971** | **4.93%** | **487,789** | **6.08%** |
| Glass - general including containers | 161,913 | 98,993 | 1.23% | 105,896 | 1.32% |
| Other Glass | 20,772 | 61,536 | 0.77% | 37,939 | 0.47% |
| Glass Subtotal | **182,685** | **160,529** | **2.00%** | **143,835** | **1.79%** |
| Electronics - general, computer related, CRT | 24,181.9 | 171,231 | 2.13% | 118,820 | 1.48% |
| White goods (appliances) | | 29,430 | 0.37% | 11,465 | 0.14% |
| Electronics Subtotal | **24,181.9** | **200,661** | **2.50%** | **130,285** | **1.62%** |
| Total Wood | | **952,471** | **11.87%** | **848,002** | **10.57%** |
| Yard waste - general | 56,751 | 457,507 | 5.70% | 217,003 | 2.70% |
| Food | 226,701 | 1,048,789 | 13.07% | 1,211,759 | 15.10% |
| Other R/C Organics, Branches and Stumps | 94,646 | 412,024 | 5.13% | 280,791 | 3.50% |
| Yard Waste and Organic Subtotal | **378,097** | **1,918,320** | **23.90%** | **1,709,554** | **21.30%** |
| Other Textiles, Batteries, Tires, Carpet, Light Bulbs | **132,364** | **497,639** | **6.20%** | **435,258** | **5.42%** |
| Other Non- recyclable Materials | **225** | **1,257,476** | **15.67%** | **1,360,621** | **16.95%** |
| Total | **1,414,029** | **8,026,443** | **100.00%** | **8,026,443** | **100.00%** |

*Numbers may not total due to rounding errors

## Economic Value of Landfilled Recyclables

Based on the data collected in the related MRI project, the Project Team calculated the economic impact of the current landfilled material. Both the value of the material diverted from the landfill (recyclables and organics) and the landfill cost savings is calculated. The quantity of these materials

Table 18: Value of Landfilled Material

| POTENTIAL RECYCLED COMMODITY | TONS | Percent of Total | 5 YEAR Average $/TON | VALUE Based on 5-Yr Avg. ACR | OCTOBER 2015 VALUE |
|---|---|---|---|---|---|
| **Soft Mixed Paper** | 618,283 | 32.9% | $62.83 | $38,843,613 | $26,277,017 |
| **Special De-ink Quality News (ONP)** | 154,466 | 8.2% | $82.92 | $12,807,844 | $8,881,821 |
| **Corrugated Containers (OCC)** | 455,686 | 24.3% | $112.50 | $51,264,728 | $35,315,702 |
| **Aseptic Cartons** | 11,257 | 0.6% | $49.37 | $555,704 | $1,280,446 |
| **Glass 3 Mix** | 143,835 | 7.7% | -$3.53 | -$508,218 | -$1,654,104 |
| **Aluminum Cans (Sorted, Baled)** | 13,758 | 0.7% | $1,539.00 | $21,173,787 | $14,996,379 |
| **Steel Cans (Sorted, Densified)** | 357,295 | 19.0% | $113.29 | $40,478,533 | $32,156,539 |
| **PET (Baled, picked up)** | 54,616 | 2.9% | $420.29 | $22,954,602 | $11,469,291 |
| **Natural HDPE (Bailed, picked up)** | 6,254 | 0.3% | $708.40 | $4,430,123 | $3,251,925 |
| **Colored HDPE (Bailed, picked up)** | 38,565 | 2.1% | $486.67 | $18,768,057 | $13,883,220 |
| **Comingled (#3-7, Baled, picked up)** | 25,015 | 1.3% | $1.96 | $49,112 | $1,250,741 |
| | | | | | |
| **TOTAL of Potential Recyclables** | 1,879,029 | 100.0% | | $210,817,886 | $147,108,976 |
| **Disposed Tons** | 8,026,443 | | | | |
| **Percent of Potential Recyclables versus Landfill** | 23.4% | | | $112 | $78 |
| **Jobs Created** | 12,777 | | | | |
| | | | | | |
| **OTHER MATERIAL** | | | | | |
| **C&D Wood** | 848,002 | | $15.00 | $12,720,031 | |
| **Textiles** | 238,891 | | $4.00 | $955,566 | $12,720,031 |
| **Computers** | 36,271 | | $500.00 | $18,135,738 | $955,566 |
| **LDPE (includes some bags, film)** | 382,518 | | $278.00 | $106,340,046 | $4,533,934 |
| **Durable and Rigid containers (HDPE Rigid (Baled)** | 138,207 | | $332.00 | $45,884,668 | $45,902,178 |
| **TOTAL Other Material** | 795,888 | | | $171,316,017 | $42,844,117 |
| **TOTAL** | 2,674,917 | | | $382,133,903 | $94,235,796 |
| **Potential Jobs Created** | 18,189 | | | | |

The current value of currently landfilled but potentially recyclable material based on a 5-Year Average Commodity Revenue for the Midwest is approximately $211 million, which is 143% of the value base on the current October 2015 commodity value. As stated in the value of currently recycled material, the decline in value over the past two years is driven by the global decline in commodity demand driven in large part by the slowdown in the Chinese economy. The value of the avoided disposal cost, based on the average gate rate for disposal of $35/ton is approximately $318.1 million. The number of jobs that could potentially be created by recycling all material that is currently

recyclable but landfilled is 12,777. This calculation does not attempt to assess the tradeoff in jobs due to the reduction in jobs required to collect, transfer, landfill or otherwise mange solid waste that is not currently recovered. If collection systems are optimally and efficiently managed, the gain and loss in collection would be a net neutral job change, but job gains would be seen in processing, reprocessing and remanufacturing,

If the goal of the State were to increase the recycling rate to 30% for recyclable materials then 15% of the currently landfilled material would need to be recovered. The current value of 15% of the currently landfilled but potentially recyclable material based on a 5-Year Average Commodity Revenue for the Midwest is approximately $137 million, which is 98% of the value base on the current October 2015 commodity value. The value of the avoided disposal cost, based on the average gate rate for disposal of $35/ton is approximately $206.8 million. The number of jobs that could potentially be created by recycling all material that is currently recyclable but landfilled is 8,305.

# SECTION V
# ENVIRONMENTAL IMPACTS OF RECYCLING

# ESTIMATING ENVIRONMENTAL IMPACTS OF RECYCLING

Waste and recyclables that end up in landfill is lost energy and materials. In a landfill site, organic residuals decomposing in anaerobic conditions produces landfill gas, approximately half of which is methane. When waste is recycled, landfill gas is not formed. In addition to landfill emissions, waste and contributes to greenhouse gas emissions also in other operations, such as:

- Waste collection and transport
- Waste management in other than landfill sites
- Energy consumption in the manufacture, transport and use of products and materials that end up in waste
- Other manufacturing emissions not associated with energy consumption

When properly managed, recycling can affect emissions at all of these stages. In recycling operations, refuse-derived raw materials are used in the manufacture of products or materials instead of virgin materials. In addition, this often uses less energy than the use of virgin resources, thus contributing to the reduction in greenhouse gas emissions. For example, energy consumption is reduced by some 90% in the secondary production of aluminum when compared to primary production. Recycling also reduces the use of virgin resources, either saving them to be used by future generations or freeing them for alternative purposes. In case of renewable natural resources, recycling allows the saved resources to be used in bioenergy generation, replacing fossil fuels and thus cutting down greenhouse gas emissions.

The overall benefit gained from recycling depends on a number of questions, such as what are the transport and pre-treatment requirements of the recycled materials, what kind of materials are produced and, above all, what kind of products are to be replaced by different products using new materials.

## US EPA WASTE REDUCTION MODEL

EPA created the Waste Reduction Model (WARM)[11] to help solid waste planners and organizations track and voluntarily report greenhouse gas (GHG) emissions reductions from several different waste management practices. WARM is available both as Web-based calculator and as a Microsoft Excel spreadsheet. The Excel-based version of WARM offers more functionality than the Web-based calculator.

WARM calculates and totals GHG emissions of baseline and alternative waste management practices—source reduction, recycling, composting, landfilling and combustion. The model calculates

[11] http://www3.epa.gov/warm/index.html

emissions in metric tons of carbon equivalent (MTCE), metric tons of carbon dioxide equivalent (MTCO2E), and energy units (million BTU) across a wide range of material types commonly found in municipal solid waste (MSW). For information on the data and methodologies behind the calculations, please see the model documentation.

WARM was originally developed for small to moderate-scale waste managers enabling them to understand how their "business-as-usual" waste management practices compare to alternative practices such as recycling, source reduction, or composting in terms of greenhouse gas emissions and energy use. Its user base has expanded to include various community officials, EPA WasteWise partners, and municipalities interested in learning more about the climate and waste connection. However, the results garnered from using WARM are estimates and the model approach is not appropriate for use in inventories because WARM aggregates diffuse emissions and emission reductions form several materials within a single emission factor.

WARM is periodically updated as new information becomes available and new material types are added. Users may refer to the model history to better understand the differences among various versions of WARM. WARM was last updated March 2015. WARM now recognizes 54 material types, which are presented in the table below; their emission factors are available for viewing in units of metric tons of carbon dioxide equivalent (MTCO2E) or metric tons of carbon equivalent (MTCE). Note that the emission factors represent the GHG emissions associated with managing 1 short ton of MSW in the manner indicated. GHG savings should be calculated by comparing the emissions associated with the alternative scenario with the emissions associated with the baseline scenario, as opposed to simply multiplying the quantity by an emission factor. For instance, the GHG savings of recycling 1 short ton of aluminum cans instead of landfilling them would be calculated as follows:

(1 short ton × -9.11 $MTCO_2E$/short ton) - (1 short ton × 0.04 $MTCO_2E$/short ton) = -9.15 $MTCO_2E$

Before using WARM, you first need to gather data on your baseline waste management practices and an alternative scenario. In order to effectively use the tool, users should know how many tons of waste was managed (or will be managed) for a given time period by material type and by waste management practice. The "mixed" material types are defined in the documentation.

## Recycling Versus Source Reduction GHG Emissions

WARM uses different emission factors to calculate emissions from source reduction, recycling, composting, landfilling, and combustion. In the case of source reduction, there are two sets of factors: one for source reduction that replaces the current mix of virgin and recycled inputs and one for source reduction that displaces 100 percent virgin inputs. In general, WARM users tend to use the source reduction emission factor for the current mix of virgin and recycled inputs.

For some materials (aluminum corrugated cardboard, newspaper, dimensional lumber, and medium-density fiberboard), the greenhouse gas (GHG) benefits of recycling are greater than source reduction for the current mix. This is because recycling is assumed to displace 100 percent virgin

inputs, whereas source reduction is assumed to displace some recycled and some virgin inputs. The following equations show how the energy-related GHG benefits for the recycling and source reduction emission factors are calculated:

- Recycling: (emissions for 100 % virgin inputs - emissions for 100 % recycled inputs) x recycling loss rate
- Source Reduction: (emissions for 100 % virgin inputs x % virgin inputs in current mix) + (emissions for 100 % recycled inputs x % recycled inputs in current mix)

Therefore, depending on (1) the energy and fuel mix required to manufacture the material from virgin versus recycled inputs, (2) the recycling loss rate, and (3) the percent virgin materials in the current mix, the energy-related GHG savings from recycling may be greater than the total energy savings from source reduction. This is most likely to be the case when there is a large difference in emissions between the virgin and recycled processes, and where the current manufacturing mix includes a significant proportion of recycled inputs.

This methodology assumes the following: (1) in the recycling scenario, the demand for products is constant, and therefore, at the margin, any additional recycling increases remanufacturing and reduces virgin production; and (2) source reduction reduces overall demand for production of a material, and the effects of this reduction are distributed to remanufacturing and virgin production in proportion to their current rate of production. These assumptions are intended to support analysis of *marginal* changes in recycling or source reduction and simplify actual conditions in that they do not account for dynamic markets or supply and demand price effects.

When comparing the recycling emission factors to the source reduction factors *assuming 100 percent virgin inputs*, one can see that the GHG benefits of source reduction are greater than recycling in every case except dimensional lumber and medium-density fiberboard. This result is a function of the life-cycle framework that was used to estimate forest carbon sequestration. Estimates of forest carbon sequestration consist of two parts: (1) impact on carbon in forests and (2) impact on carbon stored in products. Both source reduction and recycling result in increased forest carbon storage - both management practices reduce the amount of carbon that is harvested to make wood products. In terms of magnitude, source reduction is slightly more beneficial. In terms of the product pool, recycling results in increased carbon storage, as recycled wood products are incorporated into new products. By definition, source reduction does not result in a new product; therefore, no carbon is added to the product pool. The net effect of these two components of the forest carbon sequestration estimates is that recycling is more beneficial from a forest carbon sequestration standpoint than source reduction.

## Waste versus. Materials Management

Conventionally, the GHG community has developed inventories using the lens of the traditional, sector-based view of emissions. In this view, waste prevention and recycling are associated with the

"waste sector", which typically appears as a minor or even trivial piece of the inventory. This is only reinforced by the common (although incorrect) perception that recycling and waste prevention is primarily about "keeping stuff out of landfills" and "extending the life of landfills". Yet most of the GHG reduction potential associated with prevention and recycling is "upstream", in other sectors. For these reasons, it is much more useful to characterize waste reduction initiatives as "materials and waste" and to avoid the narrow and restrictive terminology of "waste emissions" or "waste initiatives". The "waste" element is important - and opportunities exist to reduce "waste" emissions both through waste diversion and better landfill controls. But "materials" are also important, and recognizing them helps to expand the conversation from the narrow frame of just "waste".

## Limitations and Key Issues with WARM

The WARM is useful for comparing internal scenarios for different approaches to a comprehensive waste management approach. The West Coast Climate and Materials Management Forum is an EPA-convened collaboration of state, local, and tribal governments that develop ways to institutionalize sustainable materials management practices. The purpose is to identify and share effective greenhouse gas emission reduction strategies that also improve the way communities' source, use, and recover materials. The goal is to demonstrate effective ways for communities to reduce greenhouse gas emissions throughout the life cycle of materials. The Forum evaluated EPA's WARM tool and stated that although it remains one of the best options available for state and local governments to estimate the emissions reduction potential of prevention, recycling, and composting (relative to incineration and landfilling), WARM is not without limitations. A complete list of limitations is available in Appendix XX.

The WARM is less useful for examining the fate of individual waste streams (e.g. OCC, organics etc.). In addition, the system boundaries for organics are drawn to include processing, but presumption about end-market use is limited and do not assume displacement of convention fertilizer. This means that in the case of a comparison between thermal combustion of organics for electricity generation and composting, credit would be given for low carbon power generation and limited credit for carbon sequestration or displacement of conventional fertilizer use, both of which are well-documented benefits for composting. This disproportionately and unfairly favors incineration of organics and yard wastes. In addition, there is also no consideration to the emission of other criteria pollutants that accompany the incineration of MSW. Here are some of the key limitations when using the model[12]:

- WARM currently has no capacity to calculate reuse separate from source reduction. The source reduction management option assumes materials not manufactured.

[12] http://westcoastclimateforum.com/content/us-epas-warm-tool

- WARM focuses on materials, not products, which leaves out some significant pieces of the solid waste stream.
- In addition, WARM users face the challenge of reconciling their own materials category definitions with those the model employs – WARM's assumed composition of "mixed recyclables" or "mixed plastics" for example may vary from a community's mixture. WARM's categories for mixed paper and corrugated cardboard remain ambiguous since there are a many materials with different emissions impacts that would fall into these categories in varying ratios.
- The lack of "upstream" (or production-related) emissions for food limits WARM's utility for evaluating food waste prevention projects.
- As of August 2010, a new version of WARM includes a more comprehensive analysis of composting yard and food waste than it has in the past. The calculation of landfill emissions from organics is based on a first-order decay rate to better measure when emissions are generated. This new calculation methodology most affects food waste and grass. However, the updated model still does not include an emission factor for other compostable materials, like non-recyclable paper.
- WARM does not include GHG emissions or emissions reductions associated with other co-benefits associated with the use of compost, such as water conservation and changes in fertilizer use. WARM also does not differentiate between the potential for varying emissions from compost sites themselves as a function of technology (e.g., anaerobic vs. aerobic composting, or centralized vs. home composting).
- Currently, WARM is not intended as an inventory or accounting tool. It is not sufficiently precise and it is not easily connected to other inventory protocols.
- WARM does not currently break emissions and emissions reductions into the years in which they actually occur. Rather, WARM rolls all future emissions and emissions reductions into a single number.

## The Landfill and Climate Change

Landfills are the largest anthropogenic emitters of the greenhouse gas (GHG) methane (CH4) in the U.S. In 2006, landfills in the U.S. emitted 6,211 tons—34% of the total U.S. methane emissions (equivalent to 130.4 million tons of CO2), EPA GHG Inventory Report 2009, and second in overall methane emissions to enteric fermentation (methane produce by livestock digestion). Methane as a greenhouse gas has 20 times the potency of carbon dioxide (CO2)[1].

Paper is a long-term net emitter of GHG when placed in landfill. The equivalent of 42.7 million tons of CO2 emitted in 2006 can be attributed to the methane produced from the decay of paper products. The fact that paper and paper products make up the largest component of a landfill illustrates the impact paper and landfills have on climate change. The challenge is to reduce the volume of waste going into landfills and to impact that landfills have on climate change.

Although methane generated from landfills continues to increase year after year, methane actually emitted into the atmosphere has decreased nearly 10% from 1990 to 2007 as a result of landfill gas collection projects that are now recovering approximately 25-50% of the gases produced. Methane mitigation is expected to increase in response to federal regulations that require large municipal landfills to collect and combust their gas. However, the problem is large and there is ample opportunity not only to continue to make progress in landfill gas reclamation but also to increase waste paper recovery, keeping reusable fiber in the fiber stream.

## Overview Life Cycle Methodology

The United Nations Environment Program defines Life Cycle Assessment (LCA) as a tool for the systematic evaluation of the environmental aspects of a product or service system through all stages of its life cycle. LCA provides an adequate instrument for environmental decision support. Reliable LCA performance is crucial to achieve a life-cycle economy. The International Organization for Standardization (ISO), a worldwide federation of national standards bodies, has standardized this framework within the series ISO 14040 on LCA.

Life-cycle assessment has emerged as a valuable decision-support tool for both policy makers and industry in assessing the cradle-to-grave impacts of a product or process. Three forces are driving this evolution. First, government regulations are moving in the direction of "life-cycle accountability;" the notion that a manufacturer is responsible not only for direct production impacts, but also for impacts associated with product inputs, use, transport, and disposal. Second, business is participating in voluntary initiatives that contain LCA and product stewardship components. These include, for example, ISO 14000 and the Chemical Manufacturer Association's Responsible Care Program, both of which seek to foster continuous improvement through better environmental management systems. Third, environmental "preferability" has emerged as a criterion in both consumer markets and government procurement guidelines. Together these developments have placed LCA in a central role as a tool for identifying cradle-to-grave impacts both of products and the materials from which they are made.

The "life-cycle" or "cradle-to-grave" impacts include the extraction of raw materials; the processing, manufacturing, and fabrication of the product; the transportation or distribution of the product to the consumer; the use of the product by the consumer; and the disposal or recovery of the product after its useful life.

There are four linked components of LCA:

- Goal and Scope Definition, the product(s) or service(s) to be assessed are defined, a functional basis for comparison is chosen and the required level of detail is defined;
- Inventory Analysis of extractions and emissions, the energy and raw materials used, and emissions to the atmosphere, water and land, are quantified for each process, then combined in the process flow chart and related to the functional basis;

- Impact Assessment, the effects of the resource use and emissions generated are grouped and quantified into a limited number of impact categories which may then be weighted for importance;
- Interpretation, the results are reported in the most informative way possible and the need and opportunities to reduce the impact of the product(s) or service(s) on the environment are systematically evaluated.

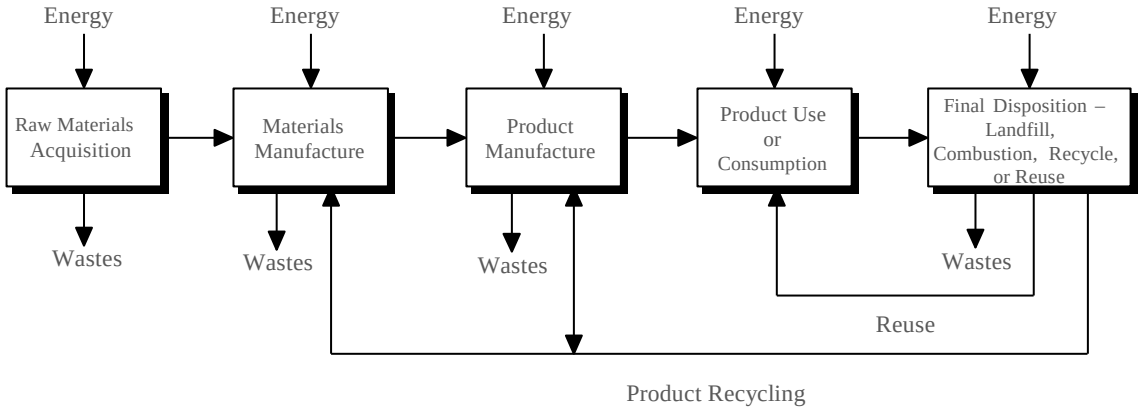
*FIGURE 12:THE PHASES OF LIFE CYCLE ASSESSMENT*

## Life Cycle Inventory

An alternative is a life cycle inventory (LCI) that quantifies the total energy requirements, energy sources, atmospheric pollutants, waterborne pollutants, and solid waste resulting from the production of feedstocks derived from recovered and recycled material, such as recycled PET and HDPE resin from postconsumer plastic. A LCI analysis does not include impact assessment. It does not attempt to determine the fate of emissions, or the relative risk to humans or to the environment due to emissions from the systems. (An exception is made in the case of global warming potential impacts, which are calculated, based on internationally accepted factors for various greenhouse gases' global warming potentials relative to carbon dioxide.)

A life cycle inventory quantifies the energy consumption and environmental emissions (i.e., atmospheric emissions, waterborne emissions, and solid wastes) for a given product based upon the study boundaries established. Figure 13 illustrates the general approach used in a full LCI analysis.

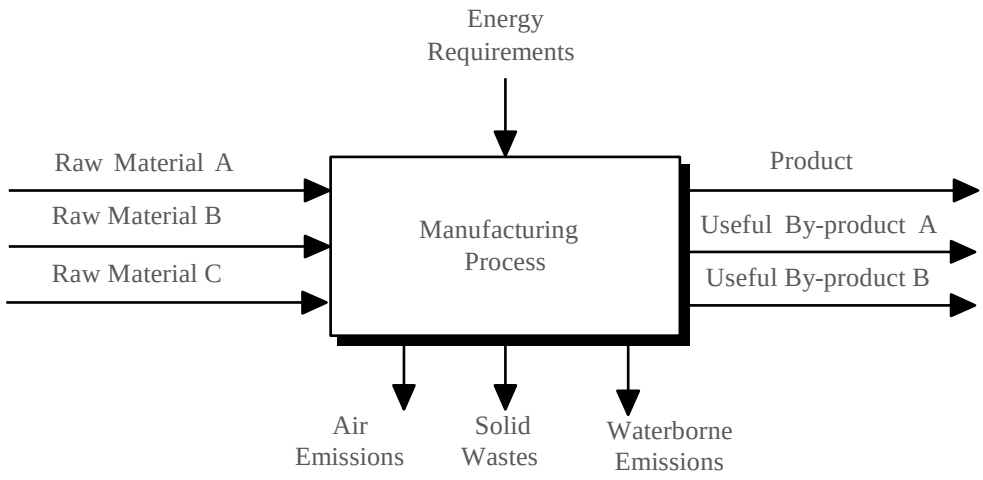
*FIGURE 13: GENERAL MATERIALS FLOW FOR "CRADLE-TOG GRAVE" ANALYSIS*



Key elements of the LCI methodology include the study boundaries, resource inventory (raw materials and energy), emissions inventory (atmospheric, waterborne, and solid waste), and disposal practices. Franklin Associates developed a methodology for performing resource and environmental profile analyses (REPA), now known as life cycle inventories (LCI). This methodology has been documented for the United States Environmental Protection Agency and is incorporated in the EPA report Product Life-Cycle Assessment Inventory Guidelines and Principles.

Figure 14 illustrates the basic approach to data development for each major process in an LCI analysis. This approach provides the essential building blocks of data used to construct a complete resource and environmental emissions inventory profile for the entire life cycle of a product. Using this approach, each individual process included in the study is examined as a closed system, or "black box", by fully accounting for all resource inputs and process outputs associated with that particular process. Resource inputs accounted for in the LCI include raw materials and energy use, while process outputs accounted for include products manufactured and environmental emissions to land, air, and water.

*FIGURE 14: CONCEPTUAL FRAMEWORK FOR DEVELOPING LCI DATA*



For each process, resource requirements and environmental emissions must be determined and expressed in terms of a standard unit of output. A standard unit of output is used as the basis for determining the total life cycle resource requirements and environmental emissions of a product.

There is general consensus among life cycle practitioners on the fundamental methodology for performing LCIs.[13] However, for some specific aspects of life cycle inventory, there is some minor variation in methodology used by experienced practitioners. These areas include the method used to allocate energy requirements and environmental releases among more than one useful product produced by a process, the method used to account for the energy contained in material feedstocks, and the methodology used to allocate environmental burdens for postconsumer recycled content and end-of-life recovery of materials for recycling. LCI practitioners vary to some extent in their approaches to these issues.

## Postconsumer Recycling Methodology

When material is used in one system and subsequently recovered, reprocessed, and used in another application, there are different methods that can be used to allocate environmental burdens among different useful lives of the material. Material production, recycling, and disposal burdens can be allocated over all the useful lives of the material, or boundaries can be drawn between each successive useful life of the material. In this analysis, separate sets of results are developed using each of these approaches.

The method in which virgin material burdens and recycling burdens are allocated among a limited number of useful lives of the material is referred to as the open-loop allocation method. In this method, the burdens for virgin material production, recovery and recycling, and ultimate disposal of recycled material are shared among all the sequential useful lives of the material.

The other method is referred to here as the "cut-off" method. Under this approach, a boundary is drawn between the initial use of the material and subsequent recovery and recycling of the material. All virgin material production burdens are assigned to the first use of the material, and the burdens assigned to the recycled resin system begin with recovery of the postconsumer material. All of the burdens for material recovery, transport, separation and sorting, and reprocessing are assigned to the recycled material.

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[13] International Standards Organization. ISO 14040:2006 Environmental management—Life cycle assessment—Principles and framework, ISO 14044:2006, Environmental management – Life cycle assessment – Requirements and guidelines.

## FINDINGS

The review of the US EPA WARM approach to evaluating the environmental impacts of recycling as well as the review of other Life Cycle approaches leads the project team to conclude that the WARM approach is an appropriate method for the State of Michigan to utilize in the evaluation of traditional recyclable materials, but the protocol for evaluating organics should be modified or alternative approaches should be developed. The WARM Model is useful for comparing internal scenarios for different approaches to a comprehensive waste management approach and should not be used to develop management protocols for individual materials.

Other LCA/LCA approaches require very detailed information of all aspects of a product, both in its manufacturing and in its end of life utilization. LCA/LCI approaches rely on detailed data on the material used in the manufacturing of a product. Performing LCI studies also require extensive data for specific materials and products. Although there are known drawbacks and criticisms of the WARM approach it is primarily focused on materials that are typically found in the municipal waste stream. As was identified in the MRI project more extensive and better data needs to be collected in Michigan on recycled materials.

The State of Michigan will need to develop more detailed data on the types of materials that are included in the WARM methodology before a comprehensive utilization of this tool can be undertaken. In addition, the protocols for organics should be improved or alternative approaches developed for these materials.

## Waste Characterization Recommendations

Several findings from the analysis can provide guidance that will strengthen the ability to increase recycling in Michigan in the future. These recommendations pertain to implementation of best practices and conducting more in depth analysis of the material that is generated as MSW in Michigan.

Other states that have regularly conducted statewide waste characterization studies have, over time, structured the studies to investigate certain waste streams in greater detail. In addition to measuring the composition of disposed wastes in total and by generator sector, some states have opted to focus on:

- Targeted generator sampling of the most prevalent business types (e.g., grocery stores, manufacturing, retail malls, etc.) that generate significant quantities of waste;
- Enhanced research into waste generation indicators for certain waste streams, especially C&D debris, to improve future sampling plans for this waste stream;
- Measuring contamination rates in disposed material (for both particulate matter and moisture) as a means of investigating dirty MRF processing potential;
- Calculating energy and heating values in disposed waste for incineration and thermal conversion processes; and
- Determining the composition of residuals from recyclables processing facilities to test recovery efficiency and potential for additional processing.

If Michigan determines that large statewide waste characterization studies should be conducted, it may consider integrating one or more of these tests in the future. Such future efforts would be limited by available funding, but could provide additional insight into diversion and recycling opportunities in Michigan.

# APPENDICES

## APPENDIX I: END MARKET COMMODITY TYPES AND MARKET INDICATOR

| Acronym | Material | MARKET INDICATOR |
|---|---|---|
| **ONP** | Old Newspaper | OBM #8 CHICAGO HIGHSIDE |
| **OMG** | Old Magazines | OBM #8 CHICAGO HIGHSIDE |
| **OCC** | Old Corrugated Cardboard | OBM #11 CHICAGO HIGHSIDE |
| **RMP** | Residential Mixed Paper | OBM #1 CHICAGO HIGHSIDE |
| **OTD** | | OBM #1 CHICAGO HIGHSIDE |
| **PLASTIC HDPE NATURAL** | High Density Polyethylene | Waste New 1st Issue of Month - Chicago Region |
| **PLASTIC - HDPE PIG** | High Density Polyethylene Pigmented | Waste New 1st Issue of Month - Chicago Region |
| **PLASTIC - PET** | Polyethylene terephthalate | Waste New 1st Issue of Month - Chicago Region |
| **GLASS-CL** | Clear | REGIONAL/LOCAL MARKET RATE |
| **GLASS-BR** | Brown | REGIONAL/LOCAL MARKET RATE |
| **GLASS- GR** | Green | REGIONAL/LOCAL MARKET RATE |
| **ALUM** | ALUMINUM | ALUMINUM METAL MARKET LOW - 1ST ISSUE OF MONTH |
| **STEEL** | Ferrous Steel and Iron | Average REGIONAL Monthly Sales |

# APPENDIX II: WARM REVIEW BY THE WEST COAST CLIMATE AND MATERIALS MANAGEMENT FORUM

See http://westcoastclimateforum.com/content/us-epas-warm-tool

The West Coast Climate and Materials Management Forum is an EPA-convened collaboration of state, local, and tribal governments that develop ways to institutionalize sustainable materials management practices. Although EPA's WARM tool remains one of the best options available for state and local governments to estimate the emissions reduction potential of prevention, recycling, and composting (relative to incineration and landfilling), WARM is not without limitations. Here are some limitations that anyone using the model should be aware of:

- WARM currently has no capacity to calculate reuse separate from source reduction. The source reduction management option assumes materials not manufactured. Using the source reduction calculations as a proxy for reuse activities only works if one assumes that the reuse actually substitutes for the mining and manufacture of virgin materials that would have otherwise been necessary. This is a shaky assumption, since some reuse activities don't actually displace production of new materials.
- WARM focuses on materials, not products, which leaves out some significant pieces of the solid waste stream. It doesn't, for example, include such categories as sheetrock, textiles (which can have multiple materials in products) or household items – furniture, toys, sporting goods, electronics other than PCs. Material list is found on the WARM homepage.
- In addition, WARM users face the challenge of reconciling their own materials category definitions with those the model employs – WARM's assumed composition of "mixed recyclables" or "mixed plastics" for example may vary from your community's mixture. WARM's categories for mixed paper and corrugated cardboard remain ambiguous since there are a many materials with different emissions impacts that would fall into these categories in varying ratios.
- Some materials management efforts are better evaluated using other methods and tools. WARM is not easily adapted to comprehensive comparisons of materials management strategies such as EPP or reuse programs. The lack of "upstream" (or production-related) emissions for food limits WARM's utility for evaluating food waste prevention projects.
- Methane Global Warming Potential (GWP): GWP is a concept designed to compare the ability of a greenhouse gas to trap heat in the atmosphere relative to another gas. The definition of a GWP for a particular greenhouse gas is the ratio of heat trapped by one unit mass of the greenhouse gas to that of one unit mass of CO2 over a specified time period. WARM uses 21 as the GWP for methane, which is the 100-year GWP listed in the IPCC's second assessment from 1996. According to the EPA, November 2009, this will not be changed anytime soon as the GWP is set by the United Nations Framework Convention on Climate Change (UNFCCC) which EPA must use for national GHG inventories (and which is based on the IPCC second assessment). It is important to note that the more recent IPCC Assessment 4 (2007) uses a 100-year GWP for methane of 25. Moreover, many state and local inventory and waste professionals believe that using the 20 year horizon GWP of 72 for methane highlights the potential for important short-term emissions reduction benefits, since methane decays quickly (it has a 12 year lifetime) and thus has its maximum warming impact well before 100 years is reached.

- As of August 2010, a new version of WARM includes a more comprehensive analysis of composting yard and food waste than it has in the past. First, the calculation of landfill emissions from organics is based on a first-order decay rate to better measure when emissions are generated. Previous versions of the model only calculated the lifetime methane yield. In addition, landfill gas capture systems are modeled with a time element, assuming systems are phased in at landfills. With these two new elements, the model is able to estimate the amount of methane being generated at a particular time and the amount of methane being captured at that time. This new calculation methodology most affects food waste and grass. The emission factors for branches, which degrade at a very slow rate, changed very little. The new emission factor takes into account the higher soil carbon sequestration capacity for compost-improved soil as well as the GHG emissions involved in composting machinery and transportation. However, the updated model still does not include an emission factor for other compostable materials, like non-recyclable paper. WARM also does not include GHG emissions or emissions reductions associated with other co-benefits associated with the use of compost, such as water conservation and changes in fertilizer use. WARM also does not differentiate between the potential for varying emissions from compost sites themselves as a function of technology (e.g., anaerobic vs. aerobic composting, or centralized vs. home composting).
- WARM counts long-term carbon sequestration in landfills, while ICLEI's GHG Emissions Analysis Protocol, and the California Air Resources Board Local Government Operations Protocol do not.
- WARM only allows comparison against a single disposal option. If your community sends waste to more than one disposal facility (for example, a landfill with gas recovery, a landfill without gas recovery, and an incinerator), then multiple runs of the model are required.
- WARM treats international production – both of virgin and recycled materials – as if production in other countries have the same emissions factors (emissions per ton) as domestic production. Given the international flow of products and recycled feedstocks, and the potential for significant regional differences in emissions based on regional fuel mixes and technology patterns, this is a potential limitation. This is particularly acute in the forest carbon sequestration element of WARM (for paper recycling and source reduction), which is based entirely on modeling of forest management practices in the domestic US. Forest management practices, and the associated carbon benefits/impacts of reducing use of wood, likely vary widely between the US and some other areas of the world, including areas that would supply virgin fiber to foreign mills were it not for their use of wastepaper exported from the US.
- Currently, WARM is not intended as an inventory or accounting tool. It is not sufficiently precise and it is not easily connected to other inventory protocols. As mentioned in the Inventories section, conventional "purist" inventories are based on single locations and designated timeframes. Emission savings in WARM will likely fall outside both of these boundaries.
- WARM does not currently break emissions and emissions reductions into the years in which they actually occur. Rather, WARM rolls all future emissions and emissions reductions into a single number. While appropriate for comparing program options against each other, this limits WARM's usefulness in inventories, since most other emissions are reported in the years in which they actually occur. Organic materials (e.g. cardboard, paper, lumber) have avoided emissions associated with source reduction and recycling that is time-sensitive.
    - Forest carbon sequestration: When paper is recycled, fewer trees are cut down. This carbon sequestration reduces the net emissions associated with paper source reduction and recycling. The reductions occur over decades, since every year following the actual recycling or source reduction event, over their lifetime, these trees absorb carbon as they continue to grow.

- Avoided landfill emissions: When paper is recycled, less of it goes into the landfill. Landfill methane emissions are reduced, and these avoided emissions reduce the net emissions associated with paper source reduction and recycling. These reductions occur over decades, since decay in the landfill occurs over decades. The same is true for diversion of other putrescible wastes, such as food waste composting.
- Carbon storage: WARM provides a credit for carbon stored in soils treated with finished compost as well as the non-putrescible fraction of biogenic wastes (such as lumber) placed into landfills.

# APPENDIX III: DETAILED STATEWIDE WASTE COMPOSITION

Thus table provides a detailed profile of the statewide disposed waste stream based on the adjusted Bottle bill scenario. For each material category, the estimated disposed tons, and mean percent are shown.

| Material Type | % | Tons | | Material Type | % | Tons |
|---|---|---|---|---|---|---|
| **PAPER** | | | | GLASS | | |
| High Grade - general | 0.68% | 54,199 | | Glass - general | 1.32% | 105,896 |
| Mixed/ unspecified Office | 0.70% | 56,492 | | Flat/plate | 0.15% | 11,882 |
| White Ledger | 0.71% | 57,326 | | Other Glass | 0.32% | 26,057 |
| Colored Ledger | 0.03% | 2,710 | | **Glass Subtotal** | **1.79%** | 143,835 |
| ONP | 1.92% | 154,466 | | ELECTRONICS | | |
| Magazines and Catalogs (OMG) | 1.44% | 115,277 | | Brown goods and electronics - general | 0.65% | 52,531 |
| Paper Bags | 0.25% | 20,220 | | Computer-related | 0.45% | 36,271 |
| Phonebooks and Directories | 0.12% | 9,797 | | Video display and CRT devices | 0.34% | 27,516 |
| OCC | 5.68% | 455,686 | | White goods (appliances) | 0.14% | 11,465 |
| Cartons, Aseptic, Poly-coated | 0.14% | 11,257 | | Other electronics | 0.03% | 2,501 |
| Compostable/soiled | 3.71% | 298,093 | | **Electronics Subtotal** | **1.62%** | 130,285 |
| Other Recyclable Paper | 3.77% | 302,262 | | WOOD | | |
| All other paper | 4.53% | 363,549 | | Wood - general | 1.92% | 154,258 |
| **Paper Subtotal** | **23.69%** | **1,901,543** | | Untreated Wood | 2.25% | 180,315 |
| **PLASTIC** | | | | Treated Wood | 2.48% | 198,868 |
| PET bottles | 0.65% | 52,531 | | Pallets and crates | 0.15% | 12,299 |
| PET containers non-bottles | 0.03% | 2,085 | | Lumber | 3.77% | 302,262 |
| HDPE Bottles Natural | 0.08% | 6,254 | | **Total Wood** | **10.57%** | 848,002 |
| HDPE Bottles not specified/Colored | 0.48% | 38,565 | | YARD WASTE | | |
| LDPE (includes some bags, film) | 4.77% | 382,518 | | Yard waste - general | 1.19% | 95,890 |
| Expanded Polystyrene (foam) | 0.94% | 75,461 | | Branches and Stumps | 0.34% | 26,891 |
| Plastic bottles and #3-7 (general) | 0.31% | 25,015 | | Prunings and Trimmings | 1.51% | 121,113 |
| Durable and Rigid containers | 1.72% | 138,207 | | Leaves and grass | 0.00% | 0 |
| All other Plastics | 3.60% | 288,921 | | Food | 15.10% | 1,211,759 |
| **Plastic Subtotal** | **12.58%** | **1,009,556** | | Other organics | 0.10% | 8,338 |
| **METAL** | | | | Other R/C Organics | 3.06% | 245,562 |
| Aluminum cans | 0.17% | 13,758 | | **Organic Subtotal** | **21.30%** | 1,709,554 |
| Aluminum (foil and other) | 0.13% | 10,423 | | **Tires** | **0.05%** | 4,169 |
| Tin/Steel Cans | 0.49% | 39,398 | | **Carpet** | **2.34%** | 188,028 |
| Ferrous metals (includes tin) | 3.96% | 317,897 | | **Textiles** | **2.98%** | 238,891 |
| Non-ferrous metals | 0.73% | 58,368 | | **Fluorescent blubs** | **0.05%** | 4,169 |
| Other Metal | 0.60% | 47,945 | | **Other Non- Recyclable Material** | **16.95%** | 1,360,621 |
| **Metal Subtotal** | **6.08%** | **487,789** | | **TOTAL** | **100.00%** | 8,026,443 |

# APPENDIX IV: LIST OF REVIEWED WASTE CHARACTERIZATION STUDIES

**Low-Diversion Profile**

- Pennsylvania Department of Environmental Protection, *Statewide Municipal Waste Composition Study,* 2003. http://www.dep.state.pa.us/dep/deputate/airwaste/wm/recycle/Waste_Comp/Study.htm
- Illinois Department of Commerce and Economic Opportunity/Illinois Recycling Association, *Illinois Commodity/Waste Generation and Characterization Study,* 2009. http://www.illinoisrecycles.org/pdffiles/ICWCGSReport052209.pdf
- Georgia Department of Community Affairs, *Georgia Statewide Waste Characterization Study: Final Report,* 2005. http://www.dca.state.ga.us/development/EnvironmentalManagement/publications/GeorgiaMSWCharacterizationStudy.pdf
- Indiana Department of Environmental Management, *Municipal Solid Waste Characterization Study for Indiana*, May, 2012
- *www.in.gov/idem/recycle/files/msw_characterizarion_study.pdf*
- US EPA, *Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Detailed Tables and Figures for 2008.* http://www.epa.gov/wastes/nonhaz/municipal/pubs/msw2008data.pdf

**Medium -Diversion Profile**

- Wisconsin Department of Natural Resources, *Statewide Waste Characterization Study,* 2003. http://dnr.wi.gov/org/aw/wm/publications/recycle/wrws-finalrpt.pdf
- Connecticut Department of Environmental Protection, *Connecticut Statewide Solid Waste Composition and Characterization Study,* 2010. http://www.ct.gov/dep/lib/dep/waste_management_and_disposal/solid_waste/wastecharstudy/ctcompositioncharstudymay2010.pdf
- California Integrated Waste Management Board, *California 2008 Statewide Waste Characterization Study,* 2009. http://www.calrecycle.ca.gov/publications/general/2009023.pdf
- US EPA, see above

**High-Diversion Profile**

- Thurston County, WA Department of Water and Waste Management, *Solid Waste System Assessment,* 2007. http://www.co.thurston.wa.us/wwm/Publications/Solid%20Waste/MFA%20SYSTEM%20ASSESSMENT%20-%20FINAL_lowres.pdf
- Snohomish County, WA Department of Public Works, *Snohomish County Waste Composition Study,* 2009. http://www.co.snohomish.wa.us/documents/Departments/Public_Works/SolidWaste/Information/Brochures/WasteComp2009Final.pdf
- Clark County, WA, *Clark County 2008 Waste Stream Analysis,* 2008. http://www.clark.wa.gov/recycle/documents/11.08%20Appendix%20I%202008%20Waste%20Stream%20Analysis.pdf

- Seattle, WA Public Utilities, *Residential Waste Stream Composition Study,* 2006; *Construction & Demolition Waste Composition Study,* 2007; *Commercial and Self-Haul Waste Streams Composition Study,* 2008.
  http://www.cityofseattle.net/util/About_SPU/Garbage_System/Reports/Waste_Composition_Reports/SPU_001839.asp
- San Francisco Department of the Environment, *Waste Characterization Study,* 2006.
  http://www.sfenvironment.org/downloads/library/wastecharacterizationstudy.pdf
- Palo Alto, CA, *Palo Alto Waste Composition Study,* 2006.
  http://www.cityofpaloalto.org/civica/filebank/blobdload.asp?BlobID=7136
- California Integrated Waste Management Board, see above
- US EPA, see above

**Additional Studies Consulted**

- Delaware Solid Waste Authority, *Statewide Waste Characterization Study*, 2007.
  http://www.dswa.com/pdfs/reports/Statewide%20Waste%20Characterization%20Study%202006-2007.pdf
- Iowa Department of Natural Resources, *2011 Iowa Statewide Waste Characterization Study, Final Report*, September 2011
  http://www.iowadnr.gov/Portals/idnr/uploads/waste/wastecharacterization2011.pdf
- Missouri Department of Natural Resources, *2008 Missouri Waste Composition Study*, 2009.
  *http://www.dnr.mo.gov/env/swmp/docs/wcs2008.pdf*
- Nebraska Department of Environmental Quality, *Waste Characterization Study*, 2009.
  http://www.deq.state.ne.us/Publica.nsf/23e5e39594c064ee852564ae004fa010/e3b876e52f86f1a6862575c900733cca/$FILE/Waste%20Study%20Portfolio.pdf
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# APPENDIX V: COMPREHENSIVE CHARACTERIZATION CATEGORIES

| | Residential and Commercial | | | | | | Residential | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Material Type** | **Bottle Bill Diversion** | **Bottle Bill Diversion ADJUSTED** | **Low Diversion** | **Medium Diversion** | **High Diversion** | | **Low Diversion** | **Medium Diversion** | **High Diversion** | **Bottle Bill Diversion** |
| **High Grade - general with White and Colored Ledger** | 1.37% | 1.42% | 0.35% | 1.27% | 0.48% | | 0.25% | 1.17% | 0.20% | 0.80% |
| **Mixed/ unspecified Office** | 0.68% | 0.70% | 2.37% | 0.40% | 0.23% | | 1.10% | 0.57% | 0.85% | 0.57% |
| **Low Grade - general (OMG), Boxboard, Paper Bags, Phonebooks other recyclable** | 5.37% | 5.58% | 7.63% | 4.10% | 5.22% | | 7.85% | 6.00% | 0.95% | 4.70% |
| **ONP** | 1.85% | 1.92% | 4.02% | 1.73% | 1.64% | | 4.70% | 2.83% | 1.87% | 2.20% |
| **OCC** | 5.47% | 5.68% | 10.12% | 4.87% | 2.68% | | 5.45% | 2.60% | 2.19% | 3.07% |
| **Cartons, Aseptics and Poly-coated** | 0.14% | 0.14% | 0.17% | 0.07% | 0.28% | | 0.25% | 0.03% | 0.17% | 0.07% |
| **Compostable/ soiled and all other paper** | 7.94% | 8.24% | 8.03% | 8.87% | 7.90% | | 7.70% | 10.40% | 12.62% | 10.27% |
| **Paper Subtotal** | **22.81%** | **23.69%** | **32.69%** | **21.30%** | **18.43%** | | **27.30%** | **23.60%** | **18.85%** | **21.67%** |
| **PET bottles and containers** | 0.66% | 0.68% | 1.12% | 0.67% | 0.65% | | 1.30% | 0.83% | 1.10% | 0.97% |
| **HDPE Bottles Natural & Colored** | 0.54% | 0.56% | 0.99% | 0.43% | 0.54% | | 1.10% | 0.73% | 0.75% | 0.77% |
| **Plastic bottles and #3-7 (general)** | 0.30% | 0.31% | 0.42% | 0.17% | 0.70% | | 0.65% | 0.40% | 0.76% | 0.70% |
| **All other Plastics and Packaging, LDPE, Polystyrene, Durable /Rigid containers and PP tubs)** | 10.62% | 11.03% | 11.35% | 10.37% | 10.88% | | 9.70% | 9.13% | 9.49% | 9.80% |
| **Plastic Subtotal** | **12.11%** | **12.58%** | **13.88%** | **11.63%** | **12.77%** | | **12.75%** | **11.10%** | **12.09%** | **12.23%** |
| **Aluminum cans** | 0.17% | 0.17% | 0.54% | 0.20% | 0.30% | | 0.55% | 0.30% | 0.37% | 0.27% |
| **Ferrous metals (includes Tin/Steel Cans)** | 4.29% | 4.45% | 3.75% | 3.03% | 2.30% | | 3.90% | 2.67% | 2.64% | 2.77% |
| **Non-ferrous metals, Aluminum (foil) and Other Metal and Aerosol Cans** | 1.40% | 1.45% | 1.04% | 1.70% | 2.20% | | 1.20% | 1.60% | 1.86% | 1.33% |
| **Metal Subtotal** | **5.85%** | **6.08%** | **5.33%** | **4.93%** | **4.80%** | | **5.65%** | **4.57%** | **4.87%** | **4.37%** |
| **Glass - general including containers** | 1.27% | 1.32% | 2.91% | 1.23% | 1.93% | | 3.55% | 1.70% | 2.22% | 1.60% |
| **Other Glass** | 0.46% | 0.47% | 0.37% | 0.77% | 0.61% | | 0.40% | 0.73% | 0.58% | 0.63% |
| **Glass Subtotal** | **1.73%** | **1.79%** | **3.28%** | **2.00%** | **2.54%** | | **3.95%** | **2.43%** | **2.80%** | **2.23%** |
| **Electronics - general, computer, and CRT** | 1.43% | 1.48% | 2.23% | 2.13% | 0.30% | | 2.15% | 2.07% | 0.37% | 1.83% |
| **White goods (appliances)** | 0.14% | 0.14% | 0.00% | 0.37% | 0.40% | | 0.00% | 0.43% | 0.00% | 0.23% |
| **Electronics Subtotal** | **1.56%** | **1.62%** | **2.23%** | **2.50%** | **0.70%** | | **2.15%** | **2.50%** | **0.37%** | **2.07%** |
| **Total Wood** | **10.17%** | **10.57%** | **8.67%** | **11.87%** | **7.61%** | | **6.35%** | **6.27%** | **3.77%** | **5.97%** |
| **Yard waste - general** | 6.49% | 2.70% | 3.12% | 5.70% | 2.55% | | 4.90% | 7.87% | 4.58% | 9.83% |
| **Food** | 14.53% | 15.10% | 12.46% | 13.07% | 26.58% | | 13.40% | 17.50% | 23.61% | 17.57% |
| **Other R/C Organics, Branches and Stumps** | 3.37% | 3.50% | 5.20% | 5.13% | 7.23% | | 7.55% | 8.00% | 4.35% | 5.87% |
| **Organic Subtotal** | **24.39%** | **21.30%** | **20.79%** | **23.90%** | **36.35%** | | **25.85%** | **33.37%** | **32.54%** | **33.27%** |
| **Other Textiles, Tires, Carpet, Light Bulbs** | **5.22%** | **5.42%** | **6.23%** | **6.20%** | **4.56%** | | **7.65%** | **7.70%** | **3.45%** | **8.03%** |
| **OTHER NON- RECYCLABLE MATERIAL** | **16.17%** | **16.95%** | **6.87%** | **15.67%** | **12.24%** | | **8.30%** | **8.47%** | **21.28%** | **10.17%** |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

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# Impacts of State Beverage Container Deposit Laws on Recycling Rates and Local Recycling Costs

January, 2016

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# Background and Scope of Analysis

Waste reduction, recycling, and reuse help divert municipal solid waste (MSW) from disposal in landfills and provide significant environmental and economic benefits to Michigan. Despite being an early leader in recycling and continuing to operate one of the most aggressive beverage-container deposit law ("bottle bill") programs in the country, Michigan's collection and diversion of non-bottle-bill materials has remained low, and the state's overall recycling performance is a poor 14.5 percent (RRS 2015).

Michigan's Beverage Container Initiated Law (commonly known as the "bottle bill") was passed by voter referendum in 1976 to help clean up the environment and conserve energy and natural resources associated with waste creation and disposal. The law requires a deposit of $0.10/container, including any beer, soft drinks, carbonated and mineral water, wine coolers, and canned cocktails in airtight metal, glass, paper, plastic, or combination containers under one gallon, and bans these materials from waste disposal. Consumers then return empty beverage containers to retailers for a refund of their deposit. Michigan has the highest rate of redemption for its bottle-bill materials—97 percent—largely attributed to the high $0.10/container deposit amount (most states levy $0.05/container). However, bottle-bill materials make up only 16 percent of the state's total recyclable materials (PSC 2013)

Over the years, there have been discussions of bottle bills (or with those considering adoption of a bottle bill) in Michigan as well as other states about how these deposit programs impact states' recycling rates and what effect, if any, they have on local recycling programs.

While there have been numerous studies done to evaluate Michigan's recycling performance and opportunities for improving recycling, there has been little analysis of how the bottle bill affects the state's overall recycling rate and costs for local recycling programs. Public Sector Consultants (PSC) conducted a study in 2013 titled *Improving Recycling Performance in Michigan: Best Practices, Options and Potential Costs,* which looked at some of the cost and efficiency issues with a dual bottle-bill/community recycling programs system. In addition, a Michigan Beverage and Container Task Force was established in 2003, and their final report included some discussion on the impacts of the bottle bill on recycling in Michigan. These are the only studies that have looked at bottle-bill impacts in Michigan, but there are several studies that have been done in other states.

PSC reviewed these studies, as well as literature that looked more broadly at recycling behavior,[1] to evaluate whether:

- Bottle-bill programs increase state recycling rates overall compared to just local curbside and drop-off systems
- Bottle-bill programs affect the cost and viability of local recycling programs

## BOTTLE-BILL EFFECT ON RECYCLING RATES

While there is substantial research evaluating how bottle bills affect the recycling of beverage containers, there is very limited analysis of how bottle-bill programs affect statewide recycling rates overall.

[1] For its analysis, PSC reviewed a mix of peer reviewed studies, industry articles, and reports prepared by consultants or organizations to look at the impacts of bottle bills in specific states. The vast majority of the literature was made up of the latter category.

### *Do bottle bills increase the amount of beverage containers recycled?*

It is undeniable in reviewing the literature that bottle-deposit laws increase the percentage of beverage containers recycled because consumers have financial incentives to return those containers for their deposit. Across the ten current bottle-bill states, beverage container recycling rates range from 20 to 97 percent. Michigan, with the largest deposit amount ($0.10/container), is the highest (almost 97 percent of its carbonated beverage materials are returned). Curbside and drop-off recycling programs generally do not recover this amount of beverage materials. A study done in 2002 found that residents in bottle-bill states recycled an average 490 containers per capita per year, while non-bottle-bill state residents, which rely solely on curbside or drop-off recycling programs, recycled less than half as much (only 191 beverage containers per capita per year (R.W. Beck 2002)).

In addition, the materials collected through beverage-container deposit programs are higher quality than those collected in curbside programs, particularly single stream, because there is significantly less cross contamination of materials (including broken glass and non-recyclable materials). As such, they yield a greater commodity value and are more easily used for recycled products. A 2015 study found that the industry-reported average yield losses for polyethylene terephthalate (PET) bales from curbside recycling programs is 31 percent compared to a 25 percent yield loss for bales from bottle-deposit programs because of contamination by other recycled materials (MacKerron 2015).

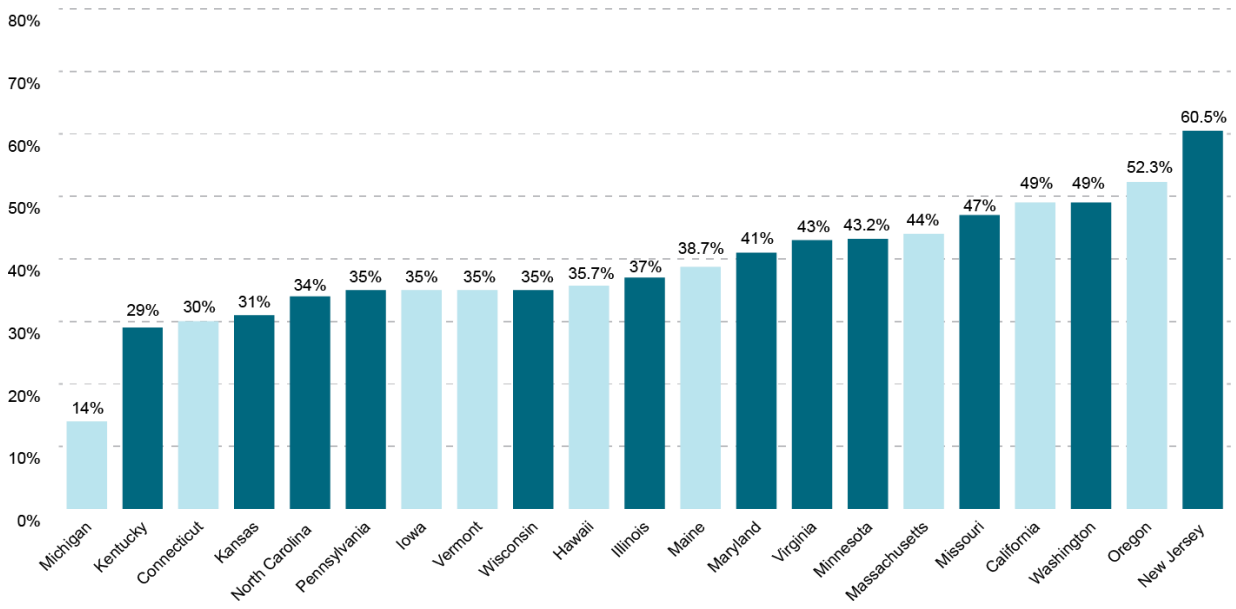
### *Do bottle-bill programs impact the recycling rate for other materials?*

The impact of bottle-bill systems on overall recycling rates, including non-beverage-container materials, is less clear. While several studies conducted over the last decade for individual states considering adoption or expansion of bottle-bill deposit programs indicate that these systems increase recycling, they only cite rates of beverage containers—not all recycled or recyclable material.

In 2013, PSC conducted a study of twenty high-performing recycling states[2] to evaluate whether there was a strong relationship between bottle-bill programs and recycling rates. PSC's analysis found that bottle-bill states made up eight out of the 20 high-performing states. However, recycling rates, which ranged from 29 percent (Kentucky) to 60.5 percent (New Jersey), varied across the 20 states regardless of bottle-bill program adoption, as shown in Exhibit 1.

[2] The high-performing states used for comparison were initially selected based on their ranking in the BioCycle 2010 State of Garbage in America report; however, given limitations with BioCycle data, actual recycling rates (bottle and non-bottle-bill materials) for these states were obtained through research and/or interviews with state staff.

**EXHIBIT 1.** Recycling Rates for High-Performing (Bottle-Bill and Non-Bottle-Bill) States




SOURCE: Public Sector Consultants. 2013. Available at: http://www.pscinc.com/LinkClick.aspx?fileticket=ZI4nyjQU2WU%3d&tabid=65

In short, using total recycling rates as a common metric of success, bottle-deposit laws do not seem to impact total statewide recycling rates one way or another.

In every state, bottle-bill materials make up a modest share of total recycled material. In Michigan, bottle-bill materials make up approximately 16 percent of total estimated recycled materials (PSC 2013). The United States Environmental Protection Agency's (EPA) waste characterization studies report a similar percentage—metals, glass, and plastics made up 15.7 percent of waste-recovery (recycling and yard waste) materials in 2012 (U.S. EPA 2012). So, while recycling rates for beverage containers may be very high in bottle-bill states, their share of total material is not enough on its own to result in high overall recycling rates.

A 2009 study done for the State of Rhode Island which compared the adoption of an expanded bottle-bill program (to include plastic water bottles) to enhanced community curbside recycling found that an enhanced community program would increase the total volume of recycled material by 15,400 tons when compared to an expanded bottle bill (a 24 percent versus 21 percent statewide recycling rate). The expanded community system achieves a higher recycling rate because it increases the recovery of fiber (paper) while the expanded bottle bill only increases recovery of beverage containers (DSM May, 2009).

### *Do bottle-bill programs affect recycling behavior?*

Given the high level of beverage-container recycling in bottle-bill states, why doesn't Michigan see a higher level of recycling for other materials in those states based on a greater awareness of recycling? The research on how bottle-bill programs affect recycling behavior is very limited. A small number of studies have looked generally at the psychology of recycling behavior, but PSC found only one that specifically looked at recycling behaviors in bottle-bill versus non-bottle-bill states. A 2012 study examining recycling rates of plastic water bottles (which are increasingly part of the national debate on bottle-bill deposit laws) examined the factors affecting water bottle recycling behavior, including financial incentives and convenience. The authors used a nationally representative survey of plastic water bottle users at the household level to assess how individual recycling behavior is shaped by state laws and financial incentives (e.g., bottle deposits), the value people place on time (convenience), and on people's environmental concerns. The study found:

- Strong recycling policies, including mandatory recycling, municipal recycling plans requirements, and/or bottle-deposit laws, are all associated with a discontinuous jump in individual recycling effort from no recycling to diligent recycling. In other words, once these policies get someone to begin recycling, those people do not tend to do so incrementally by becoming a moderate recycler. They "jump" to become a diligent recycler.
- Beverage-container deposits not only affect recycling rates of plastic water bottles by incentivizing customers to recycle those containers, they also raise the purchase price of the product if it is not recycled (due to inconvenience) and can therefore reduce the demand for (and waste associated with) those goods.
- Low-income households are much more likely to recycle beverage containers under bottle-bill deposit systems than high-income households, who are not as motivated by the modest deposit amount.
- Based on a before-and-after study of water bottle-deposit programs in Connecticut and Oregon, people increased their return of all beverage containers and the number of diligent bottle recyclers jumped from 71 to 87 percent. In addition, the percentage of people using curbside programs jumped from 54 to 59 percent, indicating that recycling overall likely increased with adoption of a bottle bill.
- There are likely substitution effects between recycling programs, with some increase in bottle-deposit returns coming from materials that would have previously been recycled at the curb and vice versa, which may account for the lack of greater progress in increasing recycling overall (Viscusi et al. 2012).

Beatty et al. conducted a study of the incremental impacts of curbside recycling in the presence of alternative recycling options (such as bottle-deposit laws), and found similar results regarding the substitution effect. The authors found that increased access to recycling at the curb resulted in a statistically significant increase in the volume of those materials collected at the curb. But their analysis also found that curbside recycling is cannibalizing from bottle-deposit return centers, diverting 21 percent of plastic from bottle-deposit return centers and almost 78 percent of glass (no diversion was found for aluminum) (Beatty et al. 2007).

## IMPACTS OF BOTTLE-BILL LAWS ON THE COST AND VIABILITY OF LOCAL RECYCLING PROGRAMS

Do bottle-bill programs keep communities from investing in curbside or drop-off recycling programs, either for cost or perceived need reasons? There have been several studies on the economic impacts of bottle-bill systems on local recycling programs in various states.[3] The research generally looks at whether bottle-bill laws "rob" local programs of high-value recyclable materials (such as aluminum), making it harder for them to operate efficient curbside or drop-off recycling, or whether they save communities collection and waste disposal costs and provide a net benefit. The literature is somewhat mixed on the magnitude of the impacts, but most studies find that bottle-bill laws are neutral or have positive impacts on the economics of local recycling programs. Some of the key studies and their findings are summarized below:

- DSM Environmental Services conducted studies on the economic and environmental impacts of bottle-bill programs for Rhode Island and Massachusetts. DSM estimated the number of beverage containers (and related tons of material) that would be diverted from curbside programs to a new bottle-deposit return system in Rhode Island, as well as an expanded bottle-deposit return system (to include plastic bottles) in Massachusetts. Based on estimated diversion rates, they projected that the total loss of revenue[4] to communities (at a statewide level) would be $1.4 million and $900 thousand respectively (DSM July, 2009; DSM May, 2009).

[3] There have been no studies done in Michigan on the economic impact of bottle-bill programs on local communities

[4] Revenue losses were estimated for individual materials (PET, aluminum, glass) based on market rates at the time and assumed communities were receiving a 50 percent revenue share from material processors. The net losses also subtracted processing fees for each ton of material (using $25/ton).

- However, DSM's studies also evaluated the impact on municipal collection costs in order to determine net economic impacts on community recycling programs. Based on reductions in the number of trucks/routes required and reduced tipping fees for waste disposal, DSM estimated that communities in Rhode Island and Massachusetts could potentially avoid between $2 and $4 million/year (aggregated at the state level) in collection and disposal costs (DSM July, 2009; DSM May, 2009). In other words, from a municipal perspective, bottle-bill programs are a net economic positive. However, as these studies point out, these costs do not include the statewide costs of operating a bottle-bill program. DSM's analysis in Rhode Island compared the adoption of an expanded bottle program to investment in an enhanced community curbside program (statewide) and found that total cost for a bottle-bill system ($14.8 million) was almost twice as much as an enhanced municipal recycling system (which was also projected to increase overall recycling volume compared to a bottle-bill system) (DSM May 2009).
- The University of Maryland Environmental Finance Center also looked at the potential economic impacts to local communities from adopting a bottle-bill program. The authors cite studies (including the DSM studies described above) showing that communities do lose revenue from the diversion of bottle-bill materials but generally have decreased collection and disposal costs. The study also cites the significant reductions in litter that have accrued in bottle-deposit states (as much as 84 percent decrease in beverage-container litter), and notes that litter pick-up costs must also be considered when evaluating the economic impacts of beverage-container laws (University of Maryland Environmental Finance Center 2011).
- Reclay Steward Edge (RSE) evaluated the economic impacts of implementing a bottle-bill program in Minnesota, a state which already has a well-established and successful recycling program. RSE found that a bottle bill would reduce local revenues (by about $600 thousand), but would decrease collection costs and tipping fees as well. The net estimated impact was about $4 million in saved costs for communities. As with the DSM studies however, RSE also estimated substantial costs for developing and operating a bottle-bill system in Minnesota—about $30 million a year in direct costs (RSE 2014).
- Finally, a 2004 study by Sound Resource Management Group done for the state of Washington also found similar results in terms of net revenue loss and costs to community recycling programs. The authors estimated between $2 and $5 million net loss in revenue to communities from material sales (at the statewide level), but over $9 million in reduced collection and disposal costs (Morris et al. 2005) for communities. The total estimated cost of administering the bottle-bill program ranged from $60 million to almost $150 million (Morris et al. 2005)

## CONCLUSIONS

While there is substantial research showing that bottle-bill laws increase the volume of recycling for beverage containers, there is no clear connection in the research between bottle-deposit systems and higher recycling rates overall. Research examining 20 high-recycling-performance states found that both bottle and non-bottle-bill states are represented in that group, and that recycling rates varied across both categories of systems.

The reasons that recycling rates overall are not higher in bottle-bill states is not well understood. There are a handful of studies that have looked at the psychology of recycling behavior and found that there are differences (among socio-economic classes and geographies) regarding whether financial incentives associated with bottle-deposit returns outweigh the convenience of curbside recycling. These studies also found that bottle-deposit and local recycling programs (curbside and drop-off) may be cannibalizing each other, which accounts for some of the lack of progress. However, additional studies that investigate how individuals make decisions about recycling might help illuminate why overall recycling rates in bottle-bill states are not amongst the highest.

The research on whether bottle-bill programs negatively or positively affect the economics of local recycling programs is more definitive. Most of the studies have shown that bottle-bill systems certainly divert materials from local programs and that there is a subsequent loss of revenues, either by communities or their material recovery facilities. But those studies have also shown that communities' collection and disposal costs are

reduced when statewide bottle-bill programs are adopted or expanded. Thus, for communities, the impact seems to be net positive. However, the studies that also looked at state-level costs of recycling overall found that states with bottle-bill programs had higher net costs[5] than those with just community recycling programs (with estimates of direct costs ranging from $14 million to $150 million a year). This held true even when researchers included investments in enhanced local curbside recycling in the analysis.

[5] Costs under bottle-bill systems are generally shared among the state, retailers, manufacturers, and distributors of beverage containers.

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